

APPENDIX A :MEMBRANE CELL & FILM DIMENSIONS

OVERVIEW

Appendix A presents critical dimensions of both the membrane cell and the membranes used

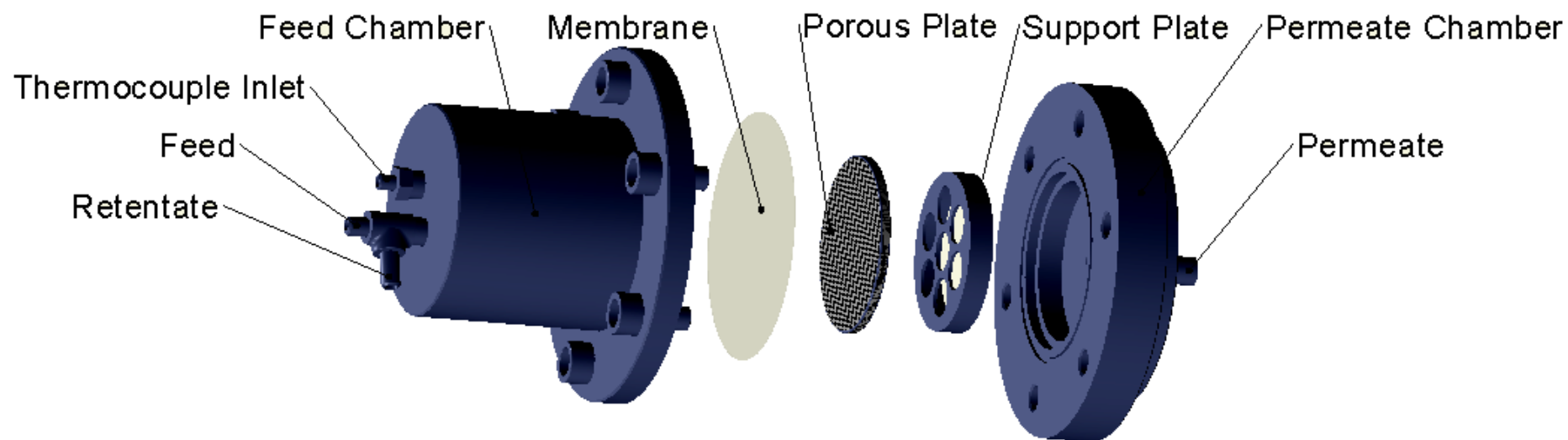


Figure A.1 Membrane cell (Effective diameter of membrane available for permeation = 42 mm)

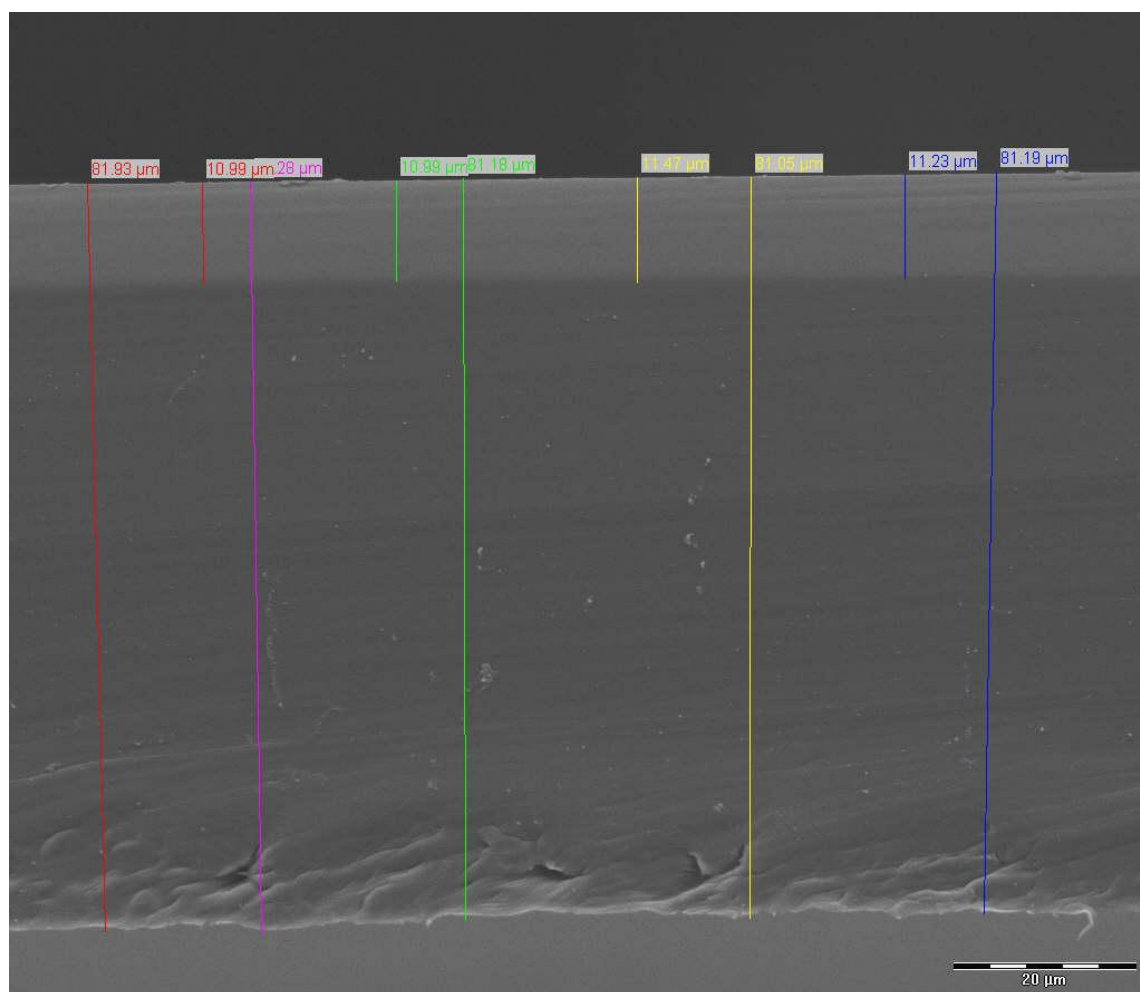


Figure A.2 Hyflon F film thickness ($81.93\mu\text{m} \pm 3\mu\text{m}$)

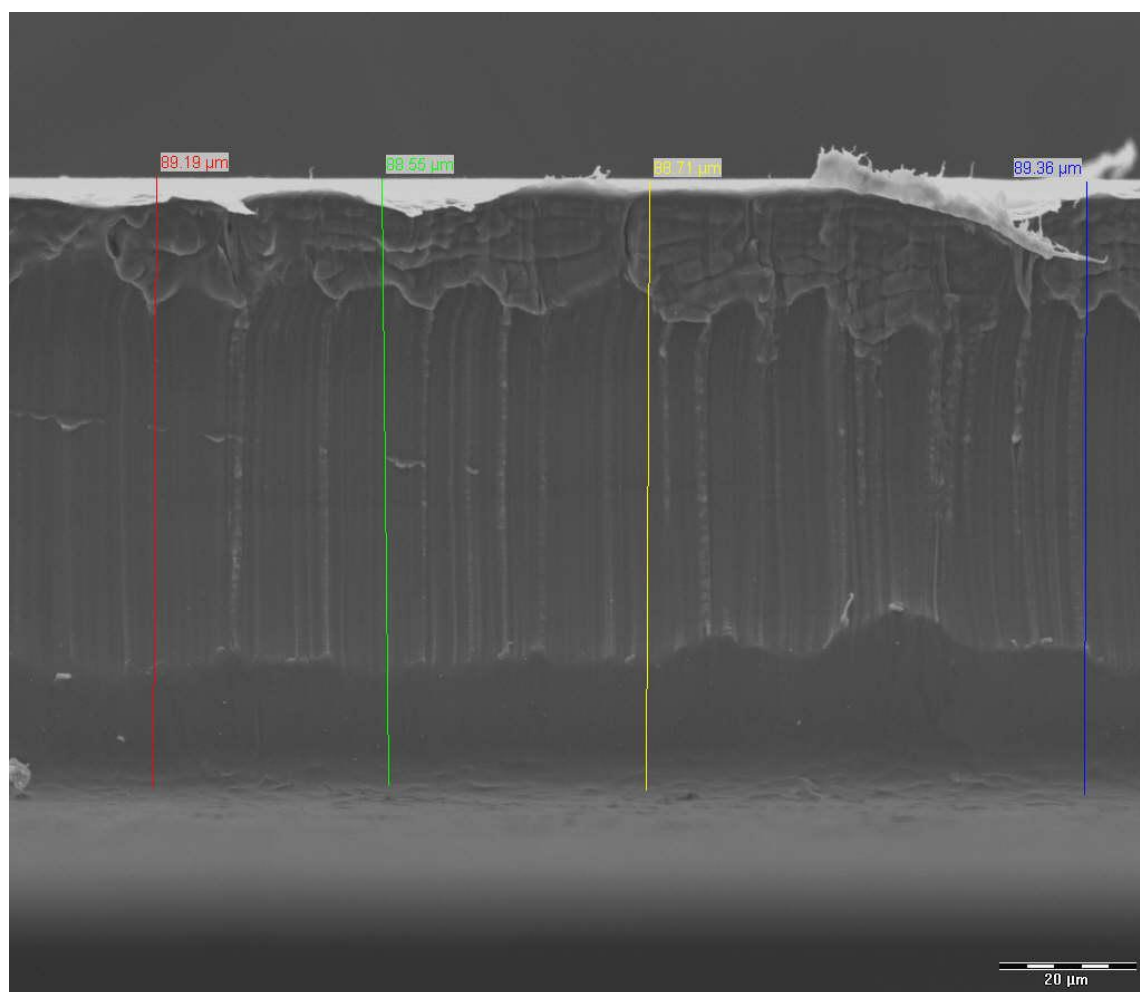


Figure A.3 Hyflon M film thickness ($89.19\mu\text{m} \pm 3\mu\text{m}$)

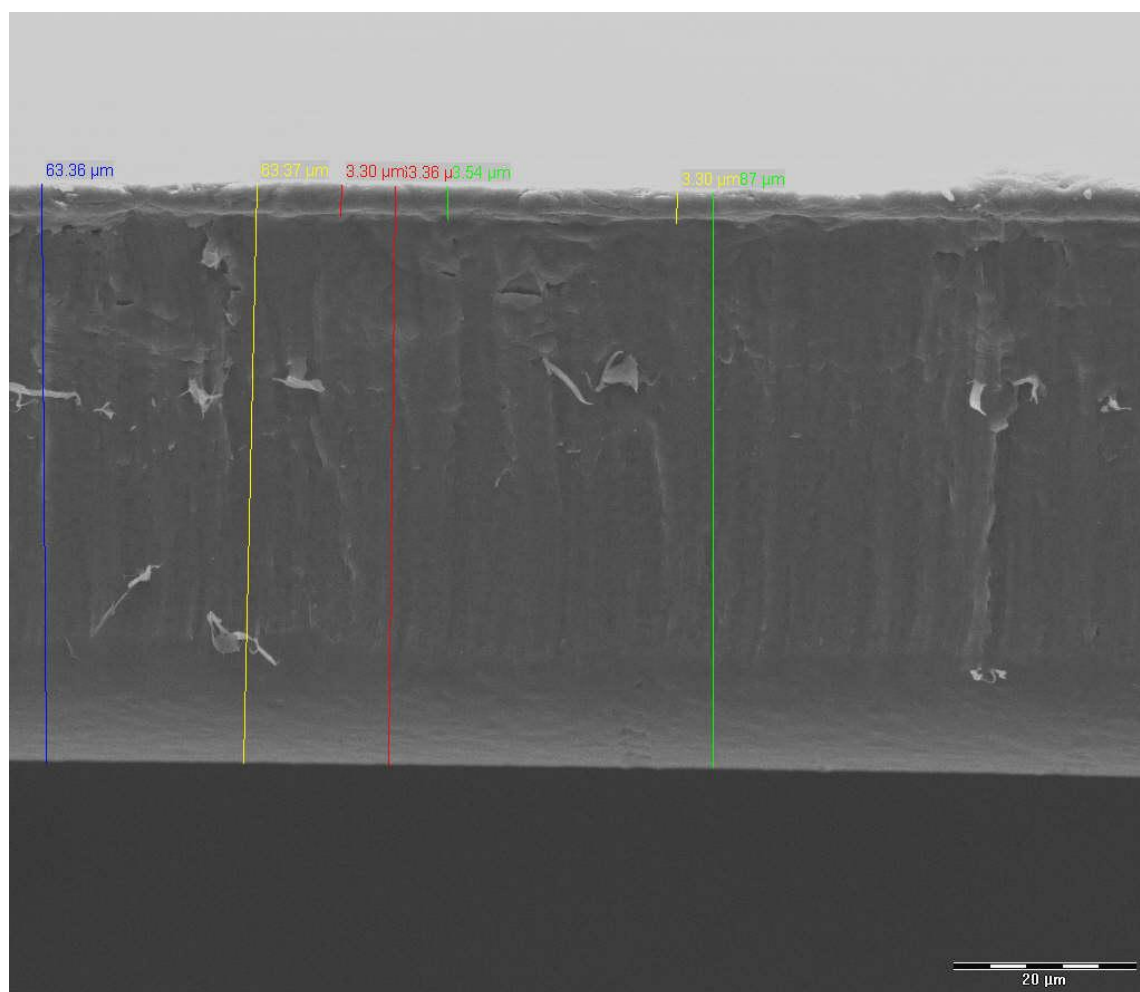


Figure A.4 Halar film thickness ($63.36\mu\text{m} \pm 3\mu\text{m}$)

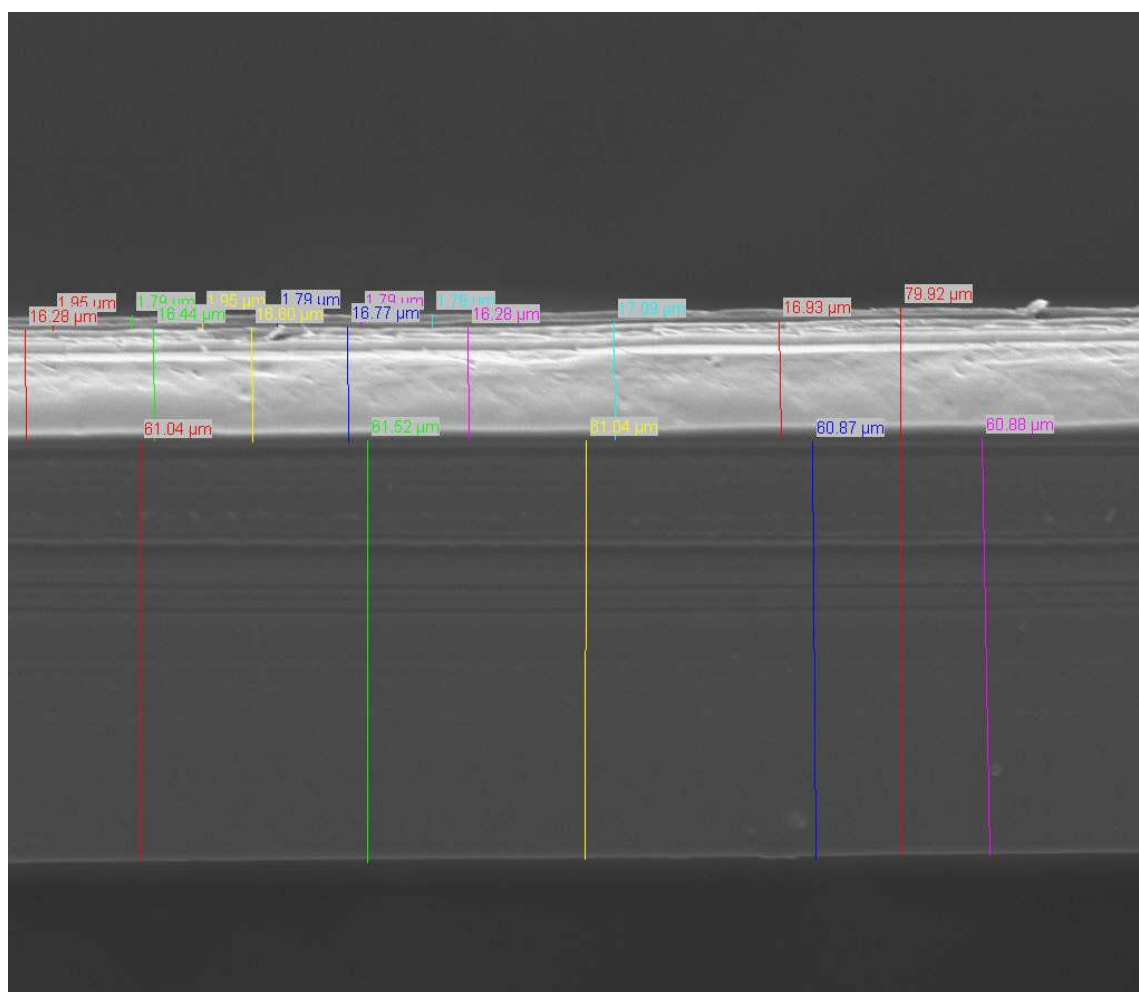


Figure A.5 Udel Polysulfone film thickness ($75 \mu\text{m} \pm 3\mu\text{m}$)

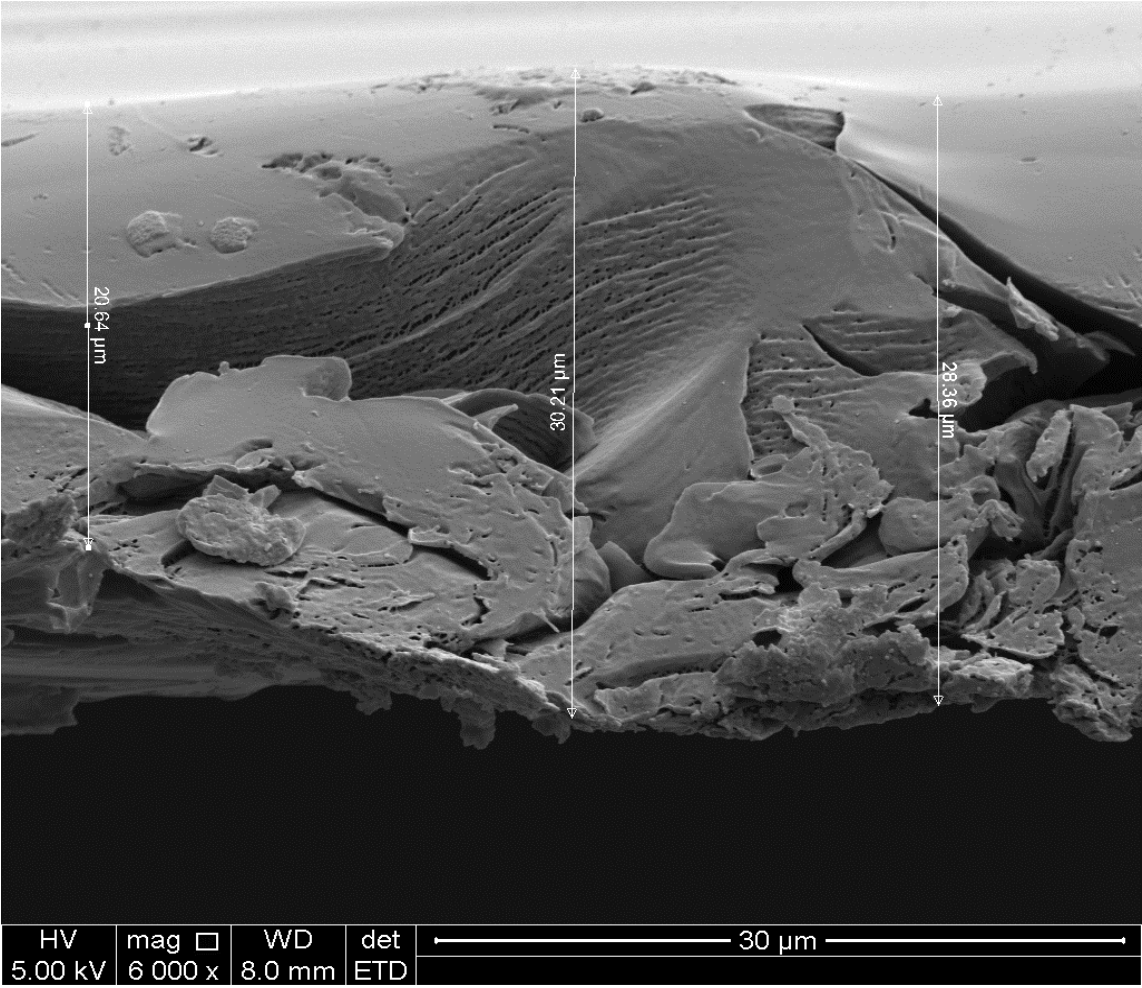


Figure A.6 Teflon AF 2400 film thickness ($30\text{ }\mu\text{m} \pm 3\text{ }\mu\text{m}$)

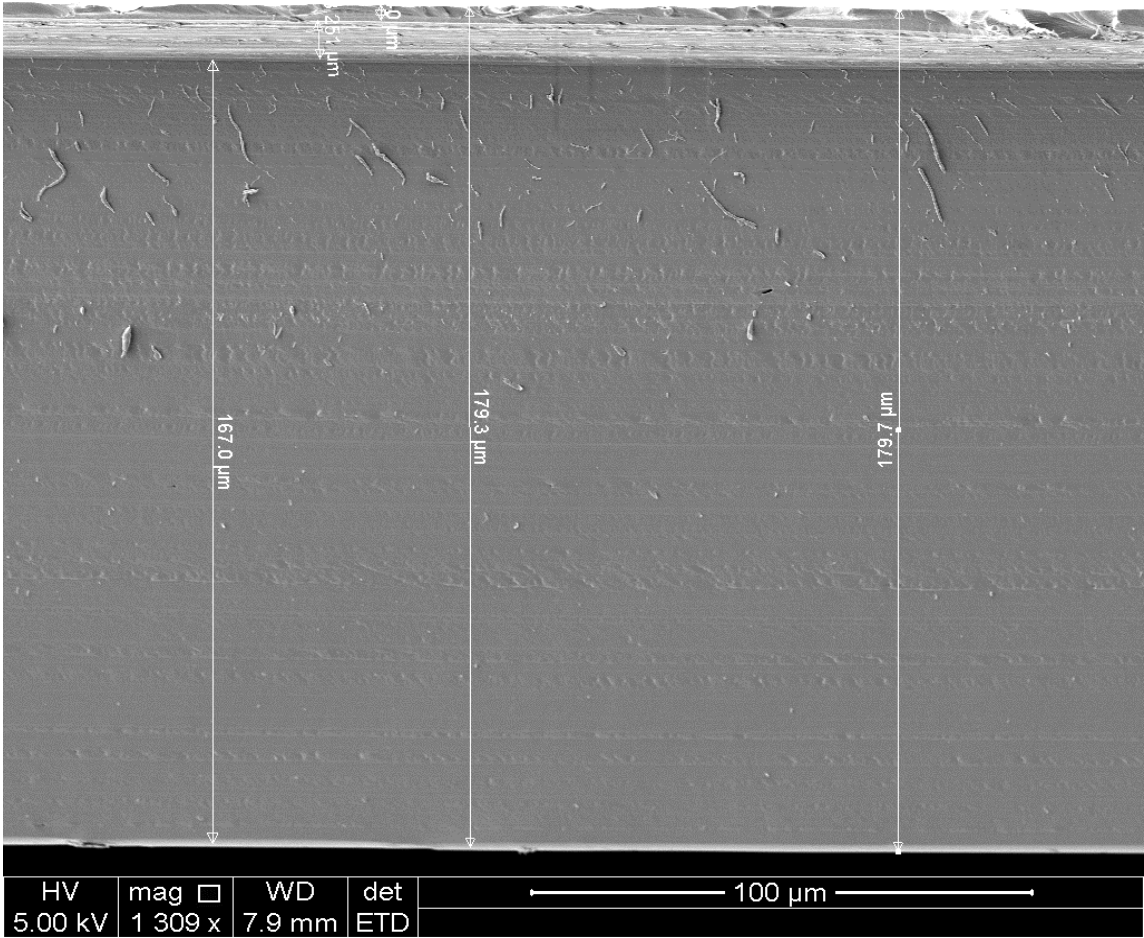


Figure A.7 Nafion 117 film thickness ($177.8\text{ }\mu\text{m} \pm 3\mu\text{m}$)

APPENDIX B :MEASUREMENT OF PERMEATE CHAMBER VOLUME

OVERVIEW

Appendix B presents the calculation procedure for determining the permeate chamber volume through the Burnett gas expansion method

MEASUREMENT OF PERMEATE CHAMBER CONSTANT VOLUME

According to the ideal gas equation:

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \quad (B1)$$

Where:

- P_1 is the pressure (pa) of the combined unknown permeate line (tubing) volume plus unknown permeate chamber volume prior to expansion.
- P_2 is the sum of the pressure (pa) of the combined unknown permeate line (tubing) volume plus unknown permeate chamber volume plus added known volume (V_0) after expansion
- V_1 is the sum of the unknown permeate line (tubing) volume (m^3) plus unknown permeate chamber volume (m^3).
- V_2 is the sum of the unknown permeate line (tubing) volume (m^3) plus unknown permeate chamber volume (m^3) plus added known volume (V_0) (m^3).
- T_1 is the temperature (K) of the combined unknown permeate line volume plus unknown permeate chamber volume prior to expansion.
- T_2 is the temperature (K) of the combined unknown permeate line volume plus unknown permeate chamber volume plus added known volume (V_0) after expansion.

Table B.1 Raw data for permeate volume calculation for Hyflon M, Halar, Nafion 117 & UPS permeation

Trial	Pressure	Temperature	Volume
1st Trial	$P_1 = 16600 \text{ pa}$	$T_1 = 299.65 \text{ K}$	$V_1 = \underline{\hspace{2cm}}$
	$P_2 = 2800 \text{ pa}$	$T_2 = 300.15 \text{ K}$	$V_2 = V_1 + V_0$
			$V_0 = 59.3 \text{ cm}^3$
2nd Trial	$P_1 = 13400 \text{ pa}$	$T_1 = 300.15 \text{ K}$	$V_1 = \underline{\hspace{2cm}}$
	$P_2 = 2200 \text{ pa}$	$T_2 = 300.15 \text{ K}$	$V_2 = V_1 + V_0$
			$V_0 = 59.3 \text{ cm}^3$
3rd Trial	$P_1 = 15800 \text{ pa}$	$T_1 = 300.15 \text{ K}$	$V_1 = \underline{\hspace{2cm}}$
	$P_2 = 2600 \text{ pa}$	$T_2 = 300.15 \text{ K}$	$V_2 = V_1 + V_0$
			$V_0 = 59.3 \text{ cm}^3$

V_1 , the volume of the permeate chamber plus the permeate line (tubing) was then calculated through substituting for values in equation B1, and an average for the three values was taken to be the working value. The three trials gave V_1 values of 12.01cm^3 , 11.65 cm^3 and 11.68 cm^3 respectively. A rounded off average value of 12 cm^3 was used.

N.B. The latter permeate chamber volume value (12cm^3) was only applicable for the single permeation experiments on Hyflon M, Halar, Nafion 117 at all feed pressures and Udel Polysulfone at feed pressures of 1 bar and 2 bar. Due to the high permeation rates of SO_2 at 3 Bar through Udel polysulfone, a larger permeate volume had to be employed by combining the permeate chamber volume of 12 cm^3 and the measuring volume of 59.3 cm^3 to make it 71.3 cm^3 .

The permeate side volume (12 cm^3) differs from that used with Hyflon F experiments due to a change of fitting types on the permeate side resulting from the failure of fittings.

Table B.2 Raw data for permeate volume calculation for Hyflon F permeation

Trial	Pressure	Temperature	Volume
1st Trial	$P_1 = 20800\text{ pa}$	$T_1 = 295.65\text{ K}$	$V_1 = \underline{\hspace{2cm}}$
	$P_2 = 11600\text{ pa}$	$T_2 = 295.65\text{ K}$	$V_2 = V_1 + V_0$
			$V_0 = 10.77\text{ cm}^3$
2nd Trial	$P_1 = 30000\text{ pa}$	$T_1 = 297.15\text{ K}$	$V_1 = \underline{\hspace{2cm}}$
	$P_2 = 16800\text{ pa}$	$T_2 = 297.15\text{ K}$	$V_2 = V_1 + V_0$
			$V_0 = 10.77\text{ cm}^3$
3rd Trial	$P_1 = 63400\text{ pa}$	$T_1 = 296.15\text{ K}$	$V_1 = \underline{\hspace{2cm}}$
	$P_2 = 35400\text{ pa}$	$T_2 = 296.15\text{ K}$	$V_2 = V_1 + V_0$
			$V_0 = 10.77\text{ cm}^3$

In the like manner V_1 , the volume of the permeate chamber plus the permeate line was then calculated through substituting for values in equation B1, and an average for the three values was taken to be the working value. The three trials gave V_1 values of 13.58cm^3 , 13.7 cm^3 and 13.61 cm^3 respectively. A rounded off average value of 13.64 cm^3 was used.

APPENDIX B MEASUREMENT OF PERMEATE CHAMBER VOLUME

Due to the need to optimise the rate of pressure build up on the permeate side for Teflon AF 2400 permeation, the permeate chamber volume had to be modified by increasing the permeate volume so as to allow for accurate recording of higher permeation rates of all test gases through Teflon AF 2400. Respective raw data is given in table B3.

Table B.3 Raw data for permeate volume calculation for Teflon AF 2400 permeation

Trial	Pressure	Temperature	Volume
1st Trial	$P_1 = 40400 \text{ pa}$	$T_1 = 300.15 \text{ K}$	$V_1 = \underline{\hspace{2cm}}$
	$P_2 = 31400 \text{ pa}$	$T_2 = 299.65 \text{ K}$	$V_2 = V_1 + V_0$
			$V_0 = 59.3 \text{ cm}^3$
2nd Trial	$P_1 = 31400 \text{ pa}$	$T_1 = 300.15 \text{ K}$	$V_1 = \underline{\hspace{2cm}}$
	$P_2 = 24400 \text{ pa}$	$T_2 = 300.15 \text{ K}$	$V_2 = V_1 + V_0$
			$V_0 = 59.3 \text{ cm}^3$
3rd Trial	$P_1 = 9000 \text{ pa}$	$T_1 = 300.15 \text{ K}$	$V_1 = \underline{\hspace{2cm}}$
	$P_2 = 7000 \text{ pa}$	$T_2 = 300.15 \text{ K}$	$V_2 = V_1 + V_0$
			$V_0 = 59.3 \text{ cm}^3$

Through substitution of raw data values into equation B1, the resulting permeate side volume values are 208.4 cm^3 , 206.7 cm^3 , 207.55 cm^3 , which give an average of 207.55 cm^3 .

Table B.4 presents the permeate volumes used for a given experiment.

N.B. All binary permeation experiments used a permeate volume of 12 cm^3 .

APPENDIX B MEASUREMENT OF PERMEATE CHAMBER VOLUME

Table B.4 Permeate chamber volumes for single permeation

Membrane	Gas	Pressure	Permeate volume	Membrane	Gas	Pressure	Permeate volume	Membrane	Gas	Pressure	Permeate volume
		Bar	cm³			Bar	cm³			Bar	cm³
Hyflon F	SO ₂	3.85	13.64	Udel Polysulfone	SO ₂	3.00	71.30	Nafion 117	SO ₂	3.00	12.00
		2.85	13.64			2.00	12.00			2.00	12.00
		1.85	13.64			1.00	12.00			1.00	12.00
	O ₂	3.85	13.64		O ₂	3.00	12.00		O ₂	3.00	12.00
		2.85	13.64			2.00	12.00			2.00	12.00
		1.85	13.64			1.00	12.00			1.00	12.00
	N ₂	3.85	13.64		N ₂	3.00	12.00		N ₂	3.00	-
		2.85	13.64			2.00	-			2.00	-
		1.85	13.64			1.00	-			1.00	-
	CO ₂	3.85	13.64		CO ₂	3.00	12.00		CO ₂	3.00	12.00
		2.85	13.64			2.00	12.00			2.00	12.00
		1.85	13.64			1.00	12.00			1.00	12.00
Hyflon M	SO ₂	3.00	12.00	Teflon AF 2400	SO ₂	3.00	207.60	Halar	SO ₂	3.00	12.00
		2.00	12.00			2.00	207.60			2.00	-
		1.00	12.00			1.00	207.60			1.00	-
	O ₂	3.00	12.00		O ₂	3.00	207.60		O ₂	3.00	12.00
		2.00	12.00			2.00	207.60			2.00	-
		1.00	12.00			1.00	207.60			1.00	-
	N ₂	3.00	12.00		N ₂	3.00	207.60		N ₂	3.00	-
		2.00	12.00			2.00	207.60			2.00	-
		1.00	12.00			1.00	207.60			1.00	-
	CO ₂	3.00	12.00		CO ₂	3.00	207.60		CO ₂	3.00	12.00
		2.00	12.00			2.00	207.60			2.00	-
		1.00	12.00			1.00	207.60			1.00	-

APPENDIX C :CONSISTENCY OF UNITS AND SAMPLE CALCULATIONS

OVERVIEW

Appendix C presents the derivation of the permeability equation for the constant volume variable pressure method and the respective consistency of units. Also presented are the single and binary permeability sample calculations. Estimation methods used to predict some permeate compositions are also presented and the calculation of membrane polymer fractional free volumes is presented.

SAMPLE CALCULATIONS

DERIVATION OF PERMEABILITY EQUATION AND CONSISTENCY OF UNITS

The Permeability coefficient is generally expressed by Equation C1.

$$P = \frac{Jl}{\Delta p} \quad (C1)$$

Where:

P is the permeability coefficient

J is the gas flux

l is the membrane thickness

Δp is the trans-membrane pressure

The flux in Equation C1, is a function of the rate of molar gas build up in the permeate chamber as is given in Equation C2.

$$J = \frac{dn}{A dt} \quad (C2)$$

Where:

J is the molar flux through the membrane

A is the effective cross-sectional area of the membrane

$\frac{dn}{dt}$ is the rate of gas molar build up in the permeate

Substituting for flux in equation C1 gives equation C3

$$P = \frac{dn}{A \cdot dt} \cdot \frac{l}{\Delta p} \quad (C3)$$

From the ideal gas equation:

$$pV = znRT \quad (C4)$$

Where:

p is the gas pressure

V is the volume of the gas

z is the compressibility factor

n is the number of gas moles

R is the molar gas constant

T is the gas temperature

Applying Equation C4 to the current setup, the pressure of the gas in the permeate is a variable, the number of moles of gas in the permeate is a variable, the volume occupied by the gas in the permeate is constant (constant volume of permeate chamber) , temperature of the setup is constant since isothermal conditions are maintained, R the molar gas constant is also a constant. An assumption is made that z the compressibility factor is unity. Making n to be the subject of the formula and taking derivatives of n and p with respect to time in Equation C4 results in Equation C5.

$$\frac{dn}{dt} = \frac{V}{RT} \frac{dp}{dt} \quad (C5)$$

Combining Equation C2 and C5 results in Equation C6

$$J = \frac{V}{ART} \frac{dp}{dt} \quad (C6)$$

Combining Equation C3 and C5 results in Equation C7

$$P = \frac{V_l}{\Delta p A R T} \frac{dp}{dt} \quad (C7)$$

Δp is basically the difference in pressure between the upstream and permeate pressures. Noting that the permeate is evacuated and the maximum allowable pressure build up in the permeate is negligible compared to the upstream pressure, and letting the constant permeate downstream volume be V_d , upstream pressure be p_2 and the permeate pressure be p_1 . Δp then simplifies to $p_2 - p_1 \approx p_2$. The permeability coefficient of the gas in question would be determined when the pressure build up of successive runs is almost identical. The latter occurs at steady state and is represented by the subscript "ss". Equation C7 then simplifies to Equation C8.

$$P = \frac{V_d l}{p_2 A R T} \left(\frac{dp_1}{dt} \right)_{ss} \quad (C8)$$

Considering the fact that the membrane cell is not completely air tight, though it is desired to have it air tight. Some gas will leak into the sub-atmospheric permeate chamber and thus alter the permeate result. To take care of this anomaly, a leak rate term is introduced to Equation C8 to produce Equation C9.

$$P = \frac{V_d l}{p_2 A R T} \left[\left(\frac{dp_1}{dt} \right)_{ss} - \left(\frac{dp_1}{dt} \right)_{leak} \right] \quad (C9)$$

$$\left(\frac{dp_1}{dt} \right)_{Total} = \left(\frac{dp_1}{dt} \right)_{ss} - \left(\frac{dp_1}{dt} \right)_{leak} \quad (C9a)$$

Equation C9 is the permeability equation that was used to determine permeability values from the experimental setup.

The method that was employed to determine the gas permeability through the polymers is the constant volume variable pressure method (ASTM D1434). The calculation of the permeability values resulting from this method was performed through equation C.9.

$$P_A = \frac{V_d I}{p_2 A R T} \left[\left(\frac{dp_1}{dt} \right)_{ss} - \left(\frac{dp_1}{dt} \right)_{leak} \right] \quad (C9)$$

Where: P_A is the gas permeability ($\text{cm}^3 \cdot \text{mm} \cdot \text{day}^{-1} \cdot \text{m}^{-2} \cdot \text{atm}^{-1}$).

V_d is the volume of the constant volume of chamber and line (cm^3).

I is the membrane thickness (mm).

A is the membrane cross-sectional area (m^2).

R is the molar gas constant ($\text{J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$).

T is the absolute temperature (K).

p_2 is the pressure on the feed side of the membrane (atm).

$(dp_1/dt)_{ss}$ is the steady state pressure build up on the permeate side of the membrane ($\text{atm} \cdot \text{s}^{-1}$).

$(dp_1/dt)_{leak}$ is the pressure increase rate on the permeate side due to leakage ($\text{atm} \cdot \text{s}^{-1}$).

$(dp_1/dt)_{Total}$ is the net pressure build up in the downstream chamber attributed to permeation

Permeability units on the right of Equation C9 = $\text{cm}^3 \cdot \text{mm} \cdot \text{atm}^{-1} \cdot \text{m}^{-2} \cdot \text{J}^{-1} \cdot \text{mol} \cdot \text{atm} \cdot \text{s}^{-1}$

$$= \text{cm}^3 \cdot \text{mm} \cdot \text{atm}^{-1} \cdot \text{m}^{-2} \cdot (\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-2})^{-1} \cdot \text{mol} \cdot \text{atm} \cdot \text{s}^{-1}$$

$$= \text{cm}^3 \cdot \text{mm} \cdot \text{m}^{-2} \cdot (\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-2})^{-1} \cdot \text{mol} \cdot \text{s}^{-1}$$

But units of Pressure(Pa) can be given as $\text{Kg} \cdot \text{m} \cdot \text{s}^{-2} \cdot \text{m}^{-2}$

We can multiply the numerator and denominator by m^2

Units of permeability then become: $\text{cm}^3.\text{mm}.\text{m}^{-2}.\text{Pa}^{-1}.\text{m}^{-1}.\text{m}^{-2}.\text{mol}.\text{s}^{-1}$

Simplifying the units gives: $\text{cm}^3.\text{mm}.\text{m}^{-2}.\text{Pa}^{-1}.\text{m}^{-1}.\text{m}^{-2}.\text{mol}.\text{s}^{-1}$

Further simplification gives: $\text{cm}^3.\text{mm}.\text{m}^{-2}.\text{Pa}^{-1}.\text{mol}.\text{m}^{-3}.\text{s}^{-1}$

The latter gives the permeability in molar units, which can be converted to volumetric units by multiplying by the molar volume of a gas at STP, which is $0.0224 \text{ m}^3.\text{mol}^{-1}$

Using the conversion factors:

$$1 \text{ Day} = 86400\text{s},$$

$$1 \text{ atm} = 101325 \text{ pa}$$

Units of permeability then can be given as: $\text{cm}^3.\text{mm}.\text{m}^{-2}.\text{atm}^{-1}.\text{day}^{-1}$

SINGLE PERMEATION SAMPLE CALCULATIONS

Permeability

The constant volume variable pressure method is often expected to give (dp/dt) results that are of the form given in Figure C.1

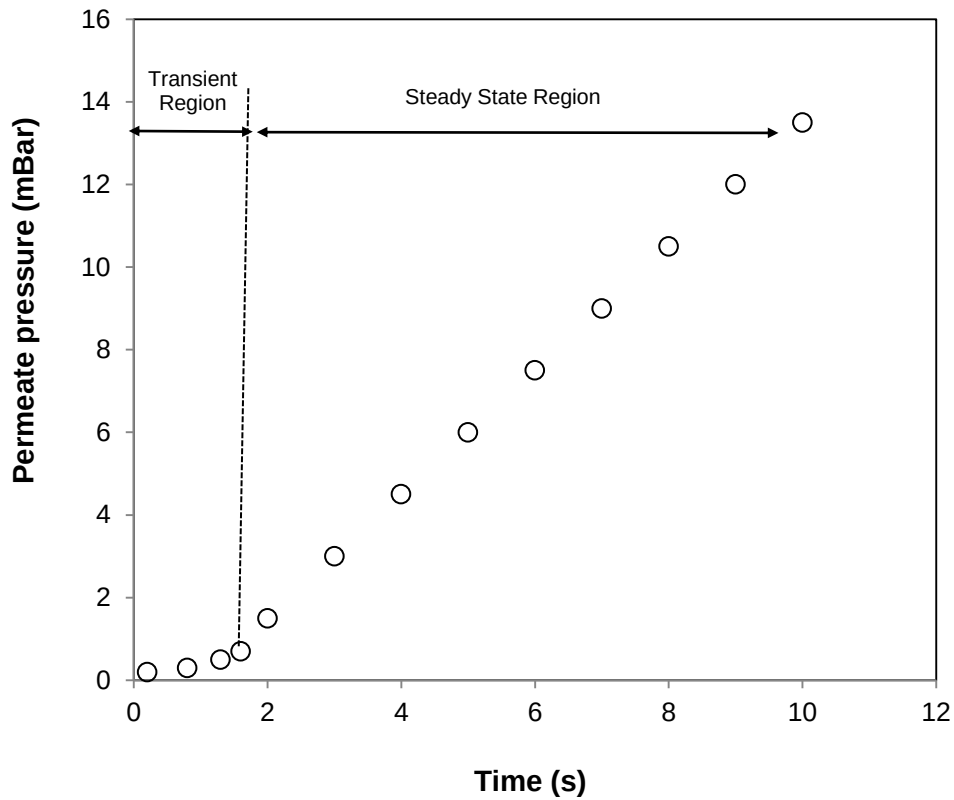


Figure C.1 Nature of expected results (Adapted from Koros & Chern, (1987:885))

However in the present study, the transient permeation part of the graph was not included, due to the accuracy constraints of the devices in use. Nonetheless, the steady state permeation region is good enough for attaining desired results. A study by Dhingra, (1997) proved that the use of the truncated steady state part of the (dp/dt) graph alone still gave acceptable results for the calculation of gas permeability (Dhingra, 1997:117).

Given the data for the calculation of O_2 permeability in Hyflon M at 3 Bar feed pressure, gotten from Table D.12 of Appendix D.

Hyflon M membrane thickness(l) = 0.08919 mm

Constant volume of permeate chamber(V_D) = 12 cm³

Pressure on the feed side of the membrane (p_2) = 3 000 mBar.

Cross-sectional area of membrane = 0.001385 m²

Molar gas constant (R) = 8.314 J.mol⁻¹.K⁻¹.

Temperature (T) = 298.15 K

(dp/dt)_{SS} = 0.0134 mBar.s⁻¹. (Data from 1st trial in Table D.12)

(dp/dt)_{Leak} = 0.000123 mBar.s⁻¹ (Data from 1st trial in Table D.12)

Molar volume of a gas at STP = 0.0224 m³.mol⁻¹.

Plugging all this given data into equation 4.1 gives:

$$P_A = \frac{12\text{cm}^3 \times 0.08919\text{mm}}{3000\text{mBar} \times 0.001385\text{m}^2 \times 8.314\text{J.mol}^{-1}.\text{K}^{-1} \times 298.15\text{K}} \left[0.0134\text{mBar}.\text{s}^{-1} - 0.000123\text{mBar}.\text{s}^{-1} \right] =$$

$$= 1.37969 \times 10^{-6} \text{cm}^3.\text{mm.m}^{-2}.\text{J}^{-1}.\text{mol.s}^{-1}$$

Multiplying by 0.0224 m³.mol⁻¹ (volume occupied by a gas at STP) so as to convert to volumetric units gives:

$$= 3.09051 \times 10^{-8} \text{cm}^3.\text{mm.m}^{-2}.\text{J}^{-1}.\text{m}^3.\text{s}^{-1}$$

Now, the Joule unit (J) in expanded form is given as Kg.m².s⁻². Which yields:

$$= 3.09051 \times 10^{-8} \text{cm}^3.\text{mm.m}^{-2}.\text{(Kg.m}^2.\text{s}^{-2})^{-1}.\text{m}^3.\text{s}^{-1}$$

Factoring out (Kg.m.s⁻².m⁻²) which is the Pascal unit gives:

$$= 3.09051 \times 10^{-8} \text{cm}^3.\text{mm.m}^{-2}.\text{(Pa)}^{-1}.\text{s}^{-1}$$

Using the relation 1 atm = 101325 pa and 1 day = 86400 s then yields:

$$\text{Permeability} = 270.56\text{cm}^3.\text{mm.m}^{-2}.\text{atm}^{-1}.\text{day}^{-1} = 4.12\text{Barrer}$$

Flux

Re-arranging Equation C1 and making flux (J) subject of the formula, the O₂ flux in Hylon M at 3 bar feed pressure was calculated accordingly.

$$J = \frac{270.56 \text{ cm}^3 \cdot \text{mm} \cdot \text{m}^{-2} \cdot \text{atm}^{-1} \cdot \text{day}^{-1} \times 3 \text{ atm}}{0.08919 \text{ mm}} = 9100.572 \text{ cm}^3 \cdot \text{m}^{-2} \cdot \text{day}^{-1}$$

Converting units to $\text{cm}^3 \cdot \text{cm}^{-2} \cdot \text{s}^{-1}$ yields:

$$J = \frac{9100.572}{10000 \times 86400} = 1.05 \times 10^{-5} \text{ cm}^3 \cdot \text{cm}^{-2} \cdot \text{s}^{-1}$$

Ideal selectivity

The ideal selectivity is merely a ratio of the permeabilities of the gases in question. Considering the permeability of gases, SO_2 and O_2 in Hyflon M at 3 bar, permeability data of first trials in each case are presented in Tables D.10 and D.12 respectively. The calculation of the ideal selectivity of SO_2 against O_2 is presented thus:

$$\alpha_{\text{SO}_2/\text{O}_2} = \frac{P_{\text{SO}_2}}{P_{\text{O}_2}} = \frac{4.7083 \text{ Barrer}}{4.1189 \text{ Barrer}} = 1.14$$

BINARY PERMEATION SAMPLE CALCULATIONS

Flux

Equation C6 (the flux equation) was used to determine binary fluxes. Equation C10a and C10b give the flux contributions of SO_2 and O_2 respectively.

$$J_{\text{SO}_2} = \frac{V_d}{ART} \left(\frac{dp_1}{dt} \right)_{\text{SO}_2} \quad \text{C10a}$$

$$J_{\text{O}_2} = \frac{V_d}{ART} \left(\frac{dp_1}{dt} \right)_{\text{O}_2} \quad \text{C10b}$$

The total flux then is:

$$J_{SO_2} + J_{O_2} = J_{Total} = \frac{V_d}{ART} \left[\left(\frac{dp_1}{dt} \right)_{SO_2} + \left(\frac{dp_1}{dt} \right)_{O_2} \right] \quad C11$$

After subtracting the $(dp_1/dt)_{leak}$ term from the gross $(dp_1/dt)_{ss}$, the remainder is multiplied by the permeate composition of the respective gases (SO_2 and O_2) so as to get the (dp_1/dt) contribution of each of the gases. The respective fluxes were then calculated. It is important to note that the permeate compositions were determined from a separate set of experiments.

Considering Table D.189 and Table D.190 for binary flux calculations the net (dp_1/dt) after subtracting $(dp/dt)_{leak}$ is equal to $0.0193 \text{ mbar.s}^{-1}$ for the first trial. J_{SO_2} was calculated as shown:

The absolute p_{SO_2} in the feed was 1.2 bar whilst the permeate chamber was initially evacuated, i.e. $\Delta p_{SO_2} = 1.2 \text{ bar}$. Tables D75, D76 and D77 have the permeate weight composition for a case with SO_2 partial pressure (p_{SO_2}) = 2 bar in the feed and a corresponding SO_2 partial permeate pressure (p_{SO_2}) of 0.8 bar, i.e. $\Delta p_{SO_2} = 1.2 \text{ bar}$. The SO_2 permeate weight composition (94.83 %) had to be converted to a molar composition (90.17 %) for the calculation of the SO_2 pressure rise contribution in the permeate.

$$\left(\frac{dp_1}{dt} \right)_{SO_2} = n_{SO_2} \left(\frac{dp_1}{dt} \right) = 0.9017 \times 0.0193 = 0.0174 \text{ mbar.s}^{-1}$$

Where n_{SO_2} is the SO_2 molar percentage composition in the permeate. The resultant flux then was calculated through Equation C10a.

Constant volume of permeate chamber (v_d) = $12 \times 10^{-6} \text{ m}^3$

Effective diameter of membrane = $42 \times 10^{-3} \text{ m}$

Area of membrane (A) = 0.001385 m²

Molar gas constant R = 8.314 J.mol⁻¹.K⁻¹

Membrane cell temperature T = 288.15 K

Nafion 117 membrane thickness (l) = 0.0001778 m

Permeate pressure rise attributed to SO₂ permeation = 0.0174 mbar.s⁻¹ = 1.74 pa.s⁻¹

$$J_{SO_2} = \frac{12 \times 10^{-6} \text{ m}^3 \times 1.74 \text{ pa.s}^{-1}}{0.001385 \text{ m}^2 \times 8.317 \text{ J.mol}^{-1} \cdot \text{K}^{-1} \times 288.15 \text{ K}} = 6.29 \times 10^{-6} \text{ m.pa.mol.s}^{-1} \cdot \text{J}^{-1}$$

The Joule unit (J) in expanded form is given as Kg.m².s⁻². Which yields:

$$J_{SO_2} = 6.29 \times 10^{-6} \text{ m.pa.mol.s}^{-1} \cdot \text{Kg}^{-1} \cdot \text{m}^{-2} \cdot \text{s}^2$$

Factoring out (Kg.m.s⁻².m⁻²) which is the Pascal unit gives:

$$J_{SO_2} = 6.29 \times 10^{-6} \text{ pa.mol.}(\text{Kg.m.s}^{-2} \cdot \text{m}^{-2})^{-1} \cdot \text{s}^{-1} \cdot \text{m}^{-2}$$

$$J_{SO_2} = 6.29 \times 10^{-6} \text{ mol.m}^{-2} \cdot \text{s}^{-1}$$

Pseudo permeability

The respective SO₂ pseudo permeability coefficient (Π_{SO_2}) which is the permeability of SO₂ in mixture and employs the SO₂ trans-membrane partial pressure (Δp_{SO_2}), was calculated using Equation C1.

$$\pi_{\text{SO}_2} = \frac{6.29 \times 10^{-6} \text{ mol.m}^{-2}.\text{s}^{-1} \times 177.80 \times 10^{-6} \text{ m}}{1.2 \times 10^5 \text{ pa}} = 9.32 \times 10^{-15} \text{ mol.m}^{-1}.\text{s}^{-1}.\text{pa}^{-1}$$

Real selectivity

Considering the upstream and permeate compositions given in Tables D75, D76 and D77, upstream SO₂ = 75 wt %, upstream O₂ = 25 wt %, permeate SO₂ = 93.83 wt % and permeate O₂ = 5.17 wt %. The resultant real selectivity of SO₂ against O₂ was calculated accordingly through Equation 4.2 of Section 4.3.1.

$$\alpha_{\text{SO}_2/\text{O}_2} = y(1-x)/x(1-y)$$

where: $\alpha_{\text{SO}_2/\text{O}_2}$ is the SO₂/O₂ selectivity

y, is the permeate mass fraction of SO₂

x, is the upstream mass fraction of SO₂

$$\alpha_{\text{SO}_2/\text{O}_2} = \frac{0.9483 \times (1-0.75)}{0.75 \times (1-0.9483)} = 6.11$$

Note: The permeate composition sample calculations from the GC calibration curve are given in Appendix G.

ESTIMATION OF SOME PERMEATE COMPOSITIONS

It is important to note that the binary permeation composition experiments were conducted separately from the binary flux experiments. Due to pressure constraints, that is, lower pressure in the gas cylinders with time, the maximum pressure at which flux experiments for (25:75, SO₂:O₂) wt % both in Udel Polysulfone and Nafion 117 was lower than the pressure used for the composition experiments. As such the gas permeate composition at the lower pressure had to be estimated using mathematical tools for use in the lower pressure flux experiments.

Estimation of Nafion 117 permeate composition with (25:75, SO₂:O₂) wt % feed at $\Delta p_{\text{SO}_2} = 1.2$ bar

The known permeate composition for (25:75, SO₂:O₂) wt % feed at a temperature range of 15°C to 55°C and $\Delta p_{\text{SO}_2} = 1.7$ bar is presented in Figure C.2.

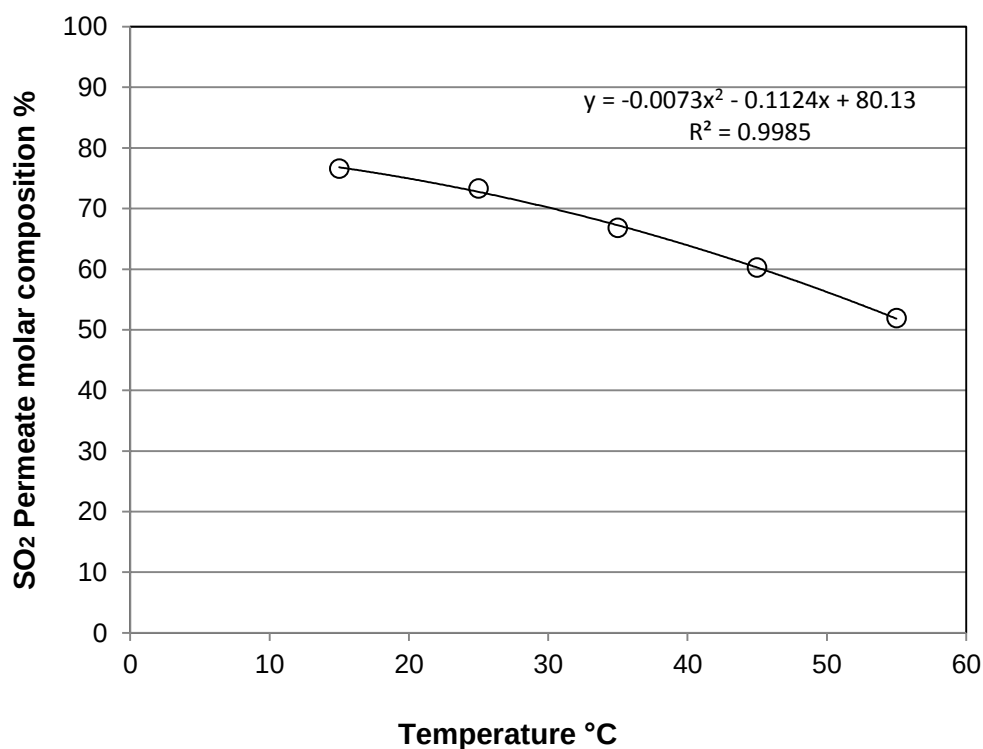


Figure C.2 SO₂ molar permeate composition at $\Delta p_{\text{SO}_2} = 1.7$ bar (p_{SO_2} feed = 2.4 bar) for (25:75, SO₂:O₂) wt % feed in Nafion 117

The plotting points for Figure C.2 were gotten from Tables D.45 to D.59 and are given in Table C.1

Table C.1 SO₂ permeate composition plotting points for (25:75, SO₂:O₂) wt % feed in Nafion 117 at $\Delta p_{\text{SO}_2} = 1.7$ bar (p_{SO_2} feed = 2.4 bar)

Temperature (°C)	SO ₂ weight composition	SO ₂ molar composition
15	86.74	76.58
25	84.62	73.34
35	80.11	66.81
45	75.2	60.26
55	68.35	51.92

For the prediction of SO₂ permeate composition at $\Delta p_{\text{SO}_2} = 1.2$ bar, it was assumed that the permeate composition – temperature plot should follow the form given in Figure C.2 and may be merely shifted up or down depending on values gotten from interpolation. The SO₂ permeate weight composition at a $\Delta p_{\text{SO}_2} = 0.8$ bar (p_{SO_2} feed = 1.4 bar) and temperature of 25°C for a (25:75, SO₂:O₂) wt % feed in Nafion 117 is known and is given in Tables D.138 to Tables D.140 and is also given in Table C.2.

Table C.2 SO₂ permeate composition at 25°C and $\Delta p_{\text{SO}_2} = 0.8$ bar (p_{SO_2} = 1.4 bar feed) in Nafion 117

Temperature (°C)	SO ₂ weight composition	SO ₂ molar composition
25	79.25	65.63

Through the use of the lagrange interpolating polynomial, the SO₂ permeate composition at $\Delta p_{\text{SO}_2} = 1.2$ bar and 25°C was calculated thus:

The Lagrange interpolating polynomial is given by Equation C12.

$$\frac{(b_2 - b_1)}{(b_3 - b_1)} = \frac{(a_2 - a_1)}{(a_3 - a_1)} \quad (\text{C12})$$

Where:

$b_1 = 73.34$ (SO₂ molar composition at 25°C and $\Delta p_{\text{SO}_2} = 1.74$ bar)

$b_2 =$ Unknown SO₂ molar composition at 25°C and $\Delta p_{\text{SO}_2} = 1.2$ bar.

$b_3 = 65.63$ (SO_2 molar composition at 25°C and $\Delta p_{\text{SO}_2} = 0.8$ bar)

$a_1 = 1.74$ bar (Δp_{SO_2} corresponding to b_1)

$a_2 = \Delta p_{\text{SO}_2} = 1.2$ bar.

$a_3 = 0.8$ bar (Δp_{SO_2} corresponding to b_3)

Plugging values into Equation C12 and making b_2 subject of the formula gives:

$$b_2 = \frac{(1.2-1.74)}{(0.8-1.74)} \times (65.63-73.34) = 68.91$$

Considering the assumption that the SO_2 permeate molar composition – temperature graph at $\Delta p_{\text{SO}_2} = 1.2$ bar is to adopt the form given in Figure C.2 at $\Delta p_{\text{SO}_2} = 1.74$ bar. Furthermore, since b_1 is a point that lies in the plot in Figure C.2, and is at 25°C and $\Delta p_{\text{SO}_2} = 1.74$ bar, the difference between b_1 and b_2 is -4.43 and thus the graph at $\Delta p_{\text{SO}_2} = 1.2$ bar should shift 4.43 units downwards but still maintaining the same form as with $\Delta p_{\text{SO}_2} = 1.74$ bar. The graphical Equation for $\Delta p_{\text{SO}_2} = 1.2$ bar derived from Figure C2 was thus estimated and presented as Equation C13.

$$y = -0.0073x^2 - 0.1124x + (80.13-4.43) = -0.0073x^2 - 0.1124x + 75.20 \quad (\text{C13})$$

Equation C13 was then used to calculate the estimated SO_2 molar permeate compositions at $\Delta p_{\text{SO}_2} = 1.2$ bar at the temperatures of 15°C , 25°C , 35°C , 45°C and 55°C . Where y is the SO_2 molar permeate composition and x is the temperature in $^\circ\text{C}$

Any other unknown SO_2 permeate composition with the feed (25:75, $\text{SO}_2:\text{O}_2$) wt % was determined through the Lagrange interpolating polynomial. The permeate molar composition for $\Delta p_{\text{SO}_2} = 0.3$ bar at 25°C was estimated to be 61.53%

Estimation of Udel Polysulfone SO_2 permeate composition with (25:75, $\text{SO}_2:\text{O}_2$) wt % feed at $\Delta p_{\text{SO}_2} = 1.2$ bar

A similar approach as was used with Nafion 117 was adopted to estimate the SO_2 permeate molar compositions in Udel Polysulfone for the feed composition of (25:75,

SO₂:O₂) wt % $\Delta p_{\text{SO}_2} = 1.2$ within the temperature range of 15°C to 55°C. The known permeate composition for (25:75, SO₂:O₂) wt % feed at a temperature range of 15°C to 55°C and $\Delta p_{\text{SO}_2} = 1.45$ bar is presented in Figure C.3.

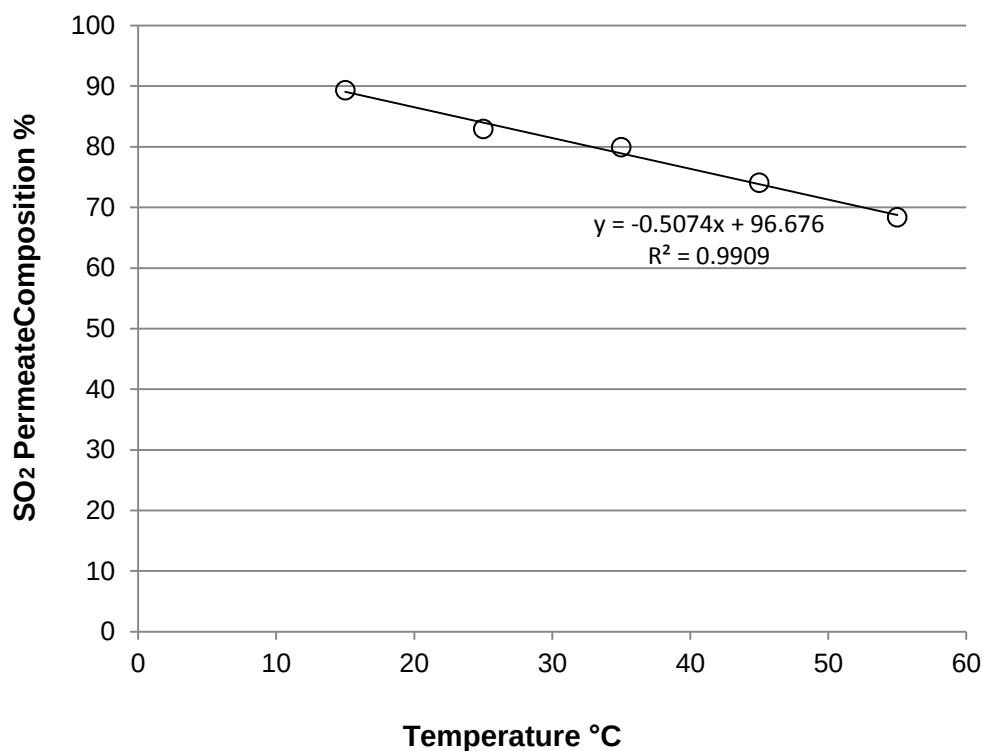


Figure C.3 SO₂ molar permeate composition at $\Delta p_{\text{SO}_2} = 1.45$ bar (p_{SO_2} feed = 2.2 bar) for (25:75, SO₂:O₂) wt % feed in Udel Polysulfone

The plotting points for Figure C.3 were gotten from Tables D.90 to D.104 and are given in Table C.3.

Table C.3 SO₂ permeate composition plotting points SO₂ permeate composition plotting points for (25:75, SO₂:O₂) wt % feed in Udel Polysulfone at $\Delta p_{\text{SO}_2} = 1.45$ bar (p_{SO_2} feed = 2.2 bar)

Temperature (°C)	SO ₂ weight composition	SO ₂ molar composition
15	94.34	89.29
25	90.68	82.95
35	88.84	79.93
45	85.09	74.05
55	81.21	68.37

For the prediction of SO₂ permeate composition at $\Delta p_{\text{SO}_2} = 1.2$ bar, it was assumed that the permeate composition – temperature plot should follow the form given in Figure C.3 and may be merely shifted up or down depending on values gotten from interpolation. The SO₂ permeate weight composition at a $\Delta p_{\text{SO}_2} = 0.6385$ bar (p_{SO_2} feed = 1.3 bar) and temperature of 25°C for a (25:75, SO₂:O₂) wt % feed in Udel polysulfone is known and is given in Tables D.168 to Tables D.170 and is also given in Table C.4.

Table C.4 SO₂ permeate composition at 25°C and $\Delta p_{\text{SO}_2} = 0.6385$ bar ($p_{\text{SO}_2} = 1.3$ bar feed) in Udel Polysulfone

Temperature (°C)	SO ₂ weight composition	SO ₂ molar composition
25	84.75	73.54

Through the use of the Lagrange interpolating polynomial, the SO₂ molar permeate composition at $\Delta p_{\text{SO}_2} = 1.2$ bar and 25°C in Udel Polysulfone was calculated to be 80.02 mol%. The graph shift factor was -2.93 and Equation C14 derived from Figure C3 was used to calculate the estimated SO₂ molar permeate compositions at $\Delta p_{\text{SO}_2} = 1.2$ bar at the temperatures of 15°C, 25°C, 35°C 45°C and 55°C. Where y is the SO₂ molar permeate composition and x is the temperature in °C.

$$y = -0.5074x + 93.75 \quad (\text{C14})$$

Any other unknown SO₂ permeate composition with the feed (25:75, SO₂:O₂) wt % in Udel polysulfone was determined through the Lagrange interpolating polynomial. The permeate molar composition for $\Delta p_{\text{SO}_2} = 0.7$ bar at 25°C was estimated to be 74.25 mol% and that at $\Delta p_{\text{SO}_2} = 0.3$ bar was estimated to be 69.63 mol%

CALCULATION OF POLYMER FREE VOLUME

The polymer free volume is generally calculated by equations C15a, C15b and C15c.

$$\text{Free Volume (FFV)} = \frac{V_F}{V} \quad (\text{C15a})$$

$$V_F = V - V_0 \quad (\text{C15b})$$

$$V_0 = 1.3V_w \quad (\text{C15c})$$

Where: FFV is the fractional free volume

V_F ($\text{cm}^3 \cdot \text{g}^{-1}$) is the specific free volume

V ($\text{cm}^3 \cdot \text{g}^{-1}$) is the experimentally observed specific volume

V_0 ($\text{cm}^3 \cdot \text{g}^{-1}$) is an estimate of the specific volume occupied by the polymer at zero Kelvin (Rezác & John, 1997:599)

V_w ($\text{cm}^3 \cdot \text{g}^{-1}$) is the van der Waals specific volume.

Halar free volume

The Halar repeat unit is given in Figure C.4

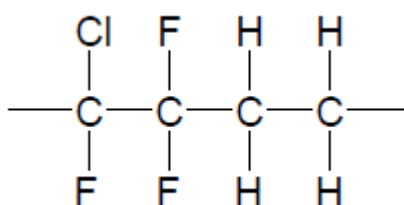


Figure C.4 Halar repeat unit

The density of Halar is known to be 1.68 g.cm⁻³ which translates to a specific volume 0.5952 cm³.g⁻¹ (Solvay, 2006b:7). A group contribution method proposed by Zhao *et al.* (2003:7368) was used to calculate V_w. Table C.5 presents the atomic contributions for the calculation of V_w.

Table C.5 Atomic contributions

Atom	Atomic contribution V _{vdW} (Å ³)	Source
H	7.24	(Zhao <i>et al.</i> 2003:7370)
C	20.58	(Zhao <i>et al.</i> 2003:7370)
O	14.71	(Zhao <i>et al.</i> 2003:7370)
F	13.31	(Zhao <i>et al.</i> 2003:7370)
Cl	22.45	(Zhao <i>et al.</i> 2003:7370)

Considering the Halar repeat unit, the calculation was performed using Equation C16.

$$\text{Total } V_{\text{vdW}} = \sum \text{All atomic contributions} - 5.92 N_B \quad (\text{C16})$$

Where:

V_{vdW} (Å³) is the van der Waals atomic volume contribution.

N_B is the number of bonds.

$$\sum \text{Carbon contributions in Halar repeat unit} = (4 \times 20.58) = 82.32$$

$$\sum \text{Hydrogen contributions in Halar repeat unit} = (4 \times 7.24) = 28.96$$

$$\sum \text{Flourine contributions in Halar repeat unit} = (3 \times 13.31) = 39.93$$

$$\sum \text{Chlorine contributions in Halar repeat unit} = (1 \times 22.45) = 22.45$$

The number of bonds in the Halar repeat unit are 11, from Equation C16, summing up the atomic contributions and the bond contribution, the total van der Waals volume V_{vdW}

$(\text{\AA}^3/\text{molecule}) = 108 (\text{\AA}^3/\text{molecule}) = 65.34 \text{ cm}^3.\text{mol}^{-1}$. The molar mass of the Halar repeat unit is:

$$\text{Molar mass of Halar repeat unit} = (12 \times 4) + (1 \times 4) + (19 \times 3) + (35.5 \times 1) = 144.5 \text{ g.mol}^{-1}$$

Thus

$$V_w (\text{cm}^3.\text{g}^{-1}) \text{ van der Waals specific volume} = \frac{65.34 \text{ cm}^3.\text{mol}^{-1}}{144.5 \text{ g.mol}^{-1}} = 0.452 \text{ cm}^3.\text{g}^{-1}$$

Using Equation C15a, C15b and C15c, and the known Halar specific volume (0.5952 $\text{cm}^3.\text{g}^{-1}$) the fractional free volume for Halar was calculated.

$$\text{FFV} = \frac{(0.5952 - 1.3 \times 0.452)}{0.5952} = 0.0124$$

Hyflon M free volume

The Hyflon M repeat unit is given in Figure C.5

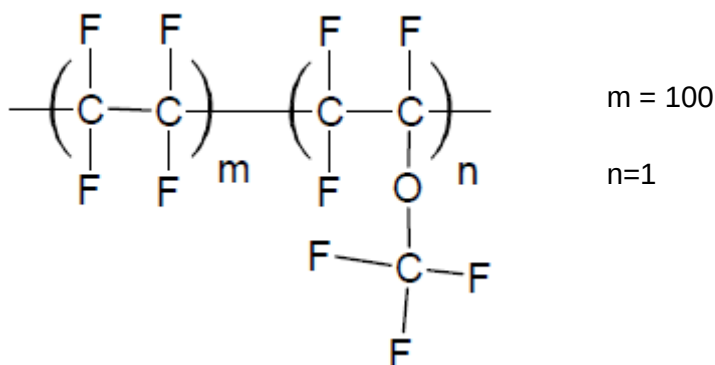


Figure C.5 Hyflon M repeat unit

The density of Hyflon M is known to be 2.17 g.cm⁻³ which translates to a specific volume of 0.461 cm³.g⁻¹ (Solvay, 2006a:7). The group contribution method proposed by Zhao *et al.* (2003:7368) was also used to calculate V_w . Based on data from Table A.4 Hyflon M V_w was calculated.

Considering the Hyflon M repeat unit, the calculation was performed using Equation C16.

$$\sum \text{Carbon contributions in Hyflon M repeat unit} = (205 \times 20.58) = 4218.5$$

$$\sum \text{Flourine contributions in Hyflon M repeat unit} = (410 \times 13.31) = 5457.1$$

$$\sum \text{Oxygen contributions in Hyflon M repeat unit} = (1 \times 14.71) = 14.71$$

The number of bonds in the Hyfon M repeat unit are 615, from Equation C16, summing up the atomic contributions and the bond contribution, the total van der Waals volume V_{vdW} (Å³/molecule) = 6040.91 (Å³/molecule) = 3642.05 cm³.mol⁻¹. The molar mass of the Hyflon M repeat unit is:

$$\text{Molar mass of Hyflon M repeat unit} = (12 \times 205) + (19 \times 410) + (16 \times 1) = 10266 \text{ g.mol}^{-1}$$

Thus

$$V_w \text{ (cm}^3\text{.g}^{-1}\text{) van der Waals specific volume} = \frac{3642.05 \text{ cm}^3\text{.mol}^{-1}}{10266 \text{ g.mol}^{-1}} = 0.35477 \text{ cm}^3\text{.g}^{-1}$$

Using Equation C15a, C15b and C15c, and the known Hyflon M specific volume (0.461 cm³.g⁻¹) the fractional free volume for Hyfon M was calculated.

$$FFV = \frac{(0.461 - 1.3 \times 0.35477)}{0.461} = -0.0008$$

An assumption is made that the negative sign could be attributed to error resulting from the estimation method, however the magnitude of the free volume proves that the Hyflon M free fractional volume is very much close to zero.

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APPENDIX D :SINGLE AND BINARY PERMEATION RESULTS

OVERVIEW

Appendix D presents single permeation flux experimental results, binary composition experimental results and binary flux experimental results

Table D.1 SO₂ permeability in Hyflon F – Raw Data

Feed Absolute Pressure	Temperature		Permeate Δt per $\Delta p=2\text{mBar}$													
mBar	°C		s													
		Run	t_0	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}	t_{11}	t_{12}	t_{13}
3850	25 ± 1	1	0.00	40.06	120.75	173.78	232.63	307.15	358.24	420.14	482.76	562.41	592.85	668.30	722.32	786.05
		2	0.00	45.50	94.84	159.73	212.58	294.25	344.07	408.92	465.12	525.87	595.73	642.69	718.10	781.84
		3	0.00	32.61	111.89	171.92	225.99	295.73	350.40	397.01	476.81	533.79	580.74	660.36	701.16	774.09
2850	25 ± 1	1	0.00	64.72	151.25	261.90	354.31	448.44	569.48	638.04	712.58	838.68	921.72	1038.26	1118.88	
		2	0.00	83.18	196.27	325.92	380.04	479.96	550.78	675.85	755.09	852.46	973.88	1080.80	1109.21	
		3	0.00	83.77	152.02	289.67	352.52	474.76	530.15	654.37	750.24	825.86	947.43	1033.68	1112.98	
1850	25 ± 1	1	0.00	158.72	315.24	399.44	638.37	782.64	896.98	1048.59	1188.08					
		2	0.00	144.26	304.14	482.04	591.44	748.14	868.07	1008.53	1129.09					
		3	0.00	123.09	323.65	448.87	614.95	770.06	913.47	1025.95	1147.41					

Table D.2 SO₂ permeability in Hyflon F – Calculated Data

Feed Absolute Pressure	Temperature	Run	$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$(\Delta p/\Delta t)_{\text{Total}}$	Permeability	Permeability	Volumetric Flux
mBar	°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	cm ³ .mm.day ⁻¹ . m ⁻² .atm ⁻¹	Barrer	cm ³ .s ⁻¹ .cm ⁻²
3850	25 ± 1	1	0.000202	0.0331	0.0329	545.2695	8.30	2.9656E-05
		2	0.000202	0.0341	0.0339	561.8440	8.56	3.0558E-05
		3	0.000202	0.0341	0.0339	561.8440	8.56	3.0558E-05
2850	25 ± 1	1	0.000202	0.0216	0.0214	479.1050	7.30	1.9289E-05
		2	0.000202	0.0215	0.0213	476.8660	7.26	1.9199E-05
		3	0.000202	0.0215	0.0213	476.8660	7.26	1.9199E-05
1850	25 ± 1	1	0.000202	0.0133	0.0131	451.7890	6.88	1.1807E-05
		2	0.000202	0.0138	0.0136	469.0355	7.14	1.2258E-05
		3	0.000202	0.0135	0.0133	458.6876	6.99	1.1988E-05

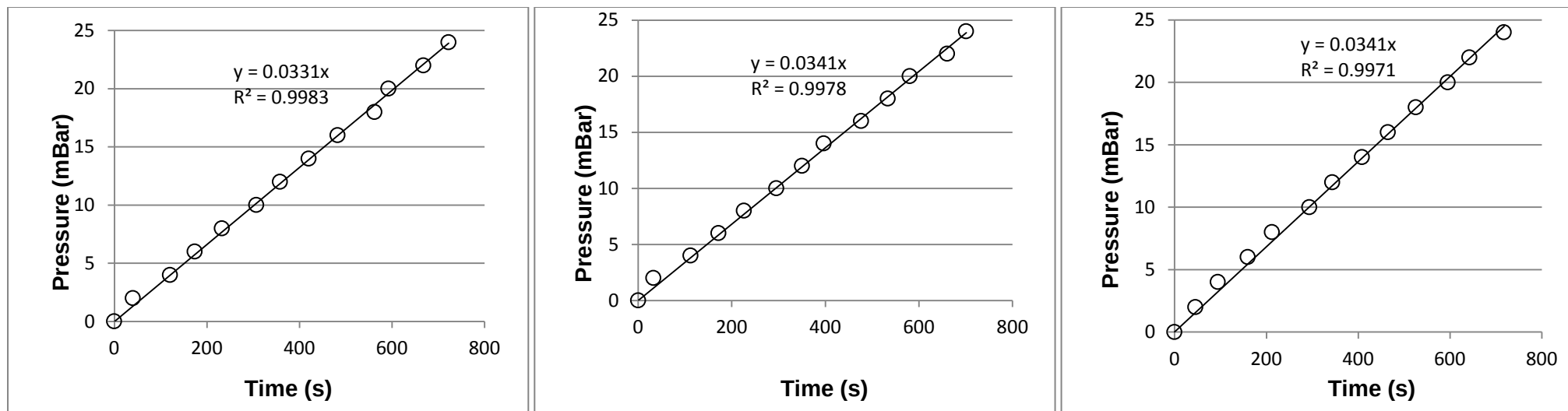


Figure D.1 Permeate pressure-time graphs for SO_2 in Hyflon F at 3.85 Bar feed pressure, 1st, 2nd & 3rd trials

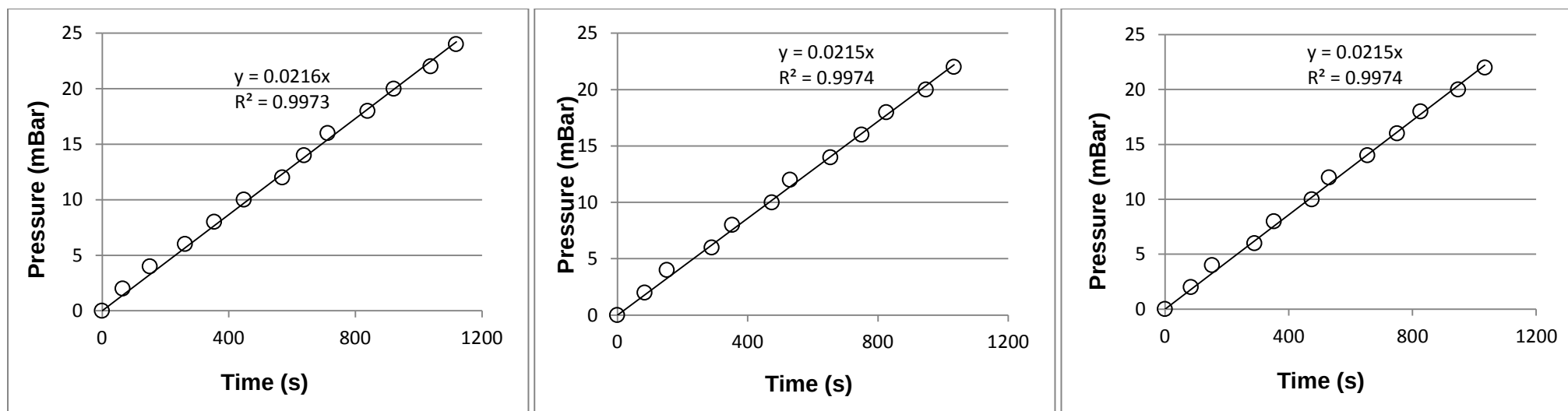


Figure D.2 Permeate pressure-time graphs for SO_2 in Hyflon F at 2.85 Bar feed pressure, 1st, 2nd & 3rd trials

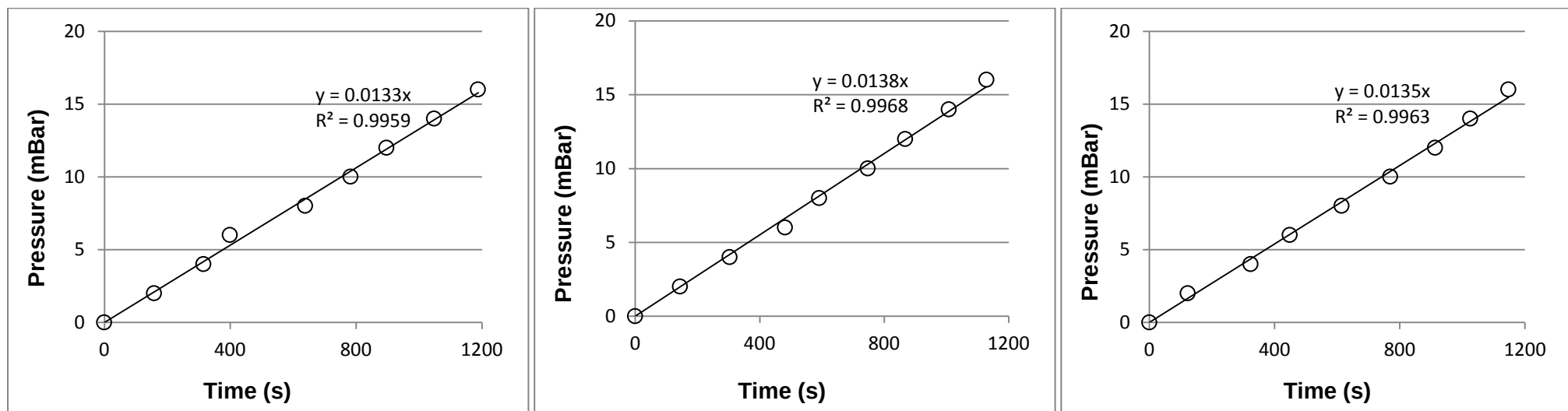


Figure D.3 Permeate pressure-time graphs for SO₂ in Hyflon F at 1.85 Bar feed pressure, 1st, 2nd & 3rd trials

Table D.3 O₂ permeability in Hyflon F – Raw Data

Feed Absolute Pressure	Temperature		Permeate Δt per $\Delta p=2\text{mBar}$											
	°C		S											
		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅	t ₆	t ₇	t ₈	t ₉	t ₁₀	t ₁₁
3850	25 ± 1	1	0.00	63.72	156.19	240.40	283.63	381.02	469.95	530.49	604.77	677.44	760.06	836.74
		2	0.00	57.98	139.36	221.30	266.77	359.77	444.80	521.79	582.13	673.22	752.49	823.43
		3	0.00	80.64	143.65	244.29	313.60	383.56	459.26	547.10	616.76	681.71	743.38	833.13
2850	25 ± 1	1	0.00	58.88	186.56	257.40	353.65	447.49	548.17	628.85	722.84	844.68	923.32	
		2	0.00	90.32	204.61	316.24	399.31	490.90	573.80	684.23	783.96	860.97	945.55	
		3	0.00	74.04	174.99	280.49	355.77	467.05	552.82	657.79	763.84	843.57	945.41	
1850	25 ± 1	1	0.00	126.14	286.16	403.87	568.60	679.18	853.04	972.36	1095.12			
		2	0.00	128.67	299.40	469.34	588.04	741.78	870.44	953.44	1166.27			
		3	0.00	163.35	268.56	470.13	588.98	705.75	848.18	976.71	1136.00			

Table D.4 O₂ permeability in Hyflon F – Calculated Data

Feed Absolute Pressure	Temperature		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$(\Delta p/\Delta t)_{\text{Total}}$	Permeability	Permeability	Volumetric Flux
	°C		mB.s^{-1}	mB.s^{-1}	mB.s^{-1}	$\text{cm}^3.\text{mm}.\text{day}^{-1}.\text{m}^{-2}.\text{atm}^{-1}$	Barrer	$\text{cm}^3.\text{s}^{-1}.\text{cm}^{-2}$
		Run						
3850	25 ± 1	1	0.000202	0.0263	0.0261	432.5625	6.5875	2.3526E-05
		2	0.000202	0.0270	0.0268	444.1647	6.7642	2.4157E-05
		3	0.000202	0.0262	0.0260	430.9051	6.5623	2.3436E-05
2850	25 ± 1	1	0.000202	0.0219	0.0217	485.8221	7.3986	2.6423E-05
		2	0.000202	0.0207	0.0205	458.9539	6.9894	2.4962E-05
		3	0.000202	0.0213	0.0211	472.3880	7.1940	2.5692E-05
1850	25 ± 1	1	0.000202	0.0144	0.0142	489.7313	7.4581	2.6636E-05
		2	0.000202	0.0138	0.0136	469.0355	7.1430	2.5510E-05
		3	0.000202	0.0141	0.0139	479.3834	7.3006	2.6073E-05

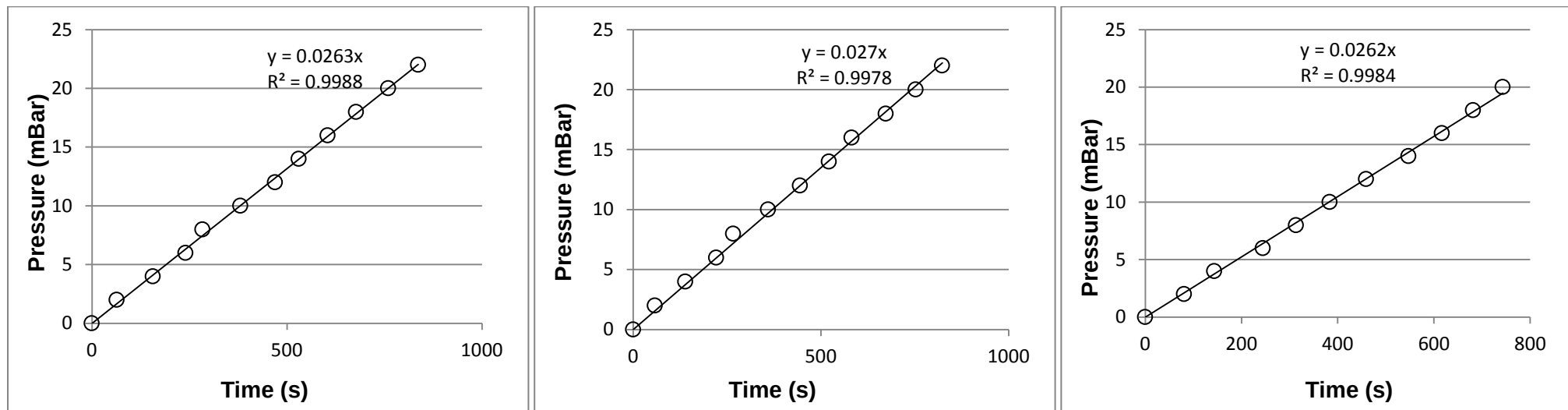


Figure D.4 Permeate pressure-time graphs for O_2 in Hyflon F at 3.85 Bar feed pressure, 1st, 2nd & 3rd trials

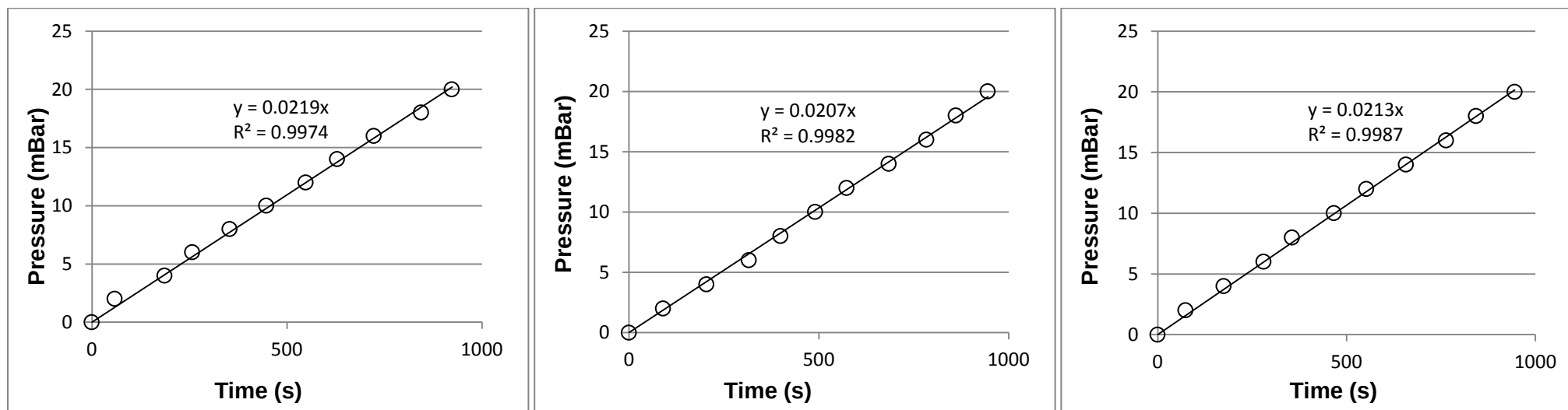


Figure D.5 Permeate pressure-time graphs for O_2 in Hyflon F at 2.85 Bar feed pressure, 1st, 2nd & 3rd trials

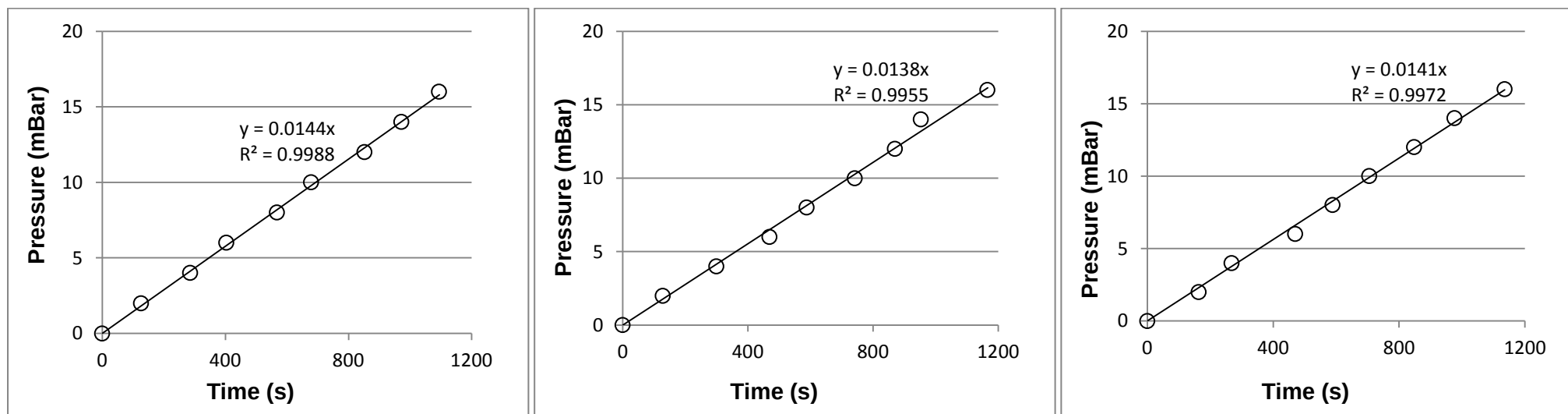


Figure D.6 Permeate pressure-time graphs for O₂ in Hyflon F at 1.85 Bar feed pressure, 1st, 2nd & 3rd trials

Table D.5 N₂ permeability in Hyflon F – Raw Data

Feed Absolute Pressure	Temperature		Permeate Δt per $\Delta p=2\text{mBar}$										
mBar	°C		S										
		Run	t_0	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}
3850	25 ± 1	1	0.00	204.44	472.82	744.20	960.95	1148.38	1389.59	1574.73	1900.53	2105.68	2250.38
		2	0.00	292.54	458.38	700.18	897.87	1160.52	1397.60	1696.84	1841.48	2221.47	2358.01
		3	0.00	265.80	436.74	744.14	887.36	1124.24	1412.83	1608.35	1862.62	2151.10	2311.96
2850	25 ± 1	1	0.00	234.20	672.95	912.21	1185.06	1521.76	1820.98	2086.78	2438.98	2691.42	
		2	0.00	245.39	544.65	892.39	1152.86	1407.98	1774.36	2035.17	2397.15	2660.40	
		3	0.00	347.40	731.06	994.08	1328.48	1589.25	1866.95	2256.79	2439.18	2752.95	
1850	25 ± 1	1	0.00	292.30	692.91	1039.79	1417.49	1947.49	2319.78	2600.54	2893.69		
		2	0.00	264.49	794.58	1051.89	1507.71	1805.61	2284.12	2603.81	3094.35		
		3	0.00	372.49	770.29	1223.84	1728.54	1987.99	2353.89	2620.26	3012.54		

Table D.6 N₂ permeability in Hyflon F – Calculated Data

Feed Absolute Pressure	Temperature		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$(\Delta p/\Delta t)_{\text{Total}}$	Permeability	Permeability	Volumetric Flux
mBar	°C		mB.s^{-1}	mB.s^{-1}	mB.s^{-1}	$\text{cm}^3.\text{mm}.\text{day}^{-1}.\text{m}^{-2}.\text{atm}^{-1}$	Barrer	$\text{cm}^3.\text{s}^{-1}.\text{cm}^{-2}$
		Run						
3850	25 ± 1	1	0.000202	0.0086	0.0084	139.1930	2.1198	7.57E-06
		2	0.000202	0.0084	0.0082	135.8781	2.0693	7.39E-06
		3	0.000202	0.0086	0.0084	139.1930	2.1198	7.57E-06
2850	25 ± 1	1	0.000202	0.0066	0.0064	143.2524	2.1816	5.77E-06
		2	0.000202	0.0068	0.0066	147.7304	2.2498	5.95E-06
		3	0.000202	0.0064	0.0062	138.7743	2.1134	5.59E-06
1850	25 ± 1	1	0.000202	0.0054	0.0052	179.2945	2.7305	4.69E-06
		2	0.000202	0.0053	0.0051	175.8452	2.6780	4.60E-06
		3	0.000202	0.0052	0.0050	172.3959	2.6254	4.51E-06

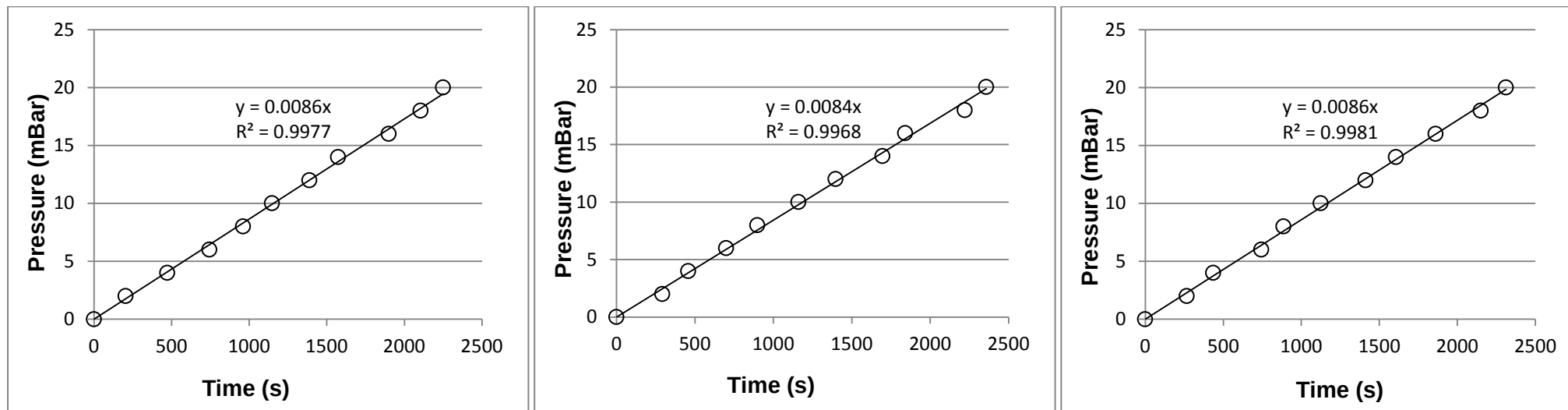


Figure D.7 Permeate pressure-time graphs for N_2 in Hyflon F at 3.85 Bar feed pressure, 1st, 2nd & 3rd trials

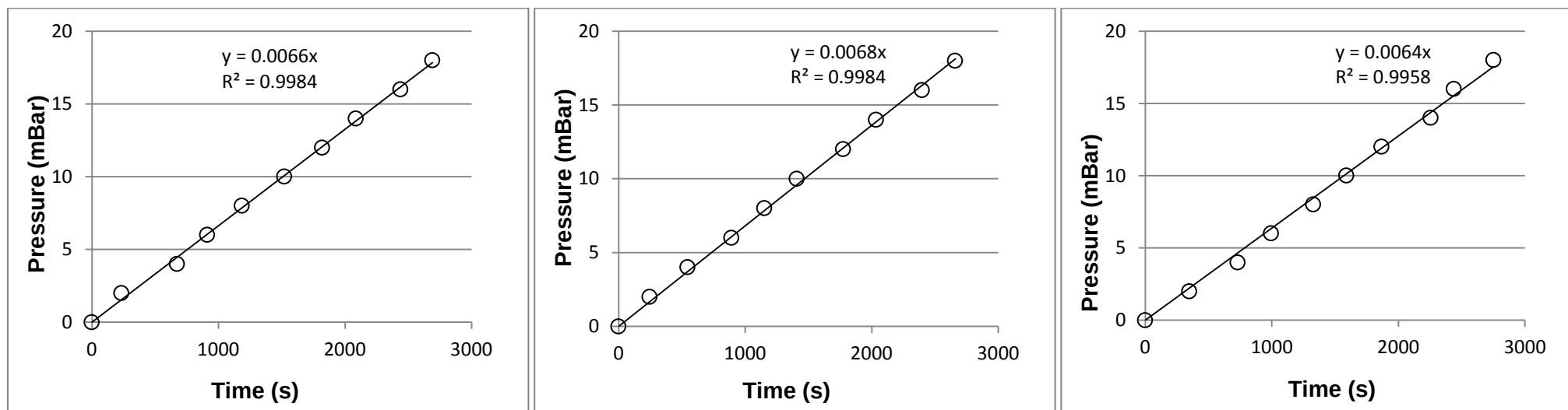


Figure D.8 Permeate pressure-time graphs for N_2 in Hyflon F at 2.85 Bar feed pressure, 1st, 2nd & 3rd trials

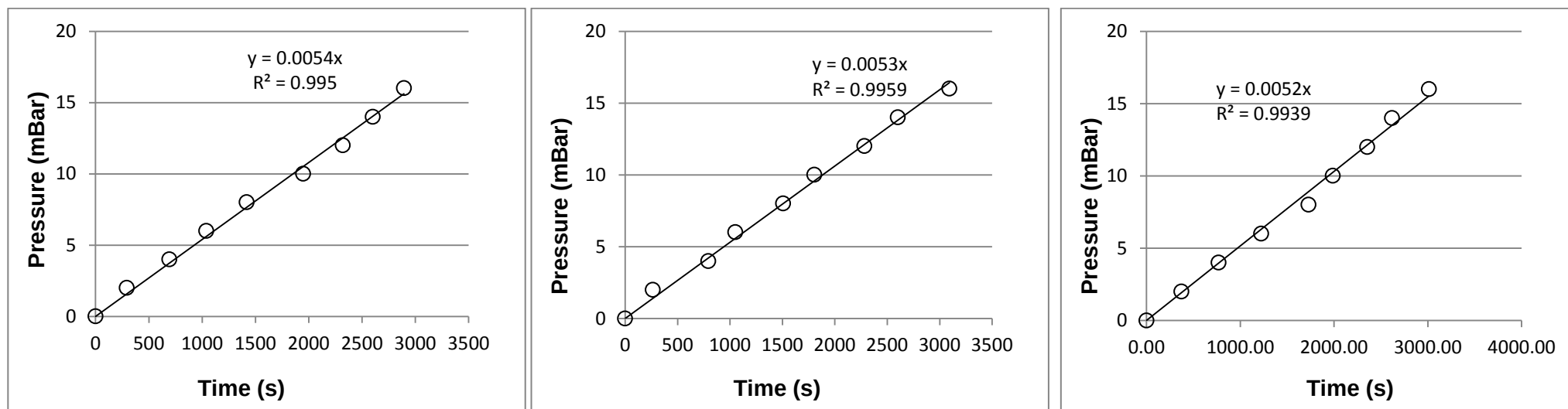


Figure D.9 Permeate pressure-time graphs for N₂ in Hyflon F at 1.85 Bar feed pressure, 1st, 2nd & 3rd trials

Table D.7 CO₂ permeability in Hyflon F – Raw Data

Feed Absolute Pressure	Temperature		Permeate Δt per $\Delta p=2\text{mBar}$										
mBar	°C		s										
		Run	t_0	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}
3850	25 ± 1	1	0.00	25.03	54.00	75.39	113.14	152.54	190.84	215.09	246.31	272.84	314.72
		2	0.00	43.46	63.98	96.02	122.47	158.79	184.18	212.91	246.52	280.19	304.03
		3	0.00	22.68	54.16	91.67	109.14	148.00	186.72	205.02	240.56	275.50	293.53
2850	25 ± 1	1	0.00	44.09	83.24	126.26	152.49	210.29	258.32	292.08	331.92	370.25	
		2	0.00	40.45	79.80	118.65	149.85	199.99	244.41	290.92	329.67	374.31	
		3	0.00	51.67	81.80	126.20	152.61	207.27	251.32	295.95	339.22	365.70	
1850	25 ± 1	1	0.00	61.91	138.87	207.40	241.84	308.67	385.37	433.38	526.30		
		2	0.00	58.74	123.70	183.89	269.20	336.12	382.49	454.35	510.17		
		3	0.00	69.55	128.62	205.43	242.74	321.98	402.38	466.02	517.93		

Table D.8 CO₂ permeability in Hyflon F – Calculated Data

Feed Absolute Pressure	Temperature		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$(\Delta p/\Delta t)_{\text{Total}}$	Permeability	Permeability	Volumetric Flux
mBar	°C		mB.s^{-1}	mB.s^{-1}	mB.s^{-1}	$\text{cm}^3.\text{mm}.\text{day}^{-1}.\text{m}^{-2}.\text{atm}^{-1}$	Barrer	$\text{cm}^3.\text{s}^{-1}.\text{cm}^{-2}$
		Run						
3850	25 ± 1	1	0.000202	0.0648	0.0646	1070.6826	16.3055	5.82E-05
		2	0.000202	0.0652	0.0650	1077.3124	16.4064	5.86E-05
		3	0.000202	0.0670	0.0668	1107.1466	16.8608	6.02E-05
2850	25 ± 1	1	0.000202	0.0481	0.0479	1072.4447	16.3323	4.32E-05
		2	0.000202	0.0488	0.0486	1088.1179	16.5710	4.38E-05
		3	0.000202	0.0482	0.0480	1074.6838	16.3664	4.33E-05
1850	25 ± 1	1	0.000202	0.0313	0.0311	1072.6626	16.3356	2.80E-05
		2	0.000202	0.0310	0.0308	1062.3147	16.1780	2.78E-05
		3	0.000202	0.0306	0.0304	1048.5175	15.9679	2.74E-05

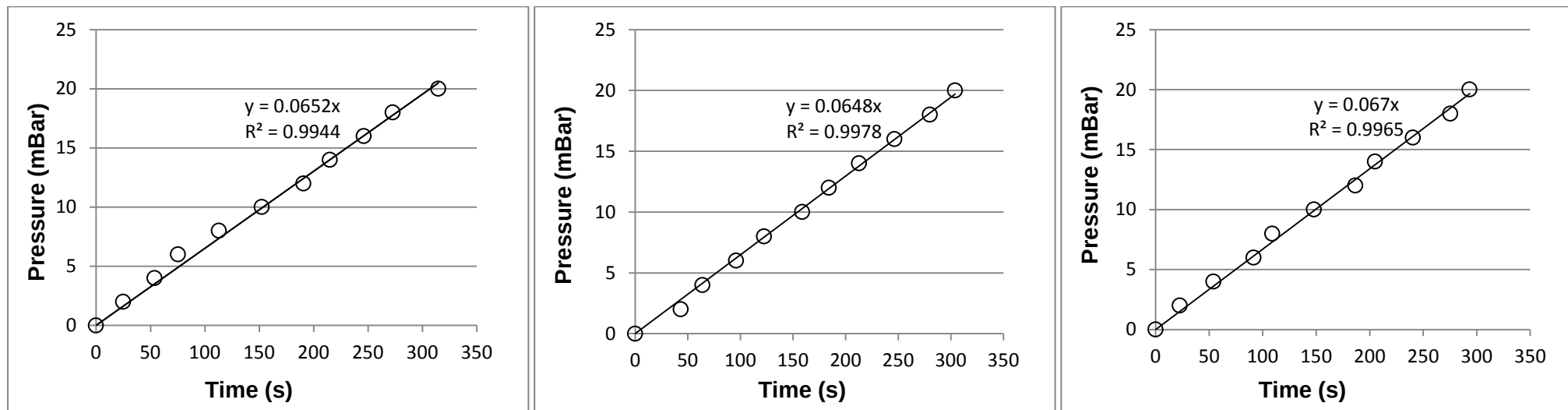


Figure D.10 Permeate pressure-time graphs for CO₂ in Hyflon F at 3.85 Bar feed pressure, 1st, 2nd & 3rd trials

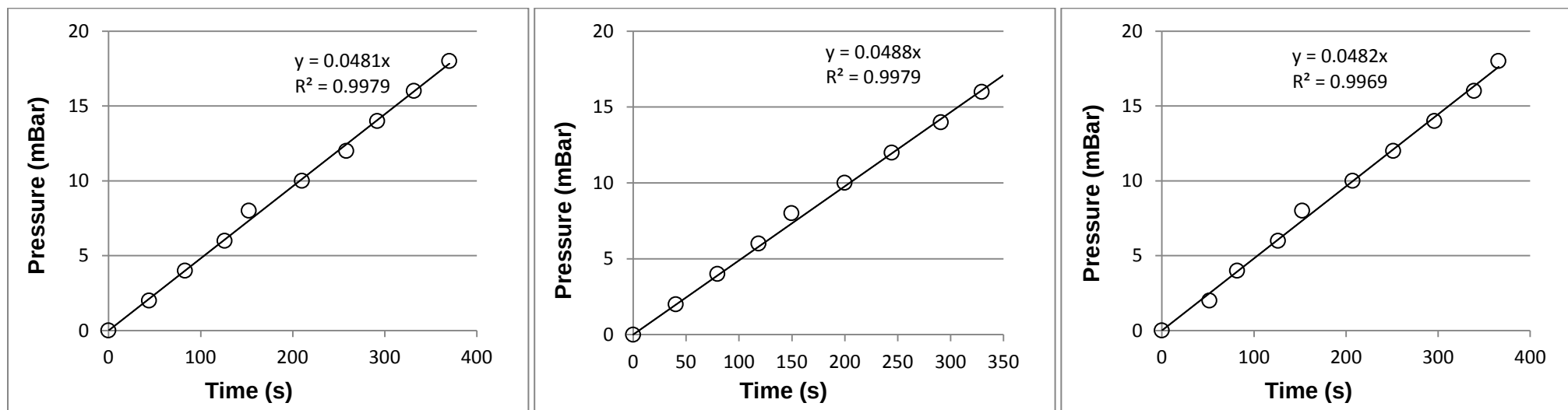


Figure D.11 Permeate pressure-time graphs for CO₂ in Hyflon F at 2.85 Bar feed pressure, 1st, 2nd & 3rd trials

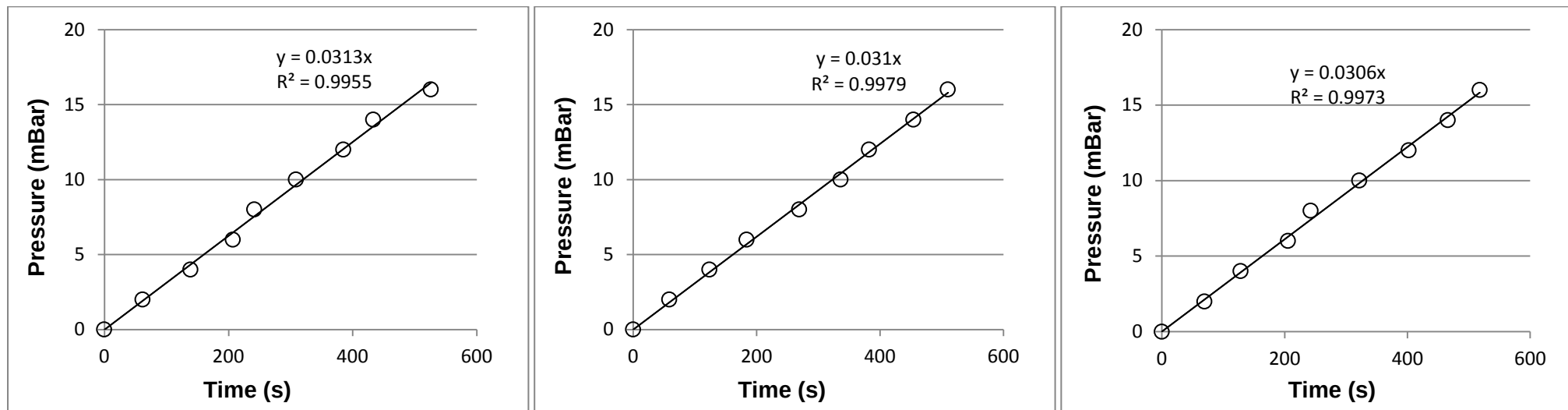


Figure D.12 Permeate pressure-time graphs for CO₂ in Hyflon F at 1.85 Bar feed pressure, 1st, 2nd & 3rd trials

Table D.9 SO₂ permeability in Hyflon M – Raw Data

Feed Absolute Pressure	Temperature		Permeate Δt per $\Delta p=2\text{mBar}$								
mBar	°C		s								
		Run	t_0	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8
3000	25 ± 1	1	0.00	91.99	297.57	347.64	558.99	662.63	740.98	912.13	1055.70
		2	0.00	178.27	266.85	402.17	575.21	673.14	833.47	951.90	1084.92
		3	0.00	146.52	288.12	389.45	558.46	690.27	826.79	940.55	1098.74
2000	25 ± 1	1	0.00	274.89	517.67	748.24	940.21	1100.96	1450.78	1583.49	
		2	0.00	220.31	487.92	669.94	975.59	1143.45	1475.27	1637.25	
		3	0.00	160.53	419.76	677.40	931.65	1129.45	1347.92	1537.64	
1000	25 ± 1	1	0.00	551.18	982.44	1499.72	2104.64	2763.12	3278.74	3547.16	
		2	0.00	467.23	809.19	1532.35	2219.71	2722.33	3020.88	3455.39	
		3	0.00	583.88	922.67	1485.05	2098.05	2832.89	3287.05	3817.27	

Table D.10 SO₂ permeability in Hyflon M – Calculated Data

Feed Absolute Pressure	Temperature		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$(\Delta p/\Delta t)_{\text{Total}}$	Permeability	Permeability	Volumetric Flux
mBar	°C		mB.s^{-1}	mB.s^{-1}	mB.s^{-1}	$\text{cm}^3.\text{mm}.\text{day}^{-1}.\text{m}^{-2}.\text{atm}^{-1}$	Barrer	$\text{cm}^3.\text{s}^{-1}.\text{cm}^{-2}$
		Run						
3000	25 ± 1	1	0.000123	0.0153	0.0152	309.1671	4.7083	1.20E-05
		2	0.000123	0.0146	0.0145	294.9071	4.4912	1.15E-05
		3	0.000123	0.0146	0.0145	294.9071	4.4912	1.15E-05
2000	25 ± 1	1	0.000123	0.00761	0.0075	228.7664	3.4839	5.94E-06
		2	0.000123	0.00844	0.0083	254.1288	3.8701	6.60E-06
		3	0.000123	0.00890	0.0088	268.1851	4.0842	6.96E-06
1000	25 ± 1	1	0.000123	0.00370	0.0036	218.5761	3.3287	2.84E-06
		2	0.000123	0.00383	0.0037	226.5209	3.4497	2.94E-06
		3	0.000123	0.00369	0.0036	217.9649	3.3194	2.83E-06

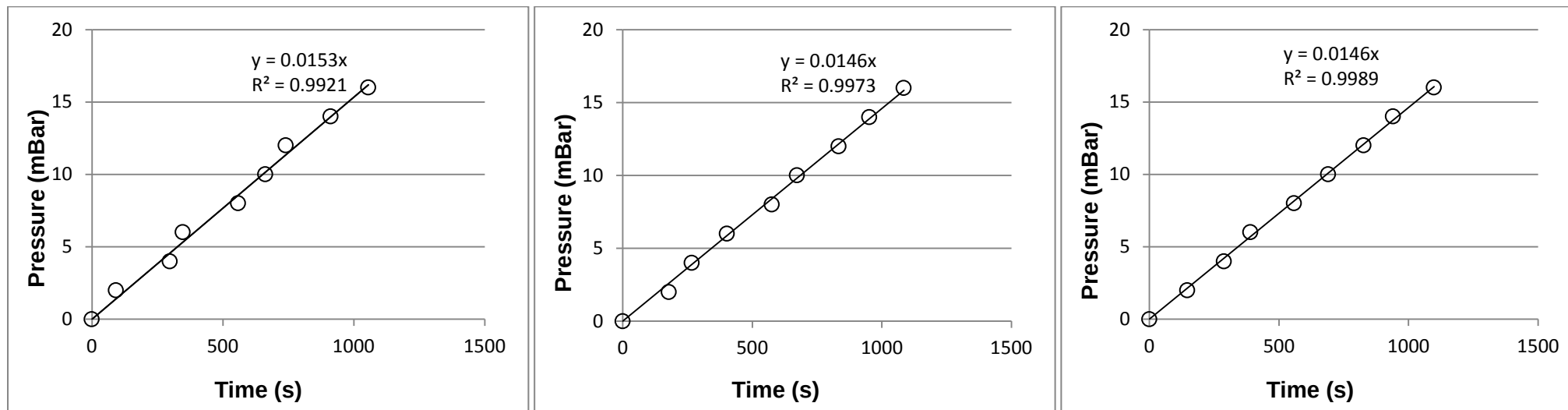


Figure D.13 Permeate pressure-time graphs for SO_2 in Hyflon M at 3 Bar feed pressure, 1st, 2nd & 3rd trials

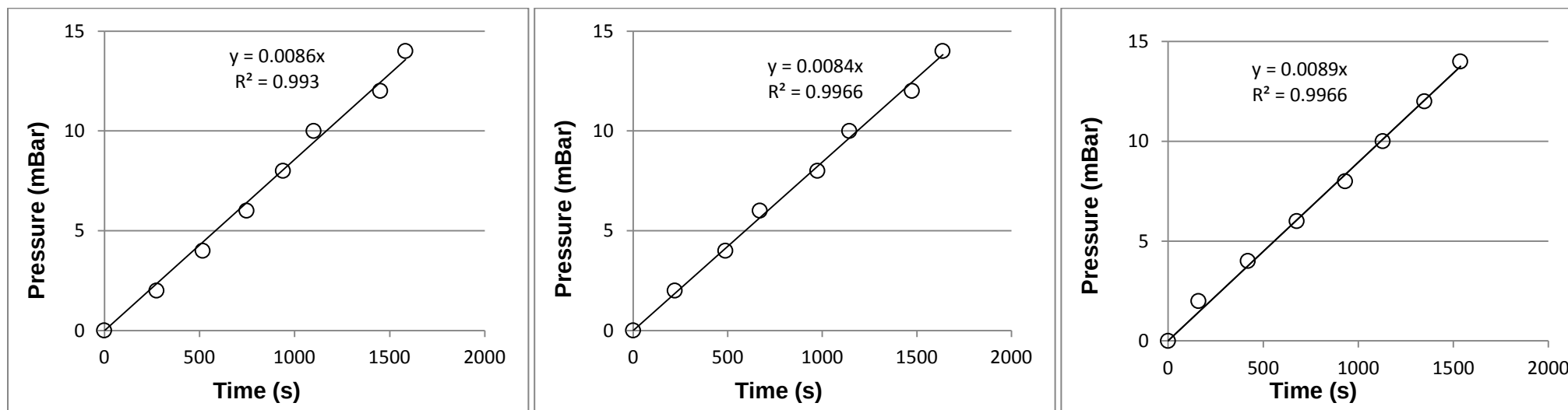


Figure D.14 Permeate pressure-time graphs for SO_2 in Hyflon M at 2 Bar feed pressure, 1st, 2nd & 3rd trials

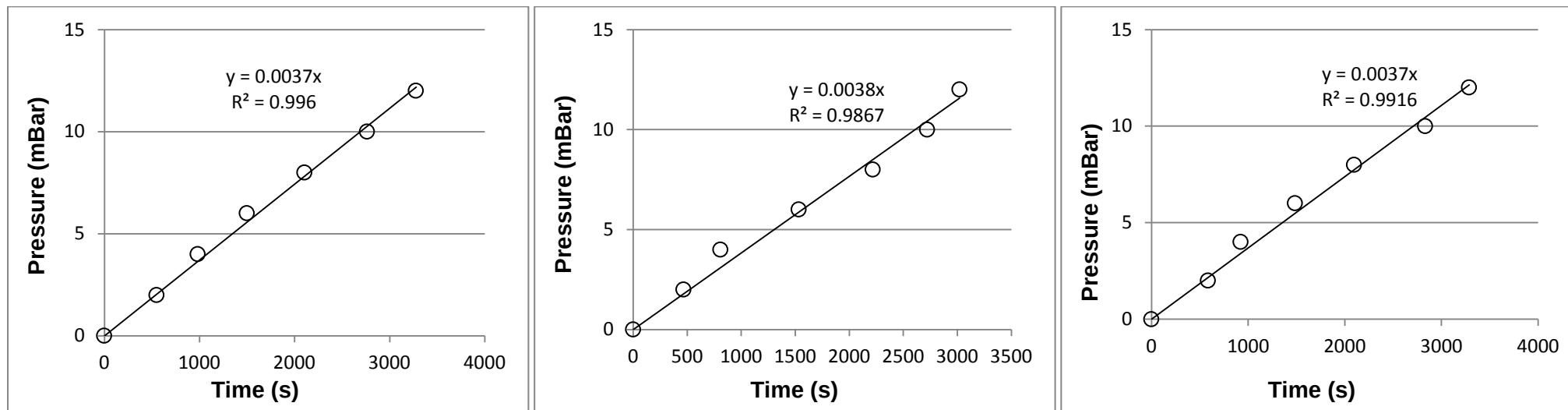


Figure D.15 Permeate pressure-time graphs for SO₂ in Hyflon M at 1 Bar feed pressure, 1st, 2nd & 3rd trials

Table D.11 O₂ permeability in Hyflon M – Raw Data

Feed Absolute Pressure	Temperature		Permeate Δt per $\Delta p=2\text{mBar}$								
	$^{\circ}\text{C}$		s								
		Run	t_0	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8
3000	25 ± 1	1	0.00	124.87	276.37	440.67	590.75	741.84	869.42	1036.28	1230.77
		2	0.00	86.49	247.32	410.94	579.13	714.58	881.33	1007.71	1200.85
		3	0.00	160.68	409.37	494.41	660.23	765.54	890.93	1050.59	1226.62
2000	25 ± 1	1	0.00	211.75	505.26	686.46	897.84	1090.11	1318.35		
		2	0.00	249.86	434.59	676.05	933.04	1083.17	1419.46		
		3	0.00	234.09	394.65	654.72	881.06	1035.96	1401.39		
1000	25 ± 1	1	0.00	649.50	1031.26	1359.38	1674.16	2221.32	2633.09		
		2	0.00	523.73	951.70	1368.76	1731.47	2239.08	2569.84		
		3	0.00	543.94	992.25	1328.46	1782.63	2199.80	2818.94		

Table D.12 O₂ permeability in Hyflon M – Calculated Data

Feed Absolute Pressure	Temperature		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$(\Delta p/\Delta t)_{\text{Total}}$	Permeability	Permeability	Volumetric Flux
mBar	$^{\circ}\text{C}$		mB.s^{-1}	mB.s^{-1}	mB.s^{-1}	$\text{cm}^3.\text{mm}.\text{day}^{-1} . \text{m}^{-2}.\text{atm}^{-1}$	Barrer	$\text{cm}^3.\text{s}^{-1}.\text{cm}^{-2}$
		Run						
3000	25 ± 1	1	0.000123	0.0134	0.0133	270.46.14	4.1189	1.05E-05
		2	0.000123	0.0137	0.0136	276.5729	4.2119	1.08E-05
		3	0.000123	0.0129	0.0128	260.2757	3.9638	1.01E-05
2000	25 ± 1	1	0.000123	0.00899	0.0089	270.9352	4.1261	7.03E-06
		2	0.000123	0.00873	0.0086	262.9904	4.0051	6.83E-06
		3	0.000123	0.0090	0.0089	271.2408	4.1307	7.04E-06
1000	25 ± 1	1	0.000123	0.00449	0.0044	266.8563	4.0640	3.46E-06
		2	0.000123	0.00454	0.0044	269.9120	4.1105	3.50E-06
		3	0.000123	0.00437	0.0042	259.5226	3.9523	3.37E-06

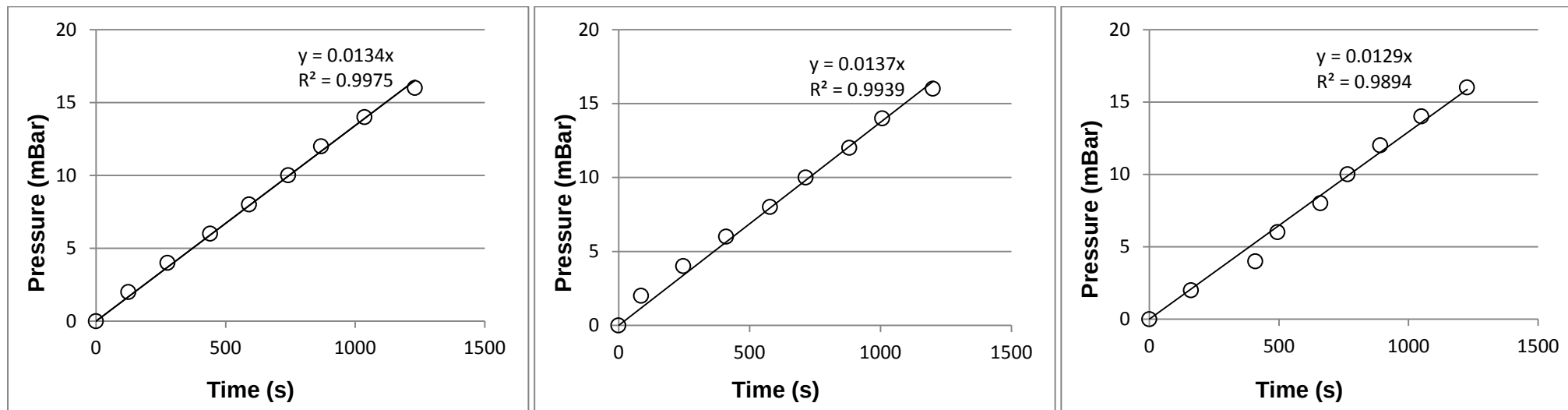


Figure D.16 Permeate pressure-time graphs for O_2 in Hyflon M at 3 Bar feed pressure, 1st, 2nd & 3rd trials

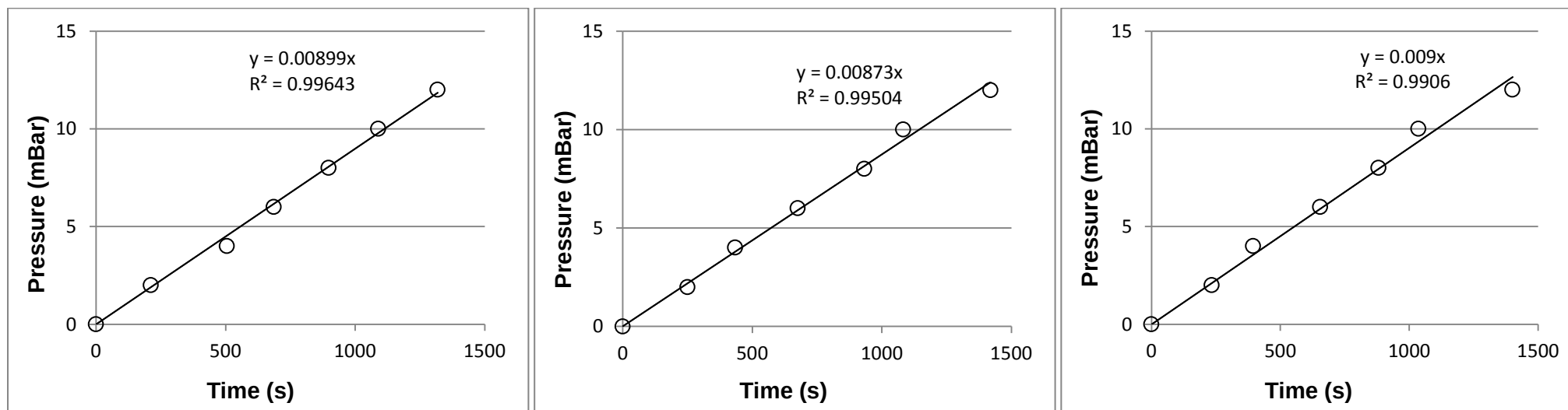


Figure D.17 Permeate pressure-time graphs for O_2 in Hyflon M at 2 Bar feed pressure, 1st, 2nd & 3rd trials

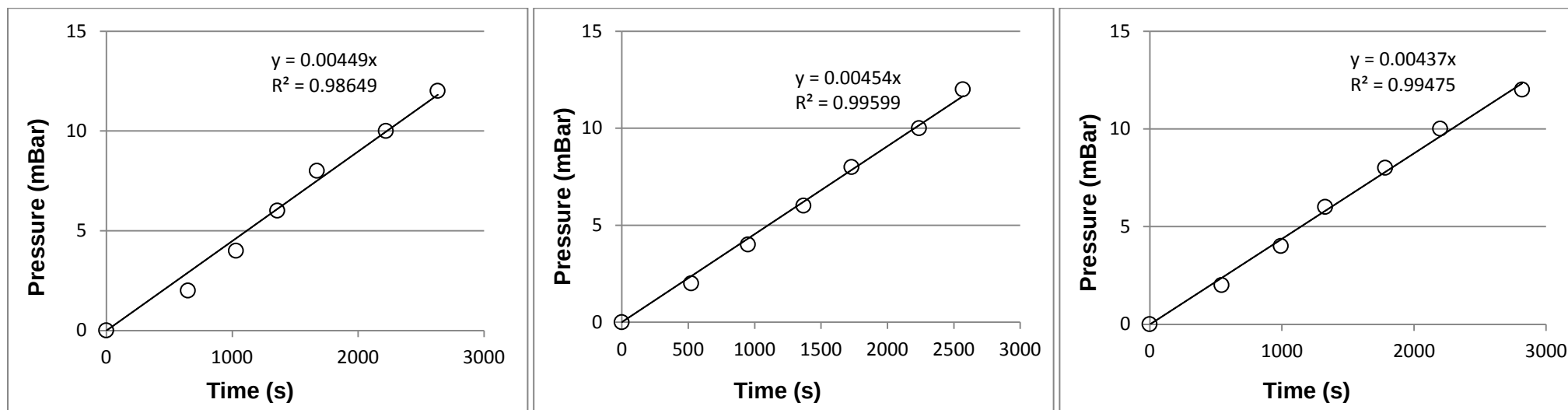


Figure D.18 Permeate pressure-time graphs for O₂ in Hyflon M at 1 Bar feed pressure, 1st, 2nd & 3rd trials

Table D.13 N₂ permeability in Hyflon M – Raw Data

Feed Absolute Pressure	Temperature		Permeate Δt per $\Delta p=2\text{mBar}$								
mBar	°C		s								
		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅	t ₆	t ₇	t ₈
3000	25 ± 1	1	0.00	250.90	819.08	1345.52	1581.42	2109.59	2627.41	3046.95	3831.59
		2	0.00	521.26	752.83	1286.37	1588.37	2271.45	2780.19	3217.57	3760.47
		3	0.00	408.27	798.86	1406.97	1799.01	2360.06	2973.09	3334.45	3718.70

Table D.14 N₂ permeability in Hyflon M – Calculated Data

Feed Absolute Pressure	Temperature		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$(\Delta p/\Delta t)_{\text{Total}}$	Permeability	Permeability	Volumetric Flux
mBar	°C					$\text{cm}^3.\text{mm}.\text{day}^{-1}.\text{m}^{-2}.\text{atm}^{-1}$	Barrer	$\text{cm}^3.\text{s}^{-1}.\text{cm}^{-2}$
		Run						
3000	25 ± 1	1	0.000123	0.0045	0.0044	88.9521	1.3547	3.46E-06
		2	0.000123	0.0044	0.0043	86.7113	1.3205	3.38E-06
		3	0.000123	0.0042	0.0041	83.8593	1.2771	3.26E-06

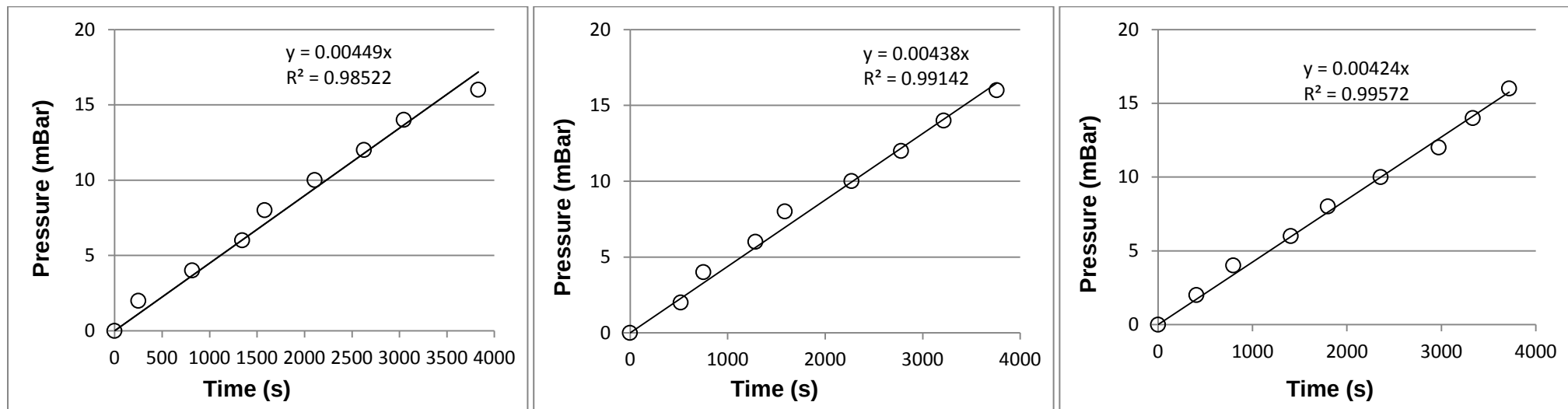


Figure D.19 Permeate pressure-time graphs for N₂ in Hyflon M at 3 Bar feed pressure, 1st, 2nd & 3rd trials

Table D.15 CO₂ permeability in Hyflon M – Raw Data

Feed Absolute Pressure	Temperature		Permeate Δt per $\Delta p=2\text{mBar}$								
mBar	°C		s								
P $\pm$ 20mBar		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅	t ₆	t ₇	t ₈
3000	25 $\pm$ 1	1	0.00	77.54	131.99	212.12	228.35	311.83	358.15	418.74	522.14
		2	0.00	73.86	144.69	179.68	244.39	299.18	364.40	423.40	495.46
		3	0.00	63.86	128.34	180.63	230.97	302.14	373.35	425.60	527.54
2000	25 $\pm$ 1	1	0.00	100.93	210.08	344.17	412.00	492.36	585.77	654.25	
		2	0.00	76.95	196.67	268.81	361.44	468.89	569.13	676.92	
		3	0.00	95.57	189.25	272.24	375.50	502.73	574.72	668.55	
1000	25 $\pm$ 1	1	0.00	172.54	402.16	626.63	784.84	958.93	1091.68		
		2	0.00	165.56	332.24	530.43	717.93	924.33	1062.70		
		3	0.00	149.48	377.73	536.61	718.37	972.90	1068.29		

Table D.16 CO₂ permeability in Hyflon M – Calculated Data

Feed Absolute Pressure	Temperature		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$(\Delta p/\Delta t)_{\text{Total}}$	Permeability	Permeability	Volumetric Flux
mBar	°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	cm ³ .mm.day ⁻¹ . m ⁻² .atm ⁻¹	Barrer	cm ³ .s ⁻¹ .cm ⁻²
P $\pm$ 20mBar		Run						
3000	25 $\pm$ 1	1	0.000123	0.0320	0.0319	649.3797	9.8894	2.53E-05
		2	0.000123	0.0326	0.0325	661.6025	10.0756	2.58E-05
		3	0.000123	0.0320	0.0319	648.9722	9.8832	2.53E-05
2000	25 $\pm$ 1	1	0.000123	0.02029	0.0202	616.2455	9.3848	1.60E-05
		2	0.000123	0.0212	0.0211	644.0525	9.8083	1.67E-05
		3	0.000123	0.02080	0.0207	631.8297	9.6222	1.64E-05
1000	25 $\pm$ 1	1	0.000123	0.01047	0.0103	632.3491	9.6301	8.21E-06
		2	0.000123	0.01110	0.0109	664.7397	10.1234	8.63E-06
		3	0.000123	0.01090	0.0108	658.6283	10.0303	8.55E-06

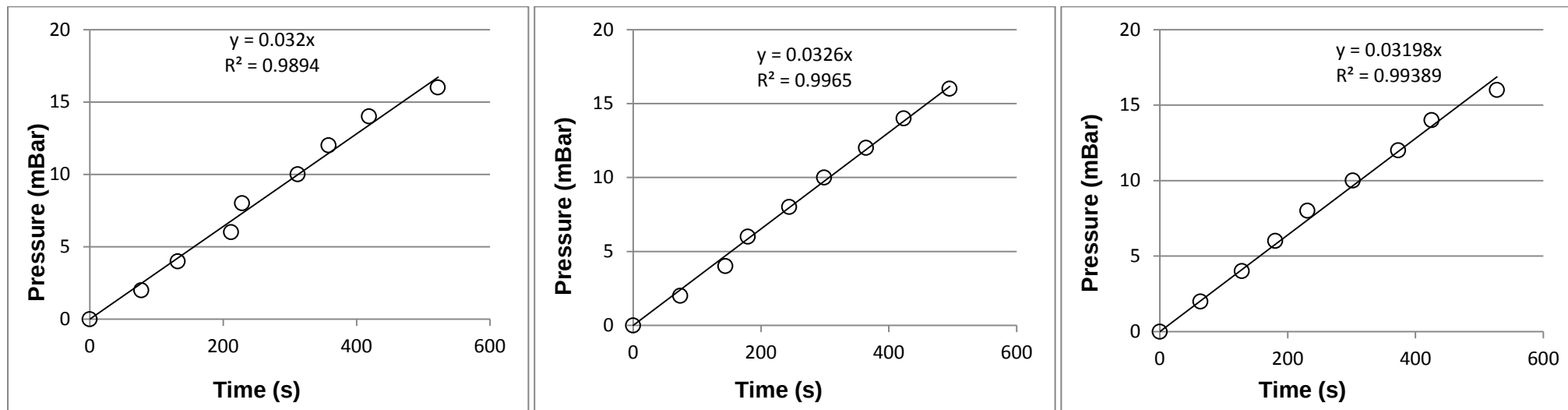


Figure D.20 Permeate pressure-time graphs for CO₂ in Hyflon M at 3 Bar feed pressure, 1st, 2nd & 3rd trials

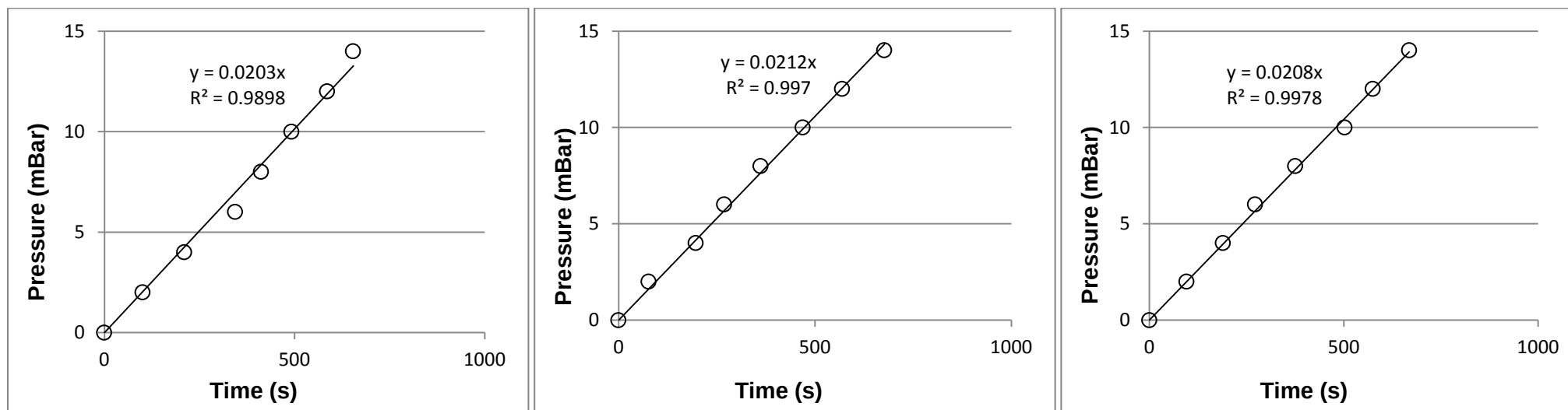


Figure D.21 Permeate pressure-time graphs for CO₂ in Hyflon M at 2 Bar feed pressure, 1st, 2nd & 3rd trials

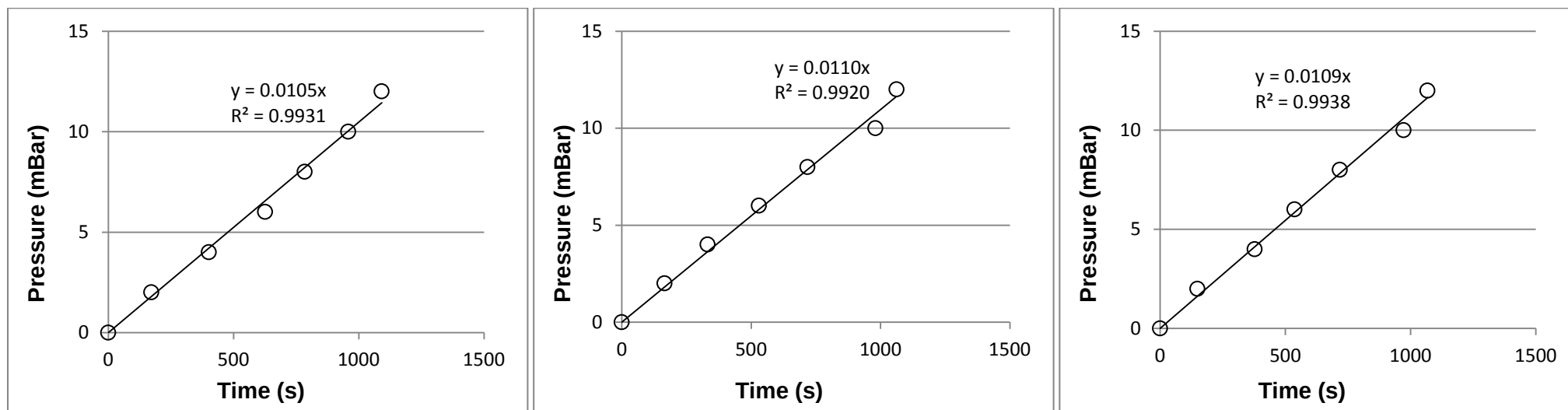


Figure D.22 Permeate pressure-time graphs for CO₂ in Hyflon M at 1 Bar feed pressure, 1st, 2nd & 3rd trials

Table D.17 SO₂ permeability in Halar – Raw Data

Feed Absolute Pressure	Temperature		Permeate Δt per $\Delta p = 2\text{mBar}$						
	°C		s						
		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅	t ₆
3000	25 ± 1	1	0.00	228.95	422.16	622.84	883.29	1109.19	1248.64
3000	25 ± 1	2	0.00	270.75	398.44	624.54	845.45	1126.15	1353.95
3000	25 ± 1	3	0.00	230.16	393.77	622.23	936.61	1092.81	1313.59

Table D.18 SO₂ permeability in Halar – Calculated Data

Feed Absolute Pressure	Temperature		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$(\Delta p/\Delta t)_{\text{Total}}$	Permeability	Permeability	Volumetric Flux
	°C		mB.s ⁻¹	mB.s ⁻¹	mB.s-1	cm ³ .mm.day ⁻¹ . m ⁻² .atm ⁻¹	Barrer	cm ³ .s ⁻¹ .cm ⁻²
		Run						
3000	25 ± 1	1	0.000123	0.009318	0.009195	132.3045	2.0149	7.29E-06
3000	25 ± 1	2	0.000123	0.009047	0.008924	128.4049	1.9555	7.08E-06
3000	25 ± 1	3	0.000123	0.009096	0.008973	129.1100	1.9662	7.12E-06

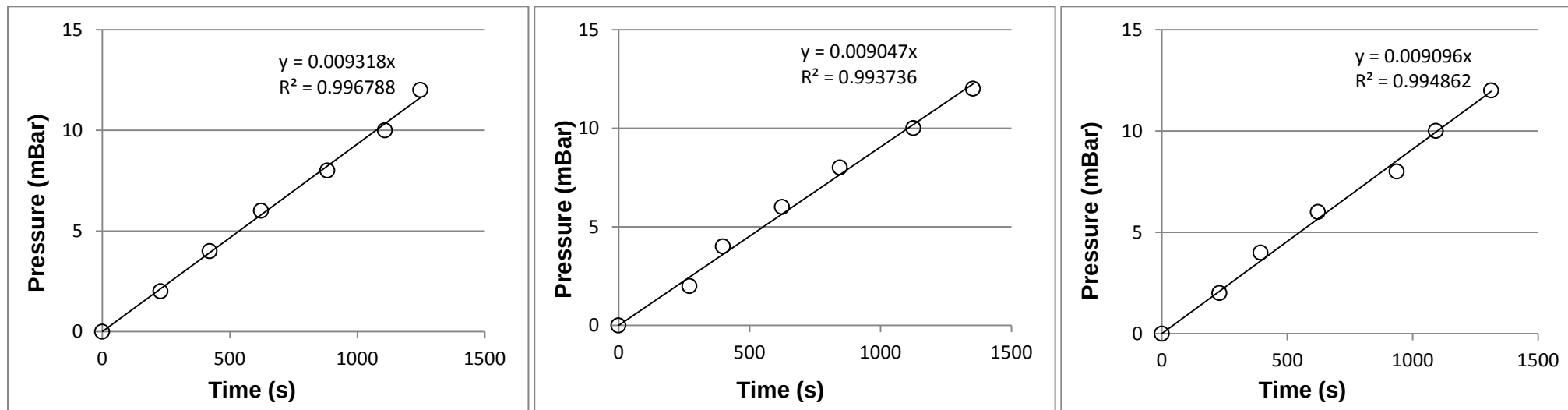


Figure D.23 Permeate pressure-time graphs for SO₂ in Halar at 3 Bar feed pressure, 1st, 2nd & 3rd trials

Table D.19 O₂ permeability in Halar – Raw Data

Feed Absolute Pressure	Temperature		Permeate Δt per $\Delta p = 2\text{mBar}$						
mBar	°C		s						
		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅	t ₆
3000	25 ± 1	1	0.00	4580.12	6548.82	9607.98	11583.46	14812.08	17797.87
3000	25 ± 1	2	0.00	4095.18	8130.50	9527.62	11259.82	15391.00	18556.83
3000	25 ± 1	3	0.00	3971.64	6460.34	8825.02	12061.64	14527.81	17736.96

Table D.20 O₂ permeability in Halar – Calculated Data

Feed Absolute Pressure	Temperature	$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{ss}$	$(\Delta p/\Delta t)_{ss}$	Permeability	Permeability	Volumetric Flux
mBar	°C	mB.s ⁻¹	mB.s ⁻¹	mB.s-1	cm ³ .mm.day ⁻¹ . m ⁻² .atm ⁻¹	Barrer	cm ³ .s ⁻¹ .cm ⁻²
3000	25 ± 1	0.000123	0.000662	0.000539	7.7490	0.1180	4.27E-07
3000	25 ± 1	0.000123	0.000640	0.000517	7.4324	0.1132	4.10E-07
3000	25 ± 1	0.000123	0.000671	0.000548	7.8785	0.1200	4.34E-07

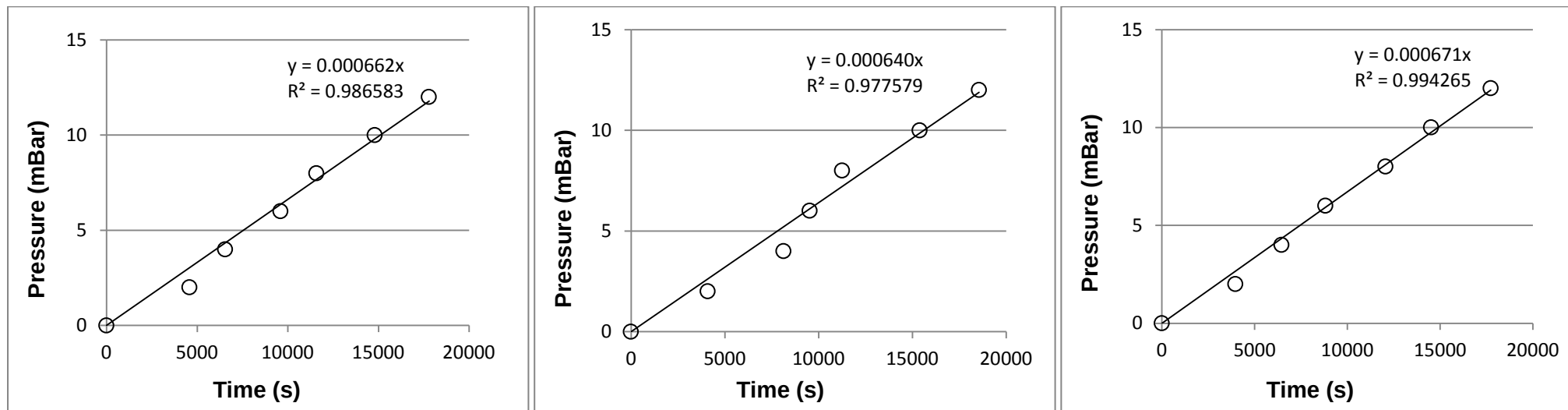


Figure D.24 Permeate pressure-time graphs for O₂ in Halar at 3 Bar feed pressure, 1st, 2nd & 3rd trials

Table D.21 CO₂ permeability in Halar – Raw Data

Feed Absolute Pressure	Temperature		Permeate Δt per $\Delta p=2\text{mBar}$										
	°C		s										
		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅	t ₆	t ₇	t ₈	t ₉	t ₁₀
3000	25 ± 1	1	0.00	465.56	947.41	1384.65	1933.98	2325.45	3104.74	3656.51	4170.51	4785.64	5203.69
3000	25 ± 1	2	0.00	432.31	895.74	1517.58	1904.68	2545.45	3016.14	3357.25	3966.09	4781.36	5463.13
3000	25 ± 1	3	0.00	421.15	1158.71	1596.14	2291.63	2828.14	3245.27	3587.36	4209.56	4897.31	5546.35

Table D.22 CO₂ permeability in Halar – Calculated Data

Feed Absolute Pressure	Temperature		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$(\Delta p/\Delta t)_{\text{Total}}$	Permeability	Permeability	Volumetric Flux
	°C		mB.s ⁻¹	mB.s ⁻¹	mB.s-1	cm ³ .mm.day ⁻¹ . m ⁻² .atm ⁻¹	Barrer	cm ³ .s ⁻¹ .cm ⁻²
		Run						
3000	25 ± 1	1	0.000202	0.00387	0.0037	52.7807	0.8038	2.91E-06
3000	25 ± 1	2	0.000202	0.00388	0.0037	52.9246	0.8060	2.92E-06
3000	25 ± 1	3	0.000202	0.00369	0.00349	50.1906	0.7644	2.77E-06

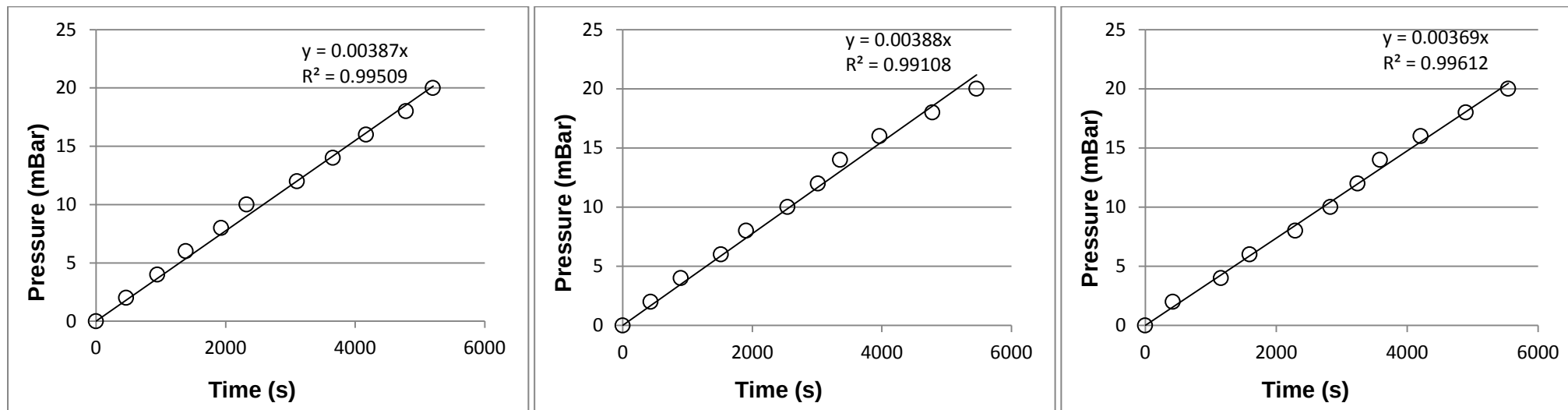


Figure D.25 Permeate pressure-time graphs for CO₂ in Halar at 3 Bar feed pressure, 1st, 2nd & 3rd trials

Table D.23 SO₂ permeability in Udel Polysulfone – Raw Data

Feed Absolute Pressure	Temperature		Permeate Δt per $\Delta p=2\text{mBar}$								
	°C		s								
		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅	t ₆	t ₇	t ₈
3000	25 ± 1	1	0.00	9.80	22.58	33.19	40.58	53.72	61.91	67.84	77.88
		2	0.00	9.72	24.07	32.51	43.67	49.26	63.40	65.43	75.07
		3	0.00	9.60	23.54	32.23	42.77	50.03	58.41	66.05	76.47
2000	25 ± 1	1	0.00	12.69	28.37	37.71	50.05	62.06	78.77	95.56	106.62
		2	0.00	11.19	19.92	35.99	49.64	63.92	78.59	93.91	107.26
		3	0.00	13.24	25.01	42.98	53.99	65.85	78.99	97.02	112.54
1000	25 ± 1	1	0.00	35.97	54.23	95.67	136.47	147.30	200.26	215.84	264.75
		2	0.00	31.09	55.89	98.76	131.48	167.55	202.16	223.89	265.99
		3	0.00	14.60	51.73	97.27	134.48	163.59	215.02	240.49	274.23

Table D.24 SO₂ permeability in Udel Polysulfone – Calculated Data

Feed Absolute Pressure	Temperature		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$(\Delta p/\Delta t)_{\text{Total}}$	Permeability	Permeability	Volumetric Flux
	°C		mB.s ⁻¹	mB.s ⁻¹	mB.s-1	cm ³ .mm.day ⁻¹ . m ⁻² .atm ⁻¹	Barrer	cm ³ .s ⁻¹ .cm ⁻²
		Run						
3000	25 ± 1	1	0.000202	0.19815	0.1979	20 147.7120	309.8304	9.33E-04
		2	0.000202	0.20153	0.2013	20 491.7380	312.0696	9.49E-04
		3	0.000202	0.20360	0.2034	20 702.4285	315.2782	9.58E-04
2000	25 ± 1	1	0.000202	0.15163	0.1514	3 891.0228	59.2566	1.20E-04
		2	0.000202	0.15282	0.1526	3 921.6005	59.7222	1.21E-04
		3	0.000202	0.14605	0.1458	3 747.6418	57.0730	1.16E-04
1000	25 ± 1	1	0.000202	0.06218	0.0620	3 185.1152	48.5063	4.92E-05
		2	0.000202	0.06075	0.0605	3 111.6260	47.3871	4.80E-05
		3	0.000202	0.05864	0.0584	3 003.1908	45.7357	4.63E-05

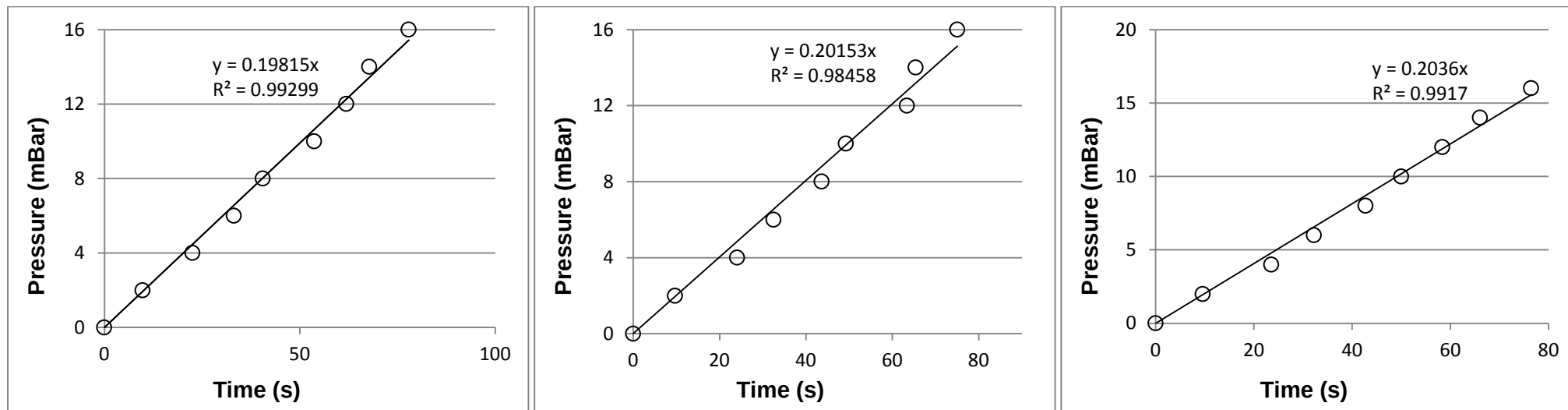


Figure D.26 Permeate pressure-time graphs for SO_2 in Udel Polysulfone at 3 Bar feed pressure, 1st, 2nd & 3rd trials

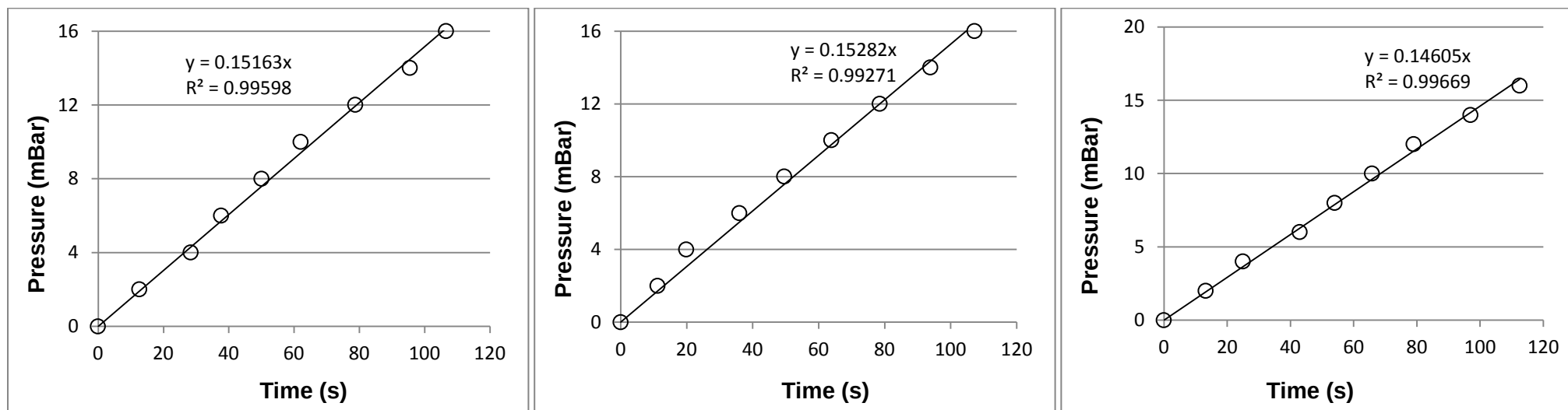


Figure D.27 Permeate pressure-time graphs for SO_2 in Udel Polysulfone at 2 Bar feed pressure, 1st, 2nd & 3rd trials

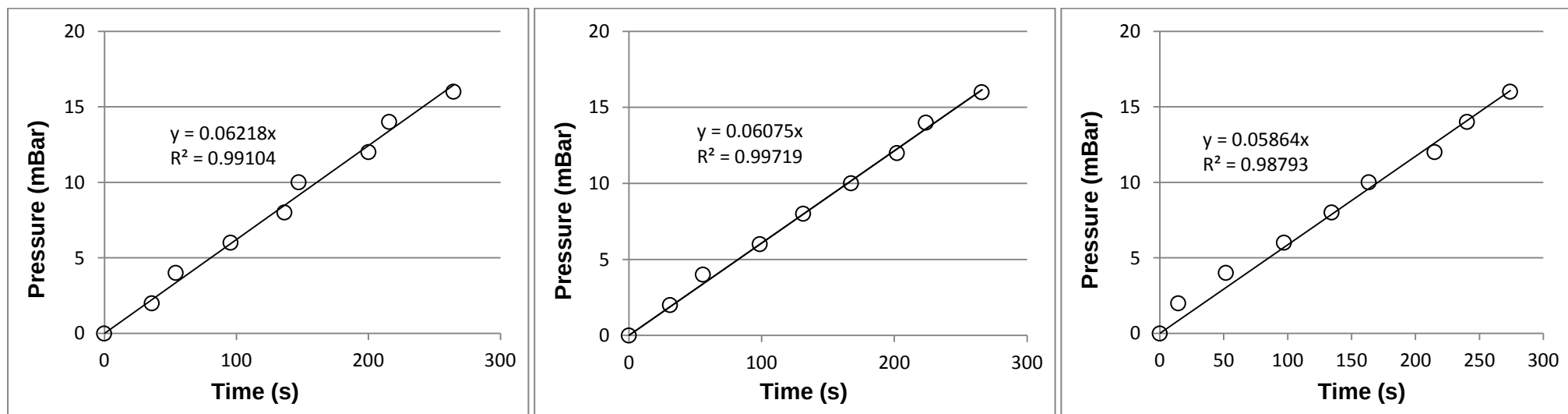


Figure D.28 Permeate pressure-time graphs for SO₂ in Udel Polysulfone at 1 Bar feed pressure, 1st, 2nd & 3rd trials

Table D.25 O₂ permeability in Udel Polysulfone – Raw Data

Feed Absolute Pressure	Temperature		Permeate Δt per $\Delta p=2\text{mBar}$								
	°C		s								
		Run	t_0	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8
3000	25 ± 1	1	0.00	351.25	943.72	1518.33	1878.13	2474.56	2830.82	3441.08	3986.37
		2	0.00	364.45	863.86	1459.38	1786.90	2586.35	3072.53	3436.29	4076.72
		3	0.00	587.16	1080.35	1553.03	2109.96	2727.07	3075.15	3649.08	3841.16
2000	25 ± 1	1	0.00	510.72	973.91	2054.74	2789.65	3455.89	4659.84	5206.42	
		2	0.00	541.66	1751.05	2351.71	3192.46	4190.27	4994.44	6046.46	
		3	0.00	393.10	1182.46	2122.63	2700.47	3946.63	4398.27	5128.87	
1000	25 ± 1	1	0.00	1722.04	2691.24	3708.94	5239.14	6993.27	8299.62		
		2	0.00	800.42	2222.40	3745.62	5124.09	6684.19	7914.23		
		3	0.00	348.81	2428.25	3868.05	4918.91	6611.85	8068.24		

Table D.26 O₂ permeability in Udel Polysulfone – Calculated Data

Feed Absolute Pressure	Temperature		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$(\Delta p/\Delta t)_{\text{Total}}$	Permeability	Permeability	Volumetric Flux
	°C		mB.s^{-1}	mB.s^{-1}	mB.s^{-1}	$\text{cm}^3.\text{mm}.\text{day}^{-1}.\text{m}^{-2}.\text{atm}^{-1}$	Barrer	$\text{cm}^3.\text{s}^{-1}.\text{cm}^{-2}$
		Run						
3000	25 ± 1	1	0.000202	0.00410	0.0039	66.7741	1.0169	3.09E-06
		2	0.000202	0.00401	0.0038	65.2324	0.9934	3.02E-06
		3	0.000202	0.00390	0.0037	63.3480	0.9647	2.93E-06
2000	25 ± 1	1	0.000202	0.00274	0.0025	65.2153	0.9932	2.01E-06
		2	0.000202	0.00283	0.0026	67.5279	1.0284	2.08E-06
		3	0.000202	0.00273	0.0025	64.9583	0.9893	2.00E-06
1000	25 ± 1	1	0.000202	0.00147	0.00127	65.1639	0.9924	1.01E-06
		2	0.000202	0.00154	0.00134	68.7612	1.0472	1.06E-06
		3	0.000202	0.00153	0.00133	68.2473	1.0393	1.05E-06

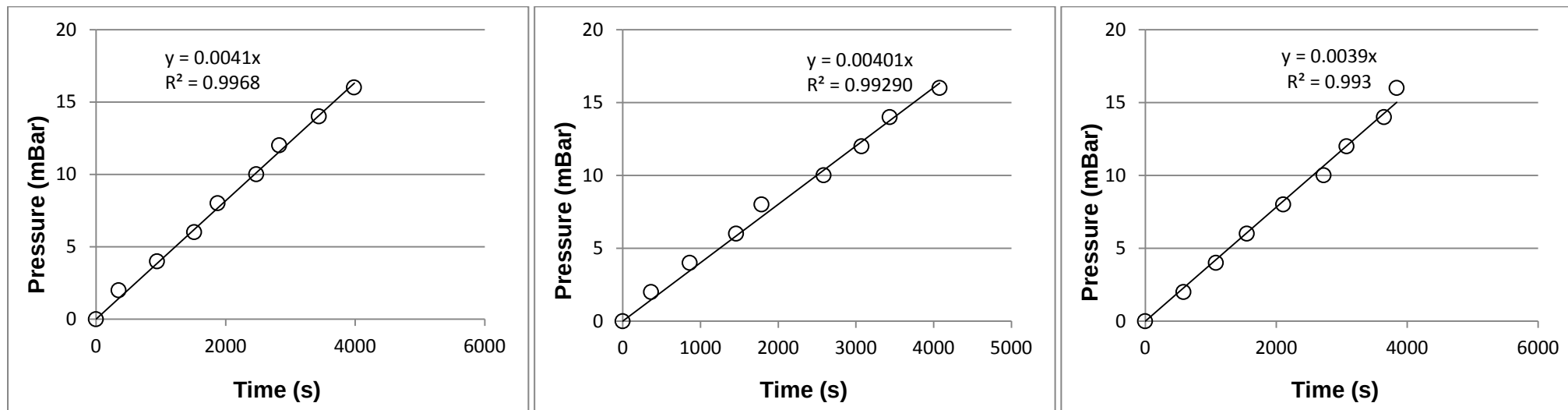


Figure D.29 Permeate pressure-time graphs for O_2 in Udel Polysulfone at 3 Bar feed pressure, 1st, 2nd & 3rd trials

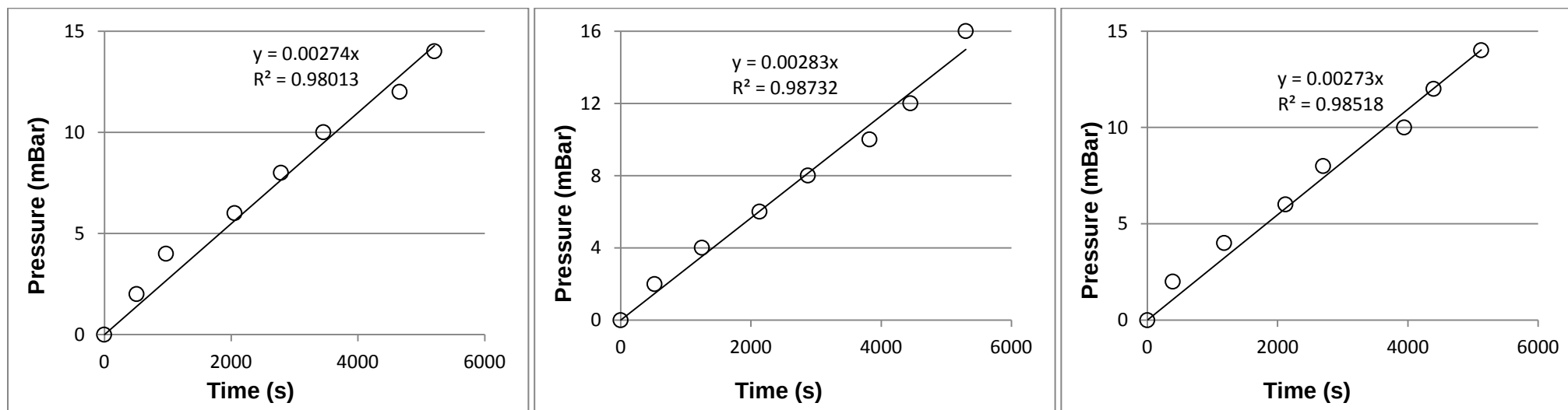


Figure D.30 Permeate pressure-time graphs for O_2 in Udel Polysulfone at 2 Bar feed pressure, 1st, 2nd & 3rd trials

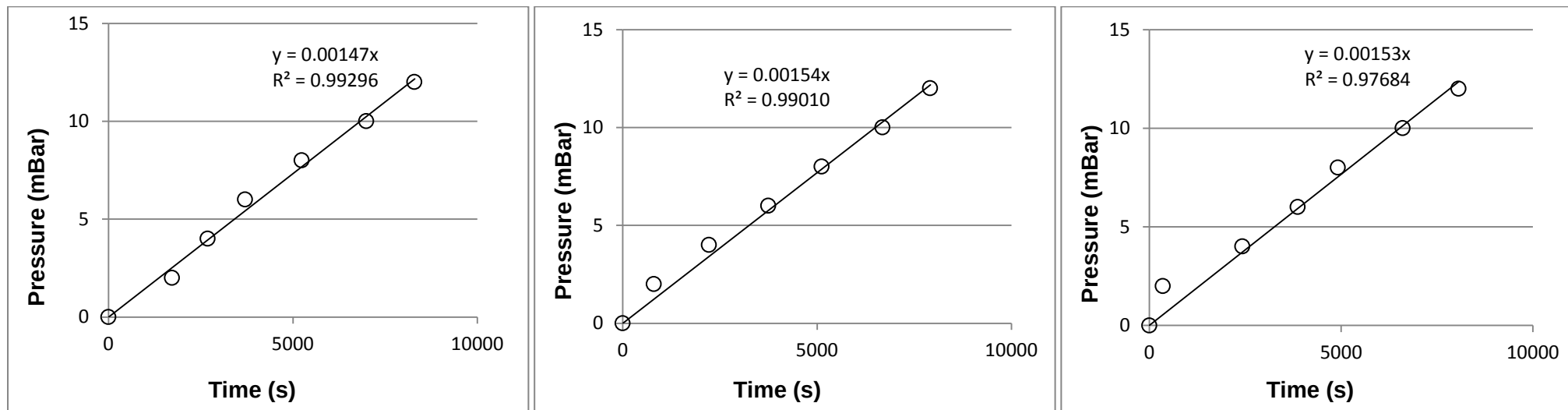


Figure D.31 Permeate pressure-time graphs for O_2 in Udel Polysulfone at 1 Bar feed pressure, 1st, 2nd & 3rd trials

Table D.27 N₂ permeability in Udel Polysulfone – Raw Data

Feed Absolute Pressure	Temperature		Permeate Δt per $\Delta p=2\text{mBar}$						
	°C		s						
		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅	t ₆
3000	25 ± 1	1	0.00	1471.94	3356.81	4576.92	8248.04	10231.89	12437.57
		2	0.00	1064.92	3203.26	4178.87	6872.09	9675.69	12468.28
		3	0.00	1307.46	3290.56	4495.47	7450.21	9826.53	12787.25

Table D.28 N₂ permeability in Udel Polysulfone – Calculated Data

Feed Absolute Pressure	Temperature		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$(\Delta p/\Delta t)_{\text{Total}}$	Permeability	Permeability	Volumetric Flux
	°C		mB.s ⁻¹	mB.s ⁻¹	mB.s-1	cm ³ .mm.day ⁻¹ . m ⁻² .atm ⁻¹	Barrer	cm ³ .s ⁻¹ .cm ⁻²
		Run						
3000	25 ± 1	1	0.000202	0.00100	0.00080	13.6700	0.2082	6.33E-07
		2	0.000202	0.00105	0.00085	14.5265	0.2212	6.73E-07
		3	0.000202	0.00102	0.00082	14.0126	0.2134	6.49E-07

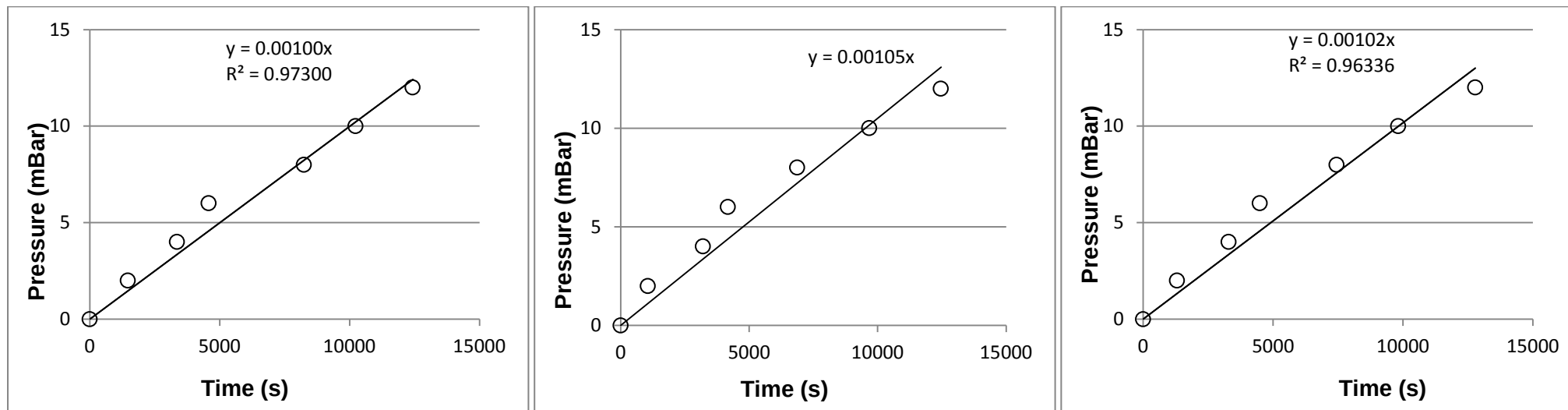


Figure D.32 Permeate pressure-time graphs for N₂ in Udel Polysulfone at 3 Bar feed pressure, 1st, 2nd & 3rd trials

Table D.29 CO₂ permeability in Udel Polysulfone – Raw Data

Feed Absolute Pressure	Temperature		Permeate Δt per $\Delta p=2\text{mBar}$								
	°C		s								
		Run	t_0	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8
3000	25 ± 1	1	0.00	90.71	197.44	306.75	353.72	458.67	556.72	628.41	734.28
		2	0.00	99.18	170.54	257.83	375.94	453.76	561.72	650.73	752.73
		3	0.00	90.74	181.58	313.52	364.71	460.18	579.99	661.48	749.87
2000	25 ± 1	1	0.00	141.55	246.07	453.82	568.17	774.47	861.42	962.95	
		2	0.00	190.69	296.91	465.43	554.78	762.41	910.23	1067.38	
		3	0.00	114.49	240.11	432.32	571.93	717.76	883.87	1092.84	
1000	25 ± 1	1	0.00	140.60	388.8	576.8	859.16	1124.6	1421.3		
		2	0.00	202.84	411.68	694.52	910.31	1285.03	1397.49		
		3	0.00	167.00	424.29	647.15	889.72	1179.10	1401.26		

Table D.30 CO₂ permeability in Udel Polysulfone – Calculated Data

Feed Absolute Pressure	Temperature		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$(\Delta p/\Delta t)_{\text{Total}}$	Permeability	Permeability	Volumetric Flux
mBar	°C		mB.s^{-1}	mB.s^{-1}	mB.s^{-1}	$\text{cm}^3.\text{mm}.\text{day}^{-1}.\text{m}^{-2}.\text{atm}^{-1}$	Barrer	$\text{cm}^3.\text{s}^{-1}.\text{cm}^{-2}$
		Run						
3000	25 ± 1	1	0.000202	0.02177	0.0216	369.4671	5.6266	1.71E-05
		2	0.000202	0.02154	0.0213	365.5271	5.5666	1.69E-05
		3	0.000202	0.02116	0.0210	359.0176	5.4675	1.66E-05
2000	25 ± 1	1	0.000202	0.0139	0.0137	351.9769	5.3603	1.09E-05
		2	0.000202	0.0132	0.0130	333.9900	5.0863	1.03E-05
		3	0.000202	0.0135	0.0133	341.6986	5.2037	1.05E-05
1000	25 ± 1	1	0.000202	0.0089	0.0087	446.9984	6.8074	6.90E-06
		2	0.000202	0.0084	0.0082	421.3029	6.4160	6.50E-06
		3	0.000202	0.00873	0.0085	438.2619	6.6743	6.76E-06

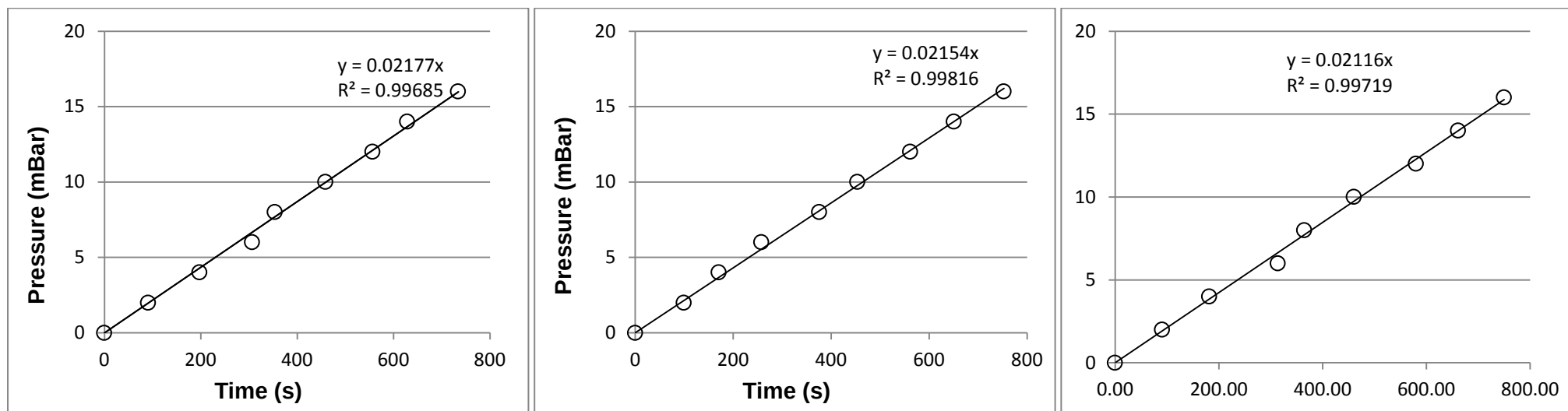


Figure D.33 Permeate pressure-time graphs for CO₂ in Udel Polysulfone at 3 Bar feed pressure, 1st, 2nd & 3rd trials

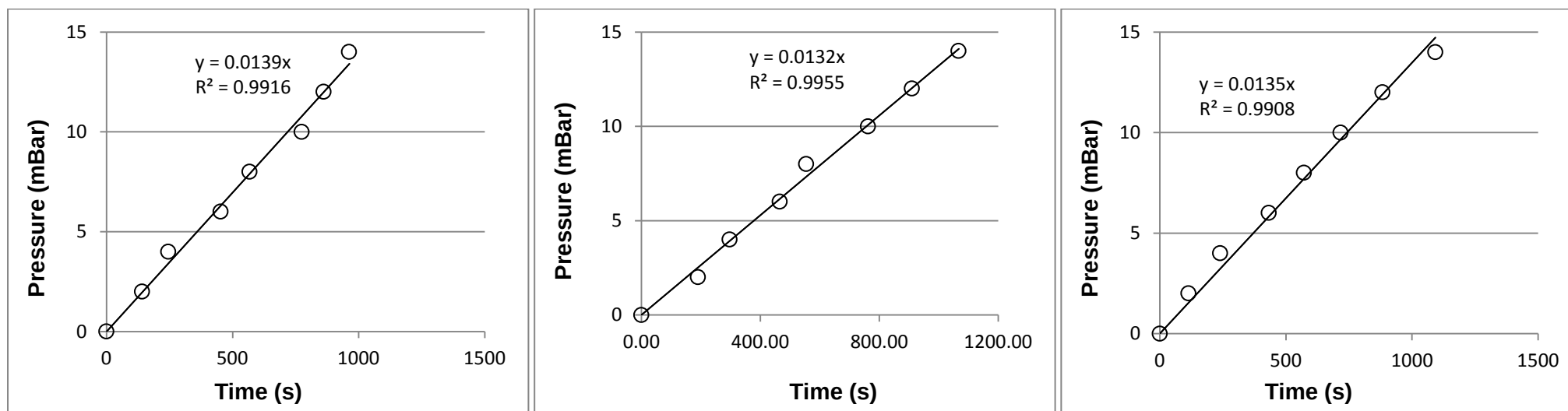


Figure D.34 Permeate pressure-time graphs for CO₂ in Udel Polysulfone at 2 Bar feed pressure, 1st, 2nd & 3rd trials

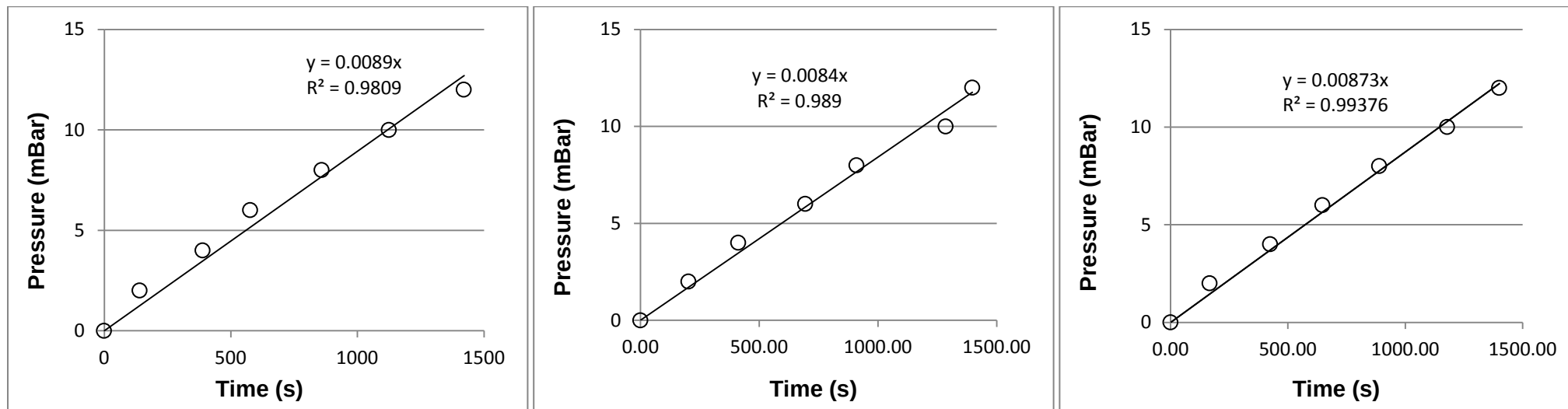


Figure D.35 Permeate pressure-time graphs for CO₂ in Udel Polysulfone at 1 Bar feed pressure, 1st, 2nd & 3rd trials

Table D.31 SO₂ permeability in Teflon AF 2400 – Raw Data

Feed Absolute Pressure	Temperature		Permeate Δt per $\Delta p=2\text{mBar}$									
mBar	°C		s									
P $\pm$ 20mBar		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅	t ₆	t ₇	t ₈	t ₉
3000	25 $\pm$ 1	1	0.00	4.05	7.26	10.83	12.30	15.29	17.58	21.63	23.98	26.38
		2	0.00	3.49	7.18	10.76	13.17	15.57	17.89	20.25	22.78	25.21
		3	0.00	4.77	7.22	9.57	13.11	15.50	18.00	20.37	22.72	25.13
2000	25 $\pm$ 1	1	0.00	6.87	11.79	17.73	21.34	26.17	29.71	34.58	37.89	44.21
		2	0.00	7.24	13.67	16.79	21.80	26.29	31.11	34.78	38.38	43.09
		3	0.00	5.65	11.75	16.39	21.42	24.79	28.42	33.10	38.14	41.62
1000	25 $\pm$ 1	1	0.00	10.70	17.85	27.43	34.71	38.42	44.97	56.27	67.01	74.52
		2	0.00	9.59	15.83	24.21	33.63	39.71	46.92	57.61	67.28	75.56
		3	0.00	9.74	19.27	27.62	35.24	38.11	45.91	55.26	65.02	72.11

Table D.32 SO₂ permeability in Teflon AF 2400 – Calculated Data

Feed Absolute Pressure	Temperature		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$(\Delta p/\Delta t)_{\text{Total}}$	Permeability	Permeability	Volumetric Flux
	°C		mB.s ⁻¹	mB.s ⁻¹	mB.s-1	cm ³ .mm.day ⁻¹ . m ⁻² .atm ⁻¹	Barrer	cm ³ .s ⁻¹ .cm ⁻²
		Run						
3000	25 $\pm$ 1	1	0.008300	0.6588	0.6505	77093.0301	1174.0532	8.92E-03
		2	0.008300	0.6765	0.6765	80174.3811	1220.9792	9.28E-03
		3	0.008300	0.6785	0.6785	80411.4080	1224.5889	9.31E-03
2000	25 $\pm$ 1	1	0.008300	0.39980	0.3915	69597.0514	1059.8966	5.37E-03
		2	0.008300	0.39711	0.3971	70594.3425	1075.0844	5.45E-03
		3	0.008300	0.41500	0.4150	73774.6522	1123.5175	5.69E-03
1000	25 $\pm$ 1	1	0.008300	0.24401	0.2357	83804.4495	1276.2617	3.23E-03
		2	0.008300	0.24236	0.2424	86168.7938	1312.2684	3.32E-03
		3	0.008300	0.24780	0.2478	88102.9340	1341.7235	3.40E-03

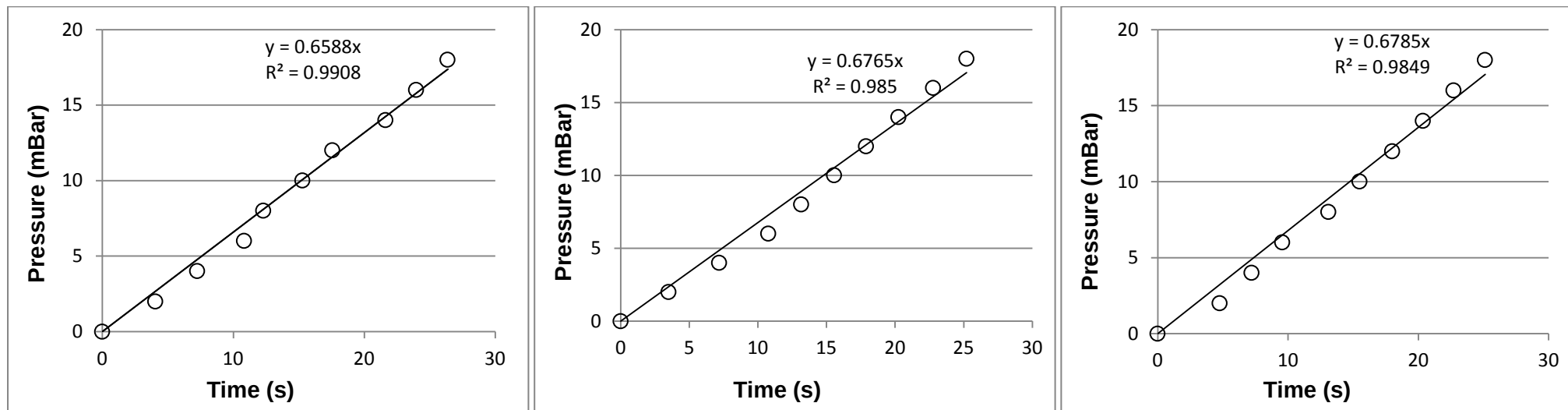


Figure D.36 Permeate pressure-time graphs for SO_2 in Teflon AF 2400 at 3 Bar feed pressure, 1st, 2nd & 3rd trials

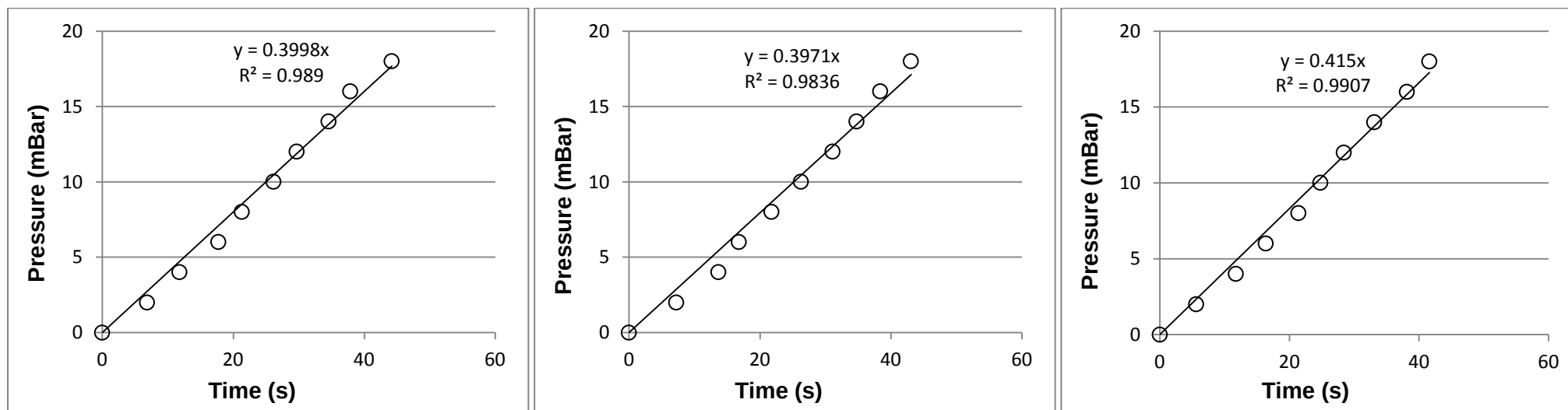


Figure D.37 Permeate pressure-time graphs for SO_2 in Teflon AF 2400 at 2 Bar feed pressure, 1st, 2nd & 3rd trials

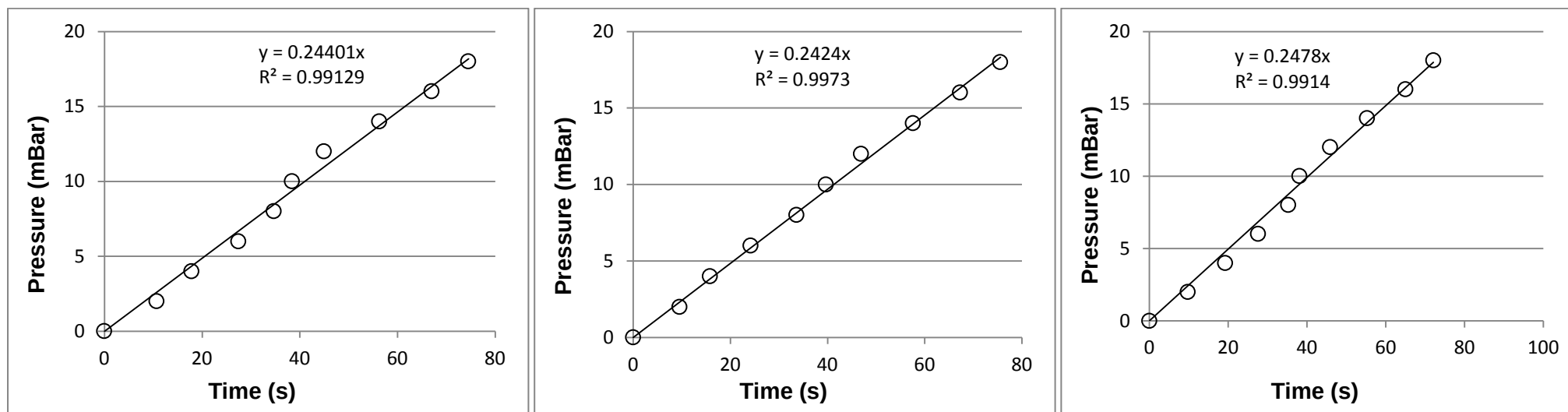


Figure D.38 Permeate pressure-time graphs for SO₂ in Teflon AF 2400 at 1 Bar feed pressure, 1st, 2nd & 3rd trials

Table D.33 O₂ permeability in Teflon AF 2400 – Raw Data

Feed Absolute Pressure	Temperature		Permeate Δt per $\Delta p=2\text{mBar}$									
	°C		s									
		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅	t ₆	t ₇	t ₈	t ₉
3000	25 ± 1	1	0.00	4.47	9.3	13.04	15.46	17.95	23.12	27.37	30.78	33.27
		2	0.00	3.63	8.91	12.59	14.95	18.52	23.3	26.96	29.32	32.87
		3	0.00	4.45	8.04	11.70	15.24	18.70	22.39	25.94	29.57	33.17
2000	25 ± 1	1	0.00	6.58	12.82	17.01	22.79	26.34	32.98	38.98	42.62	45.87
		2	0.00	5.69	11.64	16.44	21.37	26.53	30.82	36.88	41.69	46.57
		3	0.00	5.44	9.21	15.27	20.12	24.90	29.66	35.61	41.67	46.50
1000	25 ± 1	1	0.00	11.86	26.30	32.26	40.76	49.18	56.30	62.38	74.47	85.20
		2	0.00	9.48	19.54	31.06	40.64	49.10	55.34	64.76	76.98	90.20
		3	0.00	12.43	23.40	33.75	44.77	53.17	60.12	68.63	77.05	86.49

Table D.34 O₂ permeability in Teflon AF 2400 – Calculated Data

Feed Absolute Pressure	Temperature		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$(\Delta p/\Delta t)_{\text{Total}}$	Permeability	Permeability	Volumetric Flux
	°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	cm ³ .mm.day ⁻¹ . m ⁻² .atm ⁻¹	Barrer	cm ³ .s ⁻¹ .cm ⁻²
		Run						
3000	25 ± 1	1	0.000123	0.5220	0.5219	61849.4111	941.9075	7.16E-03
		2	0.000123	0.5361	0.5360	63520.4514	967.3558	7.35E-03
		3	0.000123	0.5370	0.5369	63627.1136	968.9802	7.36E-03
2000	25 ± 1	1	0.000123	0.37161	0.3715	66039.2494	1005.7147	5.10E-03
		2	0.000123	0.38184	0.3817	67857.8390	1033.4101	5.24E-03
		3	0.000123	0.39190	0.3918	69646.2076	1060.6452	5.37E-03
1000	25 ± 1	1	0.000123	0.20971	0.2096	74516.4930	1134.8150	2.87E-03
		2	0.000123	0.20605	0.2059	73215.2148	1114.9978	2.82E-03
		3	0.000123	0.19999	0.1999	71060.6394	1082.1857	2.74E-03

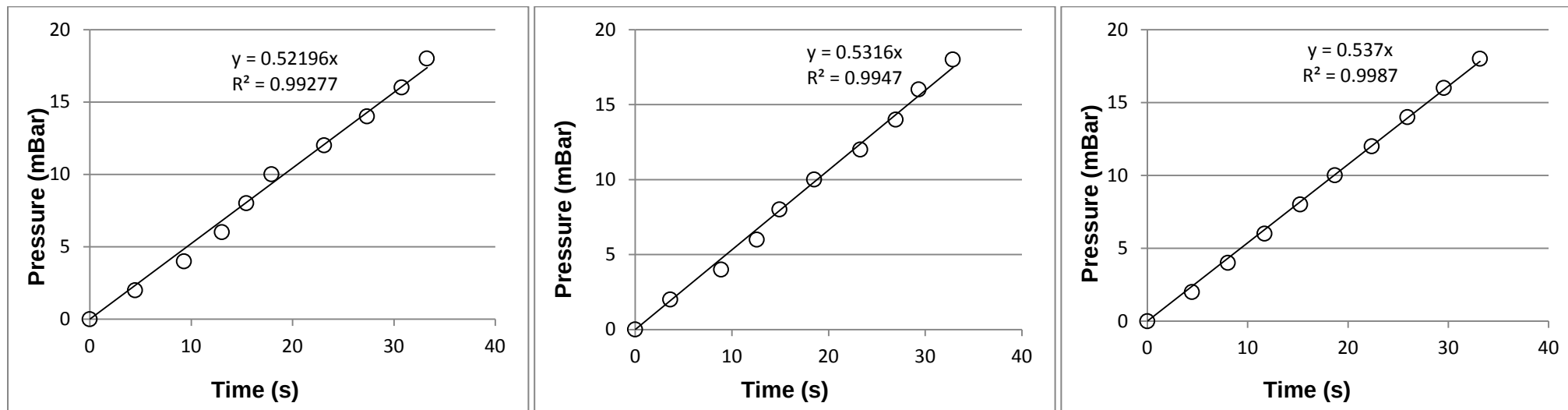


Figure D.39 Permeate pressure-time graphs for O_2 in Teflon AF 2400 at 3 Bar feed pressure, 1st, 2nd & 3rd trials

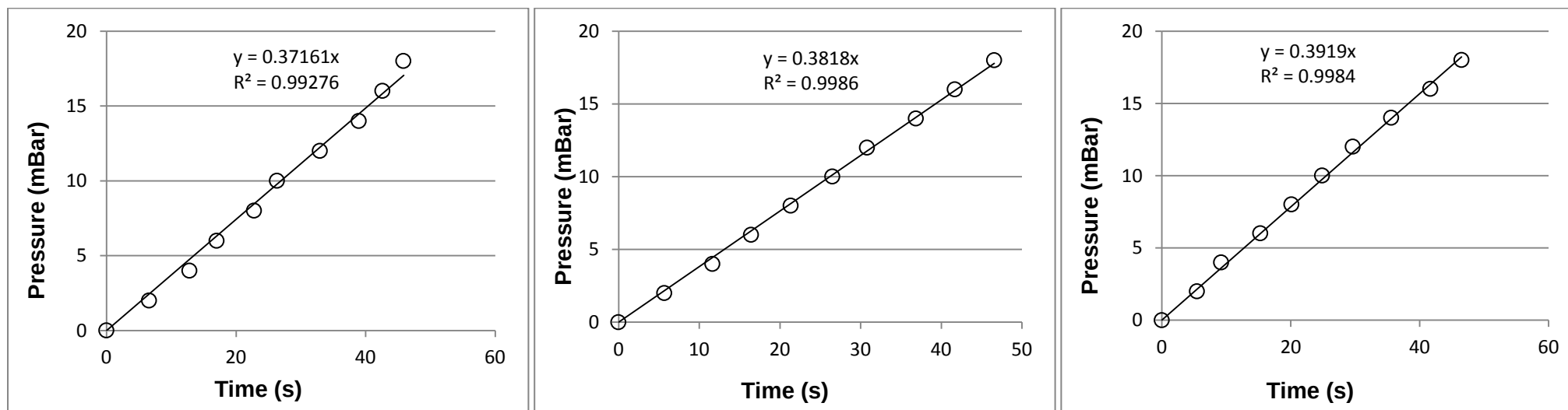


Figure D.40 Permeate pressure-time graphs for O_2 in Teflon AF 2400 at 2 Bar feed pressure, 1st, 2nd & 3rd trials

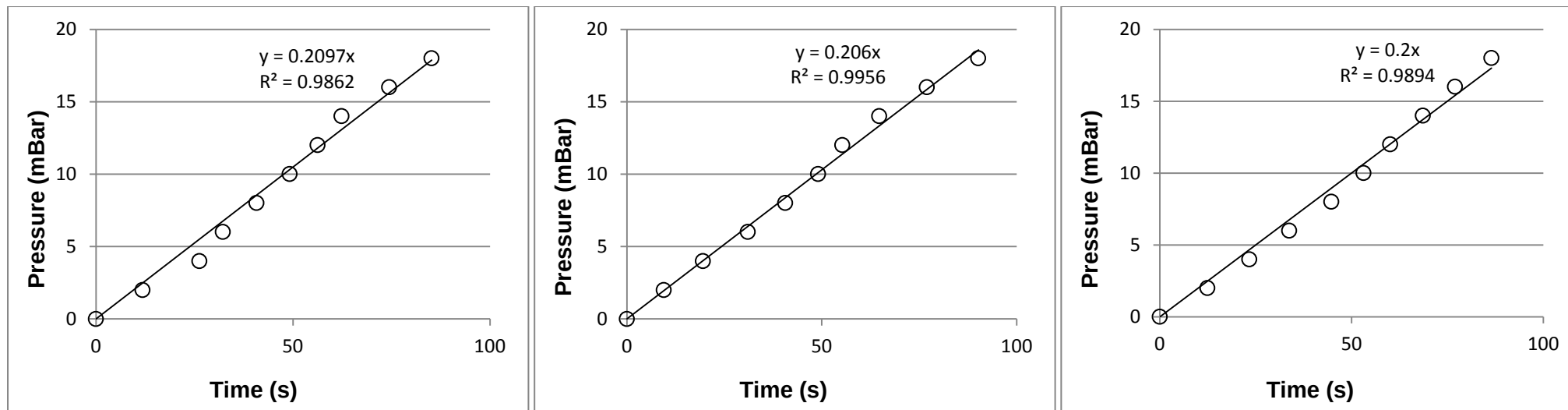


Figure D.41 Permeate pressure-time graphs for O_2 in Teflon AF 2400 at 1 Bar feed pressure, 1st, 2nd & 3rd trials

Table D.35 N₂ permeability in Teflon AF 2400 – Raw Data

Feed Absolute Pressure	Temperature		Permeate Δt per $\Delta p=2\text{mBar}$									
	°C		s									
		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅	t ₆	t ₇	t ₈	t ₉
3000	25 ± 1	1	0.00	8.27	16.57	26.23	32.22	41.83	48.99	53.95	60.20	69.31
		2	0.00	10.23	18.75	28.21	35.48	41.47	46.43	52.32	59.45	75.30
		3	0.00	10.80	19.16	26.34	34.71	40.75	46.76	55.16	62.39	67.29
2000	25 ± 1	1	0.00	10.76	28.05	35.99	50.33	56.36	69.61	77.95	87.60	101.92
		2	0.00	9.85	20.64	32.51	44.46	51.67	69.67	78.91	88.70	102.43
		3	0.00	10.75	25.19	35.94	46.74	60.07	72.28	85.32	91.36	100.78
1000	25 ± 1	1	0.00	15.06	25.18	51.5	68.48	90.11	112.9	140.6	159.2	181.4
		2	0.00	11.58	26.02	54.22	72.24	100.9	121.6	141.7	157.4	181.5
		3	0.00	23.12	37.35	55.4	80.51	111.5	122.8	138.2	156.2	182.6

Table D.36 N₂ permeability in Teflon AF 2400 – Calculated Data

Feed Absolute Pressure	Temperature		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$(\Delta p/\Delta t)_{\text{Total}}$	Permeability	Permeability	Volumetric Flux
	°C					$\text{cm}^3.\text{mm}.\text{day}^{-1}.\text{m}^{-2}.\text{atm}^{-1}$	Barrer	$\text{cm}^3.\text{s}^{-1}.\text{cm}^{-2}$
		Run						
3000	25 ± 1	1	0.008300	0.2546	0.2463	29191.0596	444.5520	3.38E-03
		2	0.008300	0.2488	0.2405	28498.9407	434.0116	3.30E-03
		3	0.008300	0.2535	0.2452	29054.7690	442.4764	3.36E-03
2000	25 ± 1	1	0.008300	0.17562	0.1673	29744.5176	452.9806	2.30E-03
		2	0.008300	0.17870	0.1704	30292.0500	461.3190	2.34E-03
		3	0.008300	0.17120	0.1629	28958.7731	441.0145	2.23E-03
1000	25 ± 1	1	0.008300	0.10296	0.0947	33 655.4630	512.5406	1.30E-03
		2	0.008300	0.10085	0.0926	32 905.2726	501.1159	1.27E-03
		3	0.008300	0.09912	0.0908	32 290.1875	491.7487	1.25E-03

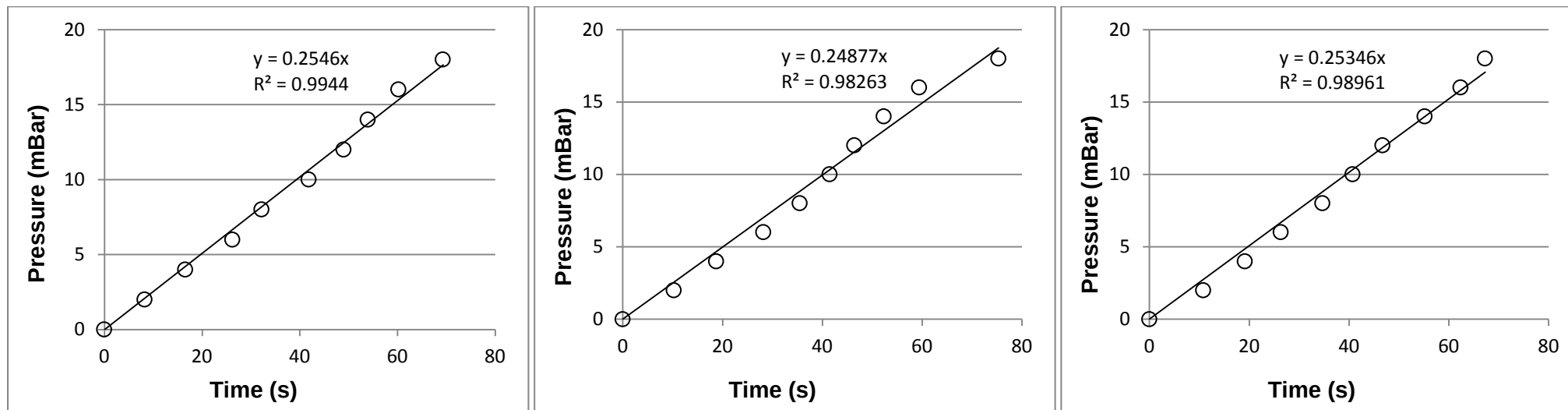


Figure D.42 Permeate pressure-time graphs for N_2 in Teflon AF 2400 at 3 Bar feed pressure, 1st, 2nd & 3rd trials

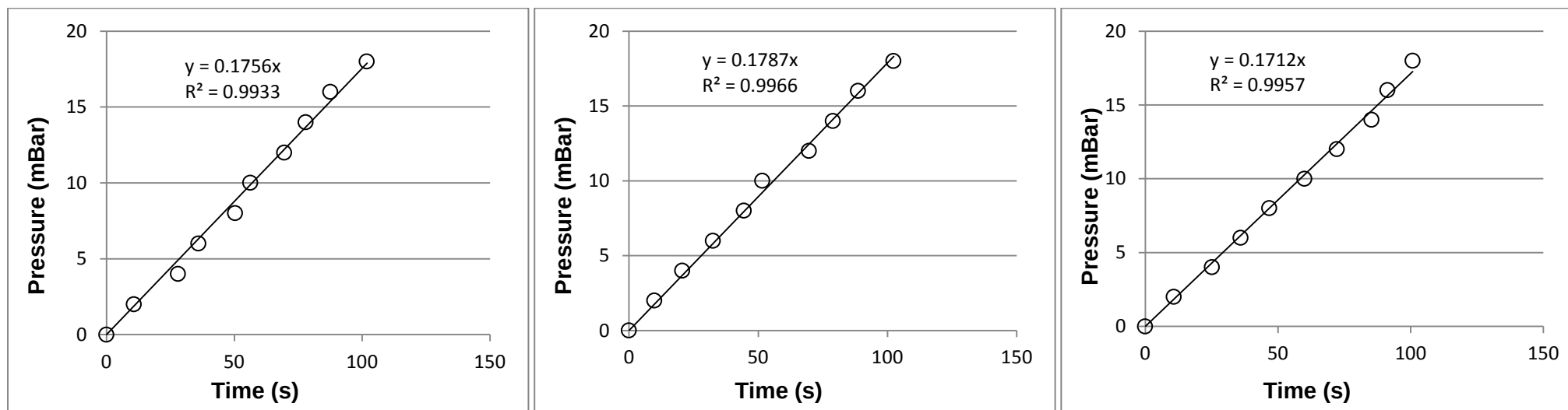


Figure D.43 Permeate pressure-time graphs for N_2 in Teflon AF 2400 at 2 Bar feed pressure, 1st, 2nd & 3rd trials

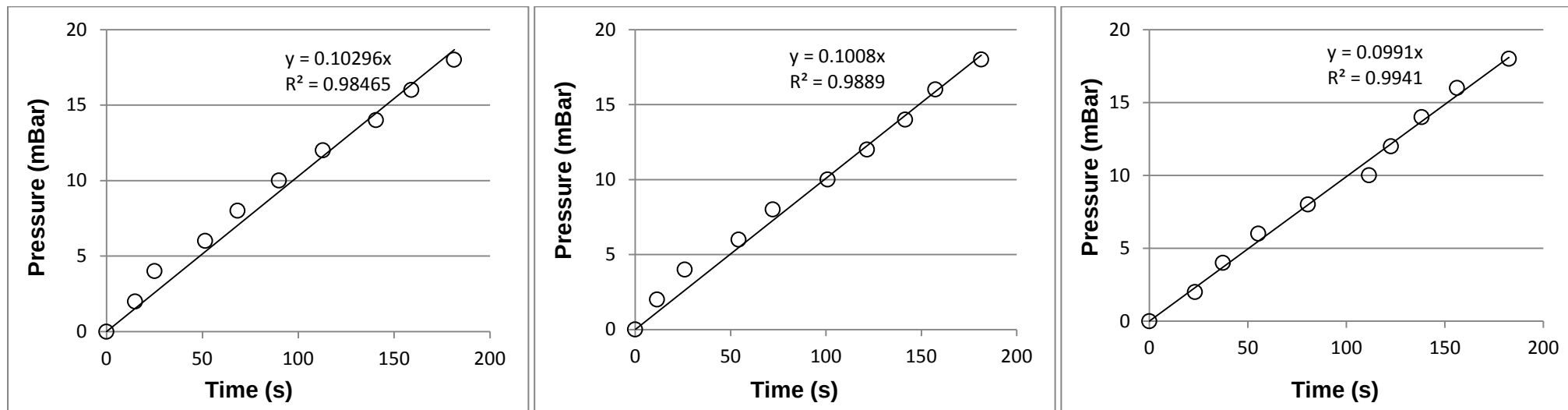


Figure D.44 Permeate pressure-time graphs for N₂ in Teflon AF 2400 at 1 Bar feed pressure, 1st, 2nd & 3rd trials

Table D.37 CO₂ permeability in Teflon AF 2400 – Raw Data

Feed Gauge Pressure	Feed Absolute Pressure	Temperature		Permeate Δt per $\Delta p=2\text{mBar}$									
mBar		°C		s									
P $\pm$ 20mBar			Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅	t ₆	t ₇	t ₈	t ₉
2238	3000	25 $\pm$ 1	1	0.00	2.21	3.63	5.02	7.22	9.66	11.04	13.19	14.47	15.64
			2	0.00	2.34	3.59	5.98	8.46	9.50	10.73	12.38	14.30	15.83
			3	0.00	2.32	4.63	7.03	8.38	9.53	11.99	13.12	14.25	15.51
1238	2000	25 $\pm$ 1	1	0.00	3.66	6.01	8.44	10.92	13.24	15.59	18.04	19.46	21.63
			2	0.00	3.50	5.92	8.30	10.66	13.13	15.52	17.91	19.17	21.62
			3	0.00	3.51	6.02	9.52	10.78	13.23	15.55	17.86	20.39	22.70
238	1000	25 $\pm$ 1	1	0.00	6.60	10.85	15.67	19.33	24.06	28.80	33.57	37.23	40.77
			2	0.00	5.94	10.78	15.57	19.13	26.29	29.91	34.79	38.38	40.87
			3	0.00	5.76	10.55	16.47	21.39	24.93	28.58	32.05	38.10	40.56

Table D.38 CO₂ permeability in Teflon AF 2400 – Calculated Data

Feed Absolute Pressure	Temperature		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$(\Delta p/\Delta t)_{\text{Total}}$	Permeability	Permeability	Volumetric Flux
	°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	cm ³ .mm.day ⁻¹ . m ⁻² .atm ⁻¹	Barrer	cm ³ .s ⁻¹ .cm ⁻²
		Run						
3000	25 $\pm$ 1	1	0.008333	1.0838	1.0755	127457.3201	1941.0532	1.48E-02
		2	0.008333	1.1001	1.0918	129389.0901	1970.4723	1.50E-02
		3	0.008333	1.0658	1.0575	125327.6325	1908.6201	1.45E-02
2000	25 $\pm$ 1	1	0.008333	0.78789	0.7796	138581.9865	2110.4713	1.07E-02
		2	0.008333	0.79494	0.7866	139835.2668	2129.5575	1.08E-02
		3	0.008333	0.76901	0.7607	135225.6843	2059.3580	1.04E-02
1000	25 $\pm$ 1	1	0.008333	0.42284	0.4145	147 373.9163	2244.3640	5.69E-03
		2	0.008333	0.41199	0.4037	143 516.3019	2185.6162	5.54E-03
		3	0.008333	0.42021	0.4119	146 438.8448	2230.1237	5.65E-03

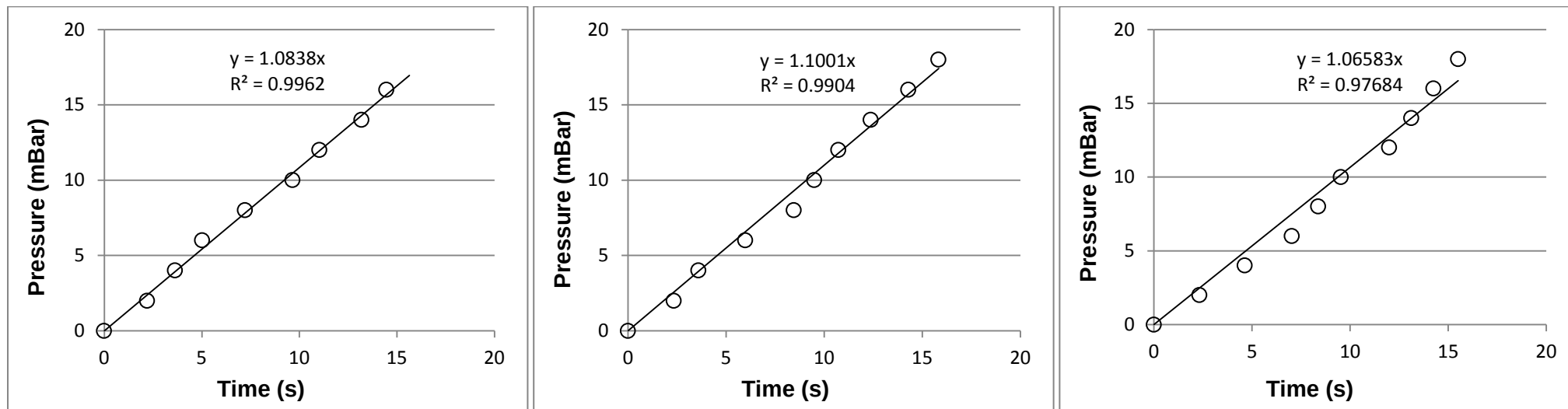


Figure D.45 Permeate pressure-time graphs for CO₂ in Teflon AF 2400 at 3 Bar feed pressure, 1st, 2nd & 3rd trials

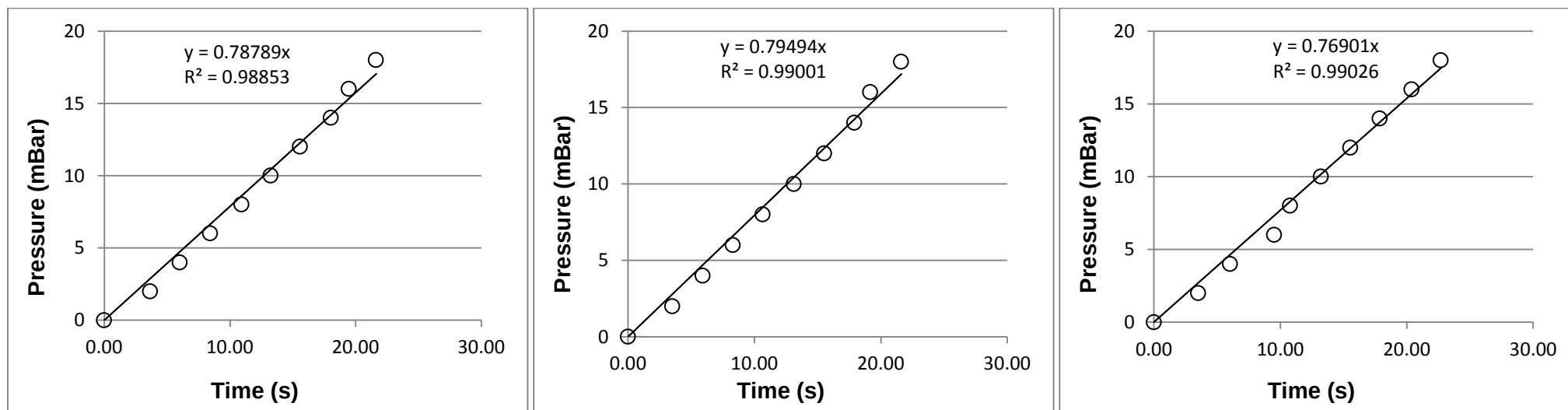


Figure D.46 Permeate pressure-time graphs for CO₂ in Teflon AF 2400 at 2 Bar feed pressure, 1st, 2nd & 3rd trials

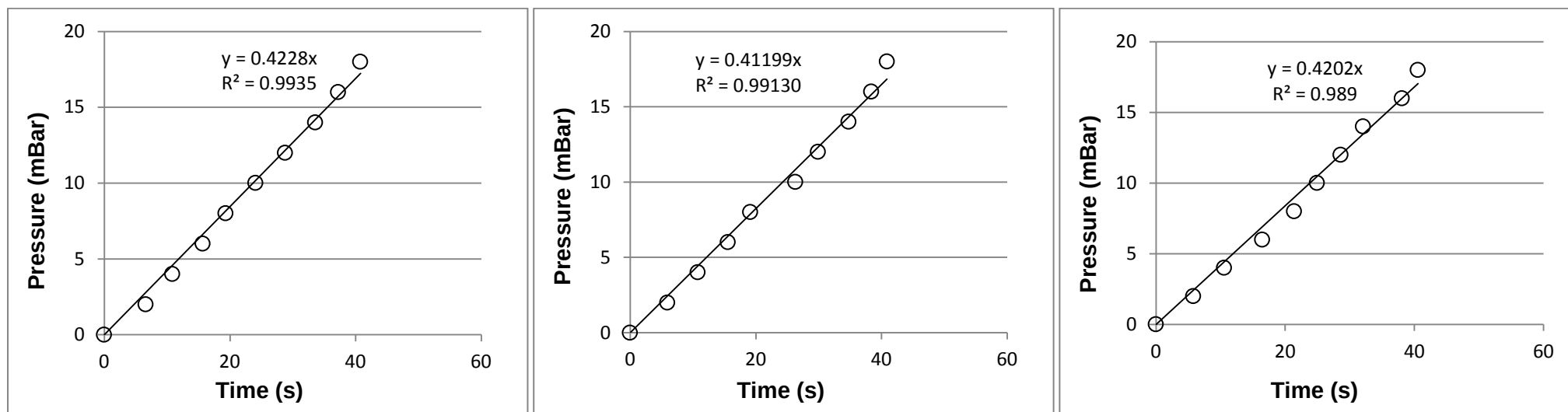


Figure D.47 Permeate pressure-time graphs for CO₂ in Teflon AF 2400 at 1 Bar feed pressure, 1st, 2nd & 3rd trials

Table D.39 SO₂ permeability in Nafion 117 – Raw Data

Feed Absolute Pressure	Temperature		Permeate Δt per $\Delta p=2\text{mBar}$								
	°C		s								
		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅	t ₆	t ₇	t ₈
3000	25 ± 1	1	0.00	7.10	11.99	16.71	21.43	27.59	34.66	38.24	46.75
		2	0.00	5.90	11.77	16.57	22.59	27.45	33.46	38.13	44.18
		3	0.00	7.18	13.25	18.06	23.98	30.28	35.43	39.86	45.62
2000	25 ± 1	1	0.00	12.01	19.21	33.58	43.15	51.89	55.33	63.60	72.32
		2	0.00	12.87	21.31	34.52	44.13	51.31	58.49	68.10	76.45
		3	0.00	14.46	23.98	32.47	42.13	52.77	56.98	67.08	77.56
1000	25 ± 1	1	0.00	12.84	41.83	73.98	89.82	100.52	126.94	146.19	176.06
		2	0.00	22.55	42.96	61.02	87.30	107.66	121.08	147.26	166.5
		3	0.00	20.17	40.57	65.87	82.52	101.91	130.77	151.25	168.78

Table D.40 SO₂ permeability in Nafion 117 – Calculated Data

Feed Absolute Pressure	Temperature		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$(\Delta p/\Delta t)_{\text{Total}}$	Permeability	Permeability	Volumetric Flux
	°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	cm ³ .mm.day ⁻¹ . m ⁻² .atm ⁻¹	Barrer	cm ³ .s ⁻¹ .cm ⁻²
		Run						
3000	25 ± 1	1	0.000123	0.3529	0.3528	14326.4005	218.1774	2.80E-04
		2	0.000123	0.3617	0.3616	14683.7717	223.6198	2.87E-04
		3	0.000123	0.3419	0.3418	13879.6866	211.3744	2.71E-04
2000	25 ± 1	1	0.000123	0.20930	0.20918	12742.1295	194.0505	1.66E-04
		2	0.000123	0.20018	0.20006	12186.5798	185.5900	1.59E-04
		3	0.000123	0.20080	0.20068	12224.3474	186.1651	1.59E-04
1000	25 ± 1	1	0.000123	0.09407	0.0939	11445.6641	174.3065	7.45E-05
		2	0.000123	0.09528	0.0952	11593.0797	176.5515	7.55E-05
		3	0.000123	0.09413	0.0940	11452.9740	174.4179	7.46E-05

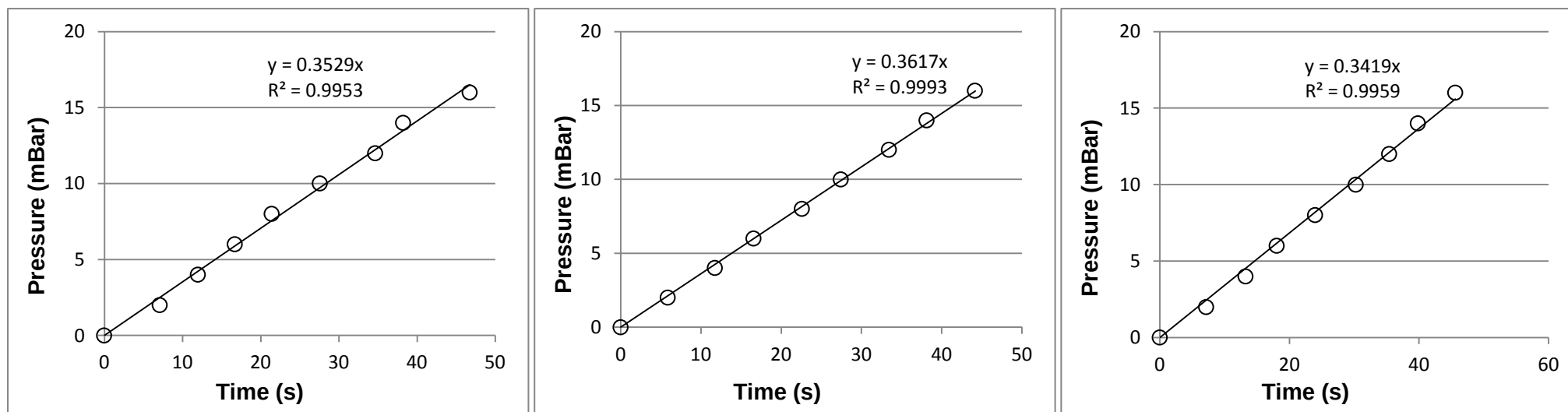


Figure D.48 Permeate pressure-time graphs for SO_2 in Nafion 117 at 3 Bar feed pressure, 1st, 2nd & 3rd trials

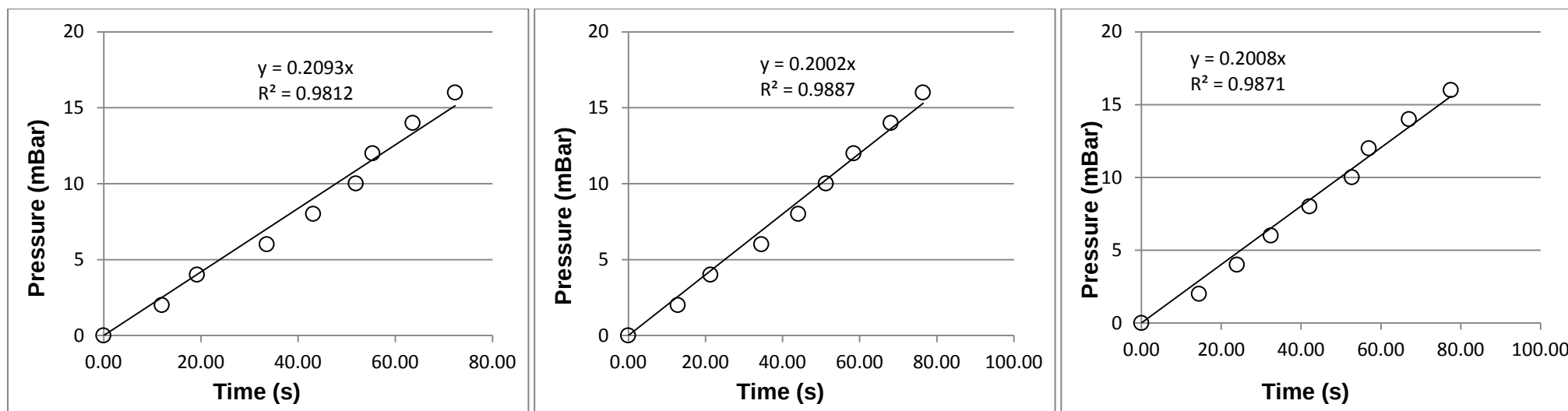


Figure D.49 Permeate pressure-time graphs for SO_2 in Nafion 117 at 2 Bar feed pressure, 1st, 2nd & 3rd trials

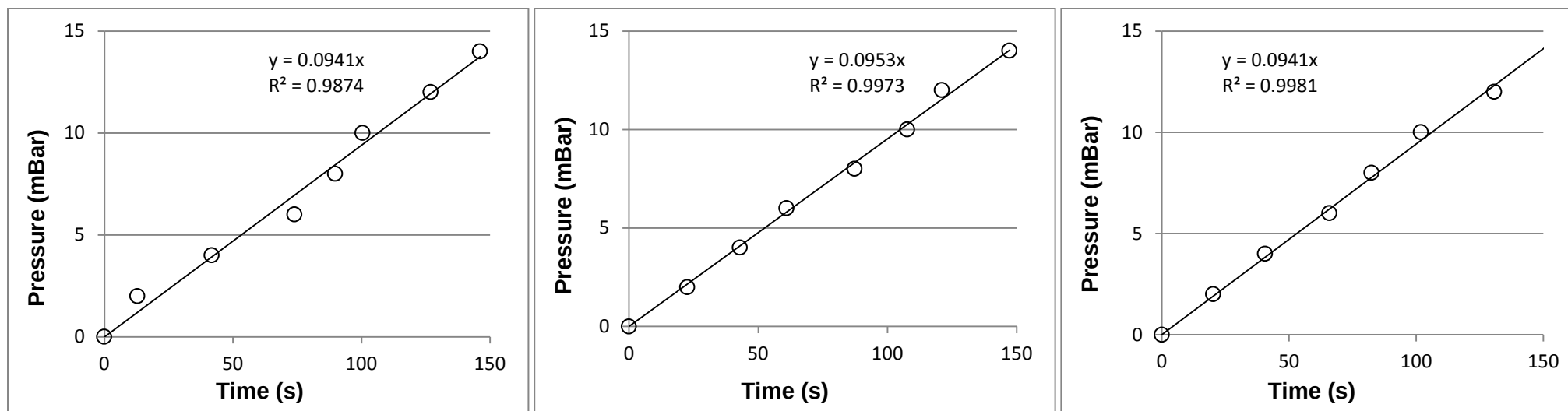


Figure D.50 Permeate pressure-time graphs for SO₂ in Nafion 117 at 1 Bar feed pressure, 1st, 2nd & 3rd trials

Table D.41 O₂ permeability in Nafion 117 – Raw Data

Feed Absolute Pressure	Temperature		Permeate Δt per $\Delta p=2\text{mBar}$								
	°C		s								
		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅	t ₆	t ₇	t ₈
3000	25 ± 1	1	0.00	195.9	498.65	750.18	990.44	1199.3	1391.63	1598.01	1835.9
		2	0.00	188.65	426.38	588.78	802.01	1015.98	1311.23	1681.60	1837.65
		3	0.00	158.87	390.90	611.34	765.94	1073.88	1282.56	1669.74	1828.81
2000	25 ± 1	1	0.00	220.95	541.54	890.92	1179.82	1577.05	1942.61	2450.11	
		2	0.00	287.27	650.47	940.57	1286.48	1780.41	1975.42	2390.41	
		3	0.00	420.67	722.94	1027.88	1313.16	1618.04	1922.76	2446.66	
1000	25 ± 1	1	0.00	353.26	1127.49	1689.32	2391.95	3016.71	3650.27		
		2	0.00	589.91	1125.83	2101.56	2531.77	3245.87	3540.23		
		3	0.00	465.20	1105.07	1687.22	2270.74	3135.27	3659.17		

Table D.42 O₂ permeability in Nafion 117 – Calculated Data

Feed Absolute Pressure	Temperature		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$(\Delta p/\Delta t)_{\text{Total}}$	Permeability	Permeability	Volumetric Flux
	°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	cm ³ .mm.day ⁻¹ . m ⁻² .atm ⁻¹	Barrer	cm ³ .s ⁻¹ .cm ⁻²
		Run						
3000	25 ± 1	1	0.000123	0.00860	0.00848	344.2343	5.2424	6.72E-06
		2	0.000123	0.00906	0.00894	362.9151	5.5269	7.09E-06
		3	0.000123	0.00898	0.00886	359.6663	5.4774	7.02E-06
2000	25 ± 1	1	0.000123	0.00614	0.00602	366.4993	5.5814	4.77E-06
		2	0.000123	0.00594	0.00582	354.3162	5.3959	4.61E-06
		3	0.000123	0.00595	0.00583	354.9253	5.4052	4.62E-06
1000	25 ± 1	1	0.000123	0.00335	0.00323	393.0899	5.9864	2.56E-06
		2	0.000123	0.00320	0.00308	374.8152	5.7081	2.44E-06
		3	0.000123	0.00333	0.00321	390.6532	5.9493	2.54E-06

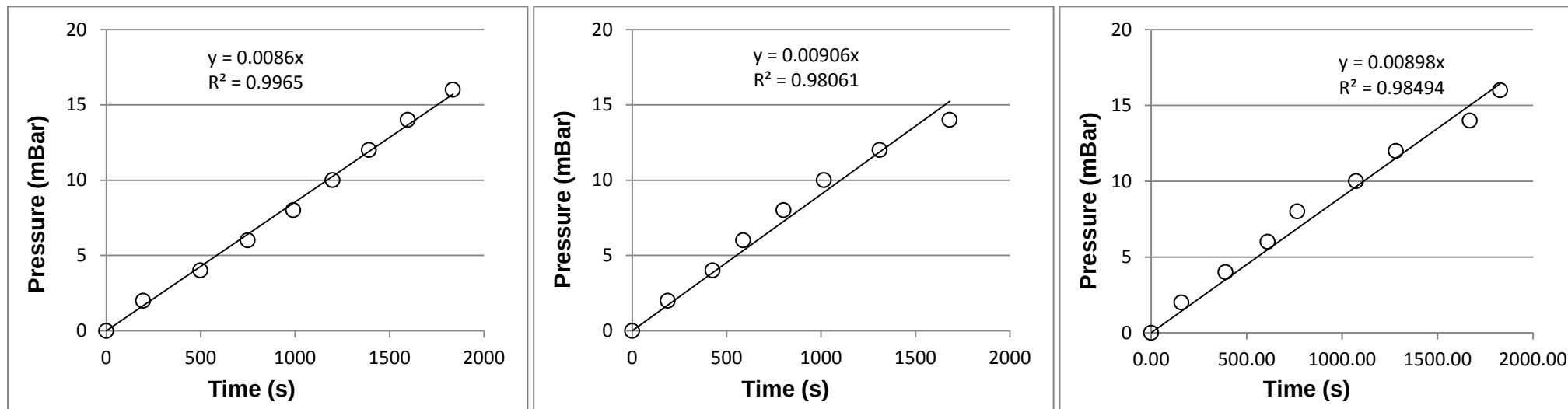


Figure D.51 Permeate pressure-time graphs for O_2 in Nafion 117 at 3 Bar feed pressure, 1st, 2nd & 3rd trials

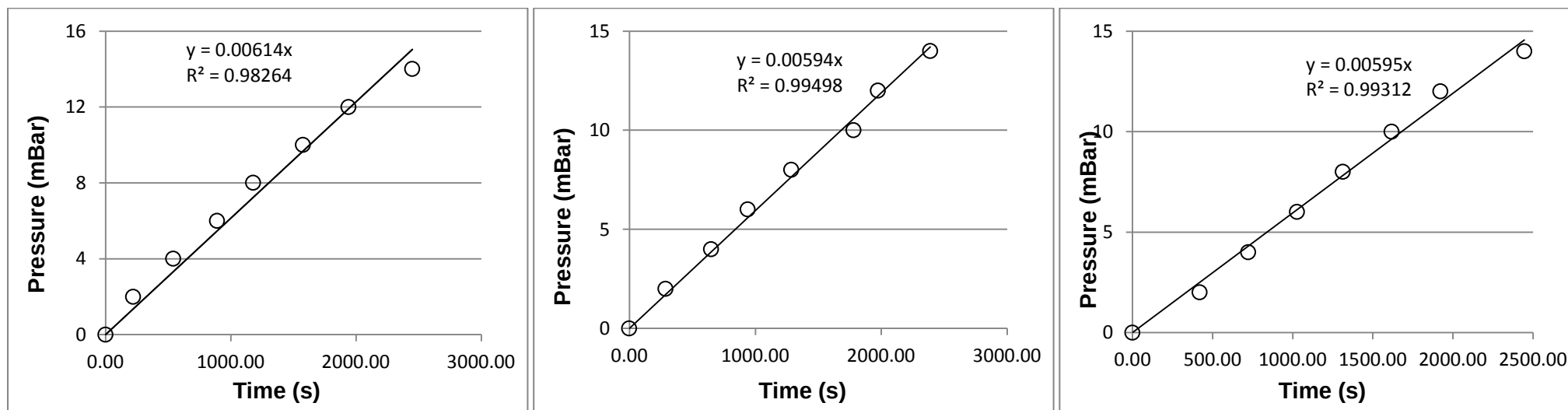


Figure D.52 Permeate pressure-time graphs for O_2 in Nafion 117 at 2 Bar feed pressure, 1st, 2nd & 3rd trials

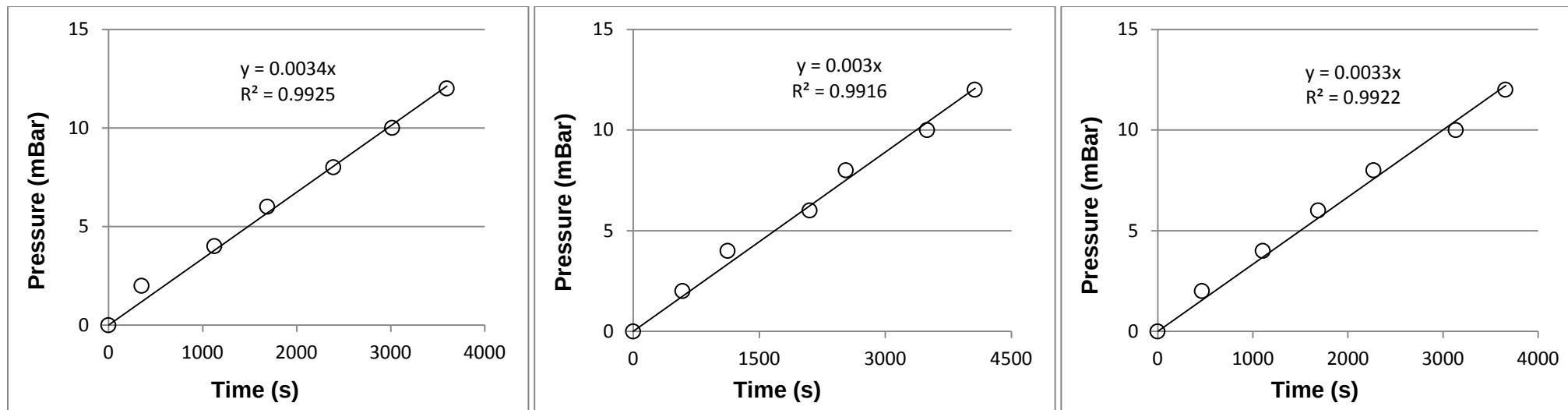


Figure D.53 Permeate pressure-time graphs for O₂ in Nafion 117 at 1 Bar feed pressure, 1st, 2nd & 3rd trials

Table D.43 CO₂ permeability in Nafion 117 – Raw Data

Feed Absolute Pressure	Temperature		Permeate Δt per $\Delta p=2\text{mBar}$								
	°C		s								
		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅	t ₆	t ₇	t ₈
3000	25 ± 1	1	0.00	111.67	190.86	316.89	401.37	469.42	543.87	642.63	691.39
		2	0.00	43.44	148.31	234.91	310.28	454.87	561.82	628.77	741.89
		3	0.00	67.28	199.45	261.98	308.32	430.01	537.67	590.61	735.56
2000	25 ± 1	1	0.00	81.68	227.01	327.85	421.69	586.17	703.24	835.04	
		2	0.00	108.47	219.74	365.02	487.58	583.53	746.47	848.88	
		3	0.00	81.94	192.11	350.68	488.86	643.40	724.03	816.43	
1000	25 ± 1	1	0.00	233.38	318.09	481.19	659.08	850.04	1121.28		
		2	0.00	204.32	367.29	547.65	698.38	835.64	1064.77		
		3	0.00	123.51	320.41	507.88	715.40	818.69	1005.89		

Table D.44 CO₂ permeability in Nafion 117 – Calculated Data

Feed Absolute Pressure	Temperature		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$(\Delta p/\Delta t)_{\text{Total}}$	Permeability	Permeability	Volumetric Flux
	°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	cm ³ .mm.day ⁻¹ . m ⁻² .atm ⁻¹	Barrer	cm ³ .s ⁻¹ .cm ⁻²
		Run						
3000	25 ± 1	1	0.000123	0.02180	0.02168	880.3107	13.4063	1.72E-05
		2	0.000123	0.02220	0.02208	896.5549	13.6537	1.75E-05
		3	0.000123	0.02275	0.02263	918.8906	13.9938	1.79E-05
2000	25 ± 1	1	0.000123	0.01725	0.01713	1043.3004	15.8885	1.36E-05
		2	0.000123	0.01652	0.01640	998.8321	15.2113	1.31E-05
		3	0.000123	0.01666	0.01654	1007.3603	15.3411	1.31E-05
1000	25 ± 1	1	0.000123	0.01137	0.01125	1 370.2341	20.8674	8.92E-06
		2	0.000123	0.01140	0.01128	1 373.8890	20.9230	8.940E-06
		3	0.000123	0.01189	0.01177	1 433.5863	21.8321	9.33E-06

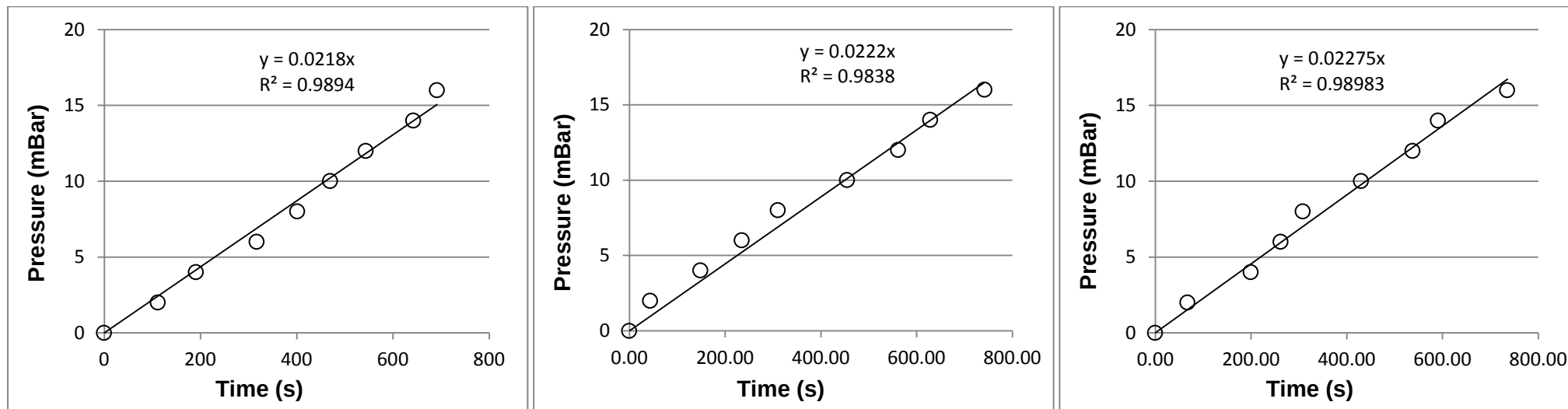


Figure D.54 Permeate pressure-time graphs for O_2 in Nafion 117 at 3 Bar feed pressure, 1st, 2nd & 3rd trials

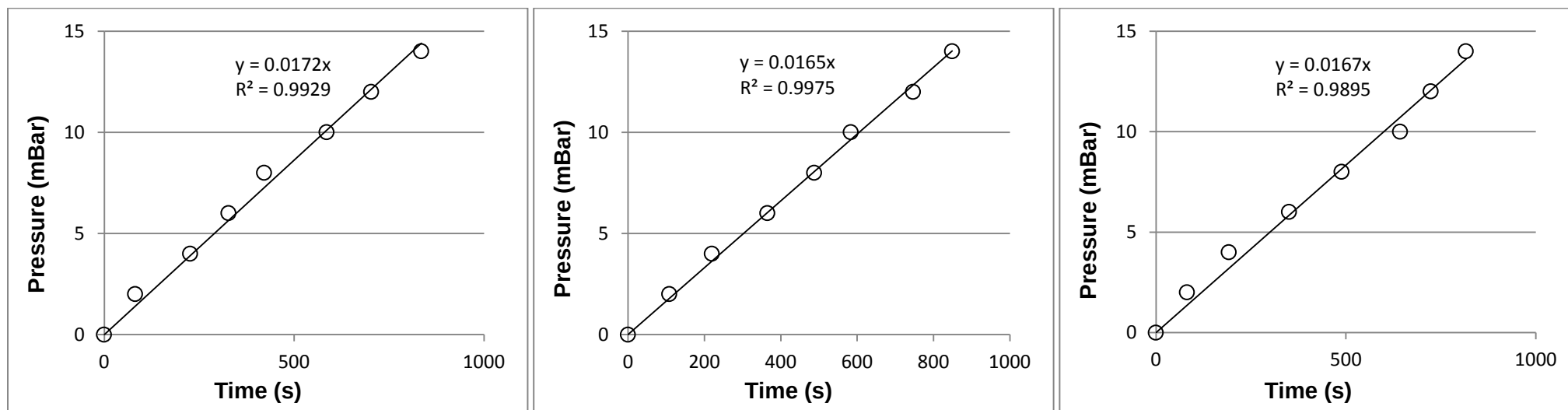


Figure D.55 Permeate pressure-time graphs for CO_2 in Nafion 117 at 2 Bar feed pressure, 1st, 2nd & 3rd trials

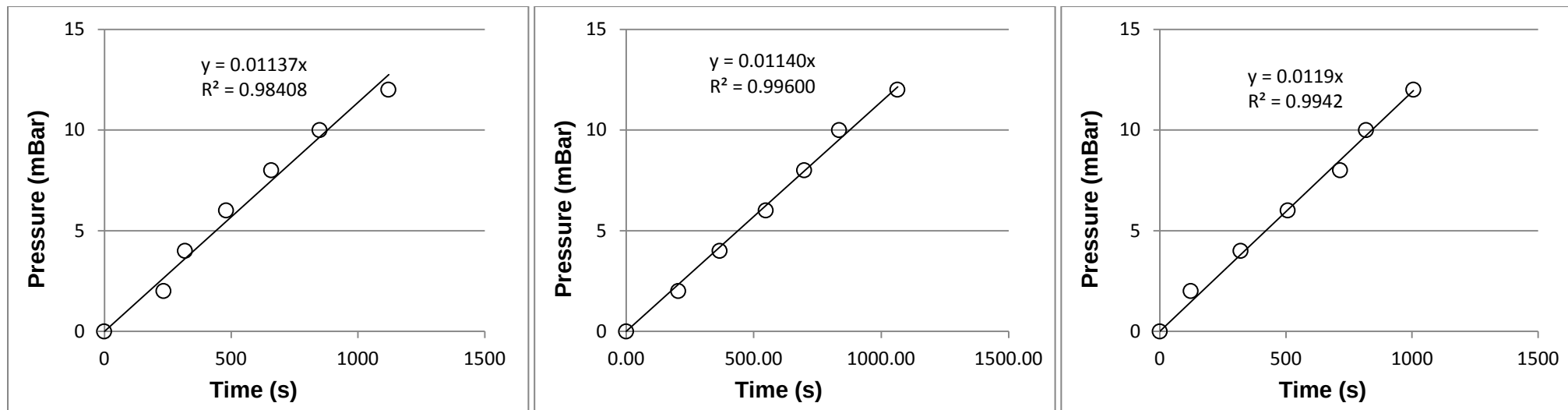


Figure D.56 Permeate pressure-time graphs for CO₂ in Nafion 117 at 1 Bar feed pressure, 1st, 2nd & 3rd trials

Table D.45 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 15°C & 2.4 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	15°C	2.4 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
24.72	75.28				5.3803	0.9596	5.3713	0.9588	5.3761	0.9595	5.6068	5.6021	5.6030

Table D.46 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 15°C & 2.4 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	15°C	2.4 ± 0.1	1.0	0.857	6.5424	6.5369	6.5379	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
24.72	75.28								86.74	13.26	86.73	13.27	86.73	13.27	86.74	13.26

Table D.47 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 15°C & 2.4 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report										Area Percent Report										Area Percent Report									
Sorted By : Signal										Sorted By : Signal										Sorted By : Signal									
Multiplier : 1.0000										Multiplier : 1.0000										Multiplier : 1.0000									
Dilution : 1.0000										Dilution : 1.0000										Dilution : 1.0000									
Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs									
Signal 1: TCD1 B,										Signal 1: TCD1 B,										Signal 1: TCD1 B,									
Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %			
1	0.909	BB S	0.0236	9595.51660	5711.27393	15.13516				1	0.908	BB S	0.0253	9588.44238	5456.66016	15.14736				1	0.908	BB S	0.0243	9595.19238	5525.61328	15.14487			
2	8.157	BB	0.6553	5.38033e4	1054.48206	84.86484				2	8.154	BB	0.6404	5.37126e4	1055.02539	84.85264				2	8.154	BB	0.6597	5.37609e4	1055.73584	84.85513			
Totals :										Totals :										Totals :									
							6.33989e4										6.33011e4										6.33560e4		
Summed Peaks Report										Summed Peaks Report										Summed Peaks Report									

Table D.48 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 25°C & 2.4 bar p_{SO₂} – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios			
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial	
SO ₂	O ₂	25°C	2.4 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	
wt%	wt%													
24.72	75.28				5.2629	1.0539	5.1690	1.0960	5.0881	1.1412	4.9937	4.7162	4.4586	

Table D.49 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 25°C & 2.4 bar p_{SO₂} – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	2.4 ± 0.1	0.9	0.857	5.8270	5.5032	5.2025	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
24.72	75.28								85.35	14.65	84.62	15.38	83.88	16.12	84.62	15.38

Table D.50 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 25°C & 2.4 bar p_{SO₂} – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : Signal							Sorted By : Signal							Sorted By : Signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.907	BB S	0.0260	1.05392e4	5790.17041	16.68434	1	0.906	BB S	0.0219	1.09633e4	6561.76416	17.49834	1	0.906	BB S	0.0227	1.14123e4	6833.35156	18.32033
2	8.184	BB	0.6567	5.26292e4	1037.32458	83.31566	2	8.199	BB	0.6523	5.16903e4	1025.05835	82.50166	2	8.212	BB	0.6412	5.08809e4	1011.58734	81.67967
Totals :				6.31684e4	6827.49500		Totals :				6.26536e4	7586.82251		Totals :				6.22932e4	7844.93890	
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.51 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 35°C & 2.4 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios			
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial	
SO ₂	O ₂	35°C	2.4 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	
wt%	wt%													
24.72	75.28				4.6243	1.3219	4.5797	1.3267	4.5408	1.3341	3.4982	3.4519	3.4036	

Table D.52 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 35°C & 2.4 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	35°C	2.4 ± 0.1	0.9	0.857	4.0819	4.0279	3.9716	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
24.72	75.28								80.32	19.68	80.11	19.89	79.89	20.11	80.11	19.89

Table D.53 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 35°C & 2.4 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : Signal							Sorted By : Signal							Sorted By : Signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %
1	0.901	BB S	0.0266	1.32186e4	6827.98828	22.23057	1	0.902	BB S	0.0257	1.32666e4	7147.45459	22.46149	1	0.901	BB S	0.0281	1.33413e4	6669.68848	22.70901
2	8.257	BB	0.6267	4.62427e4	944.07050	77.76943	2	8.258	BB	0.6285	4.57971e4	937.27844	77.53851	2	8.258	BB	0.6209	4.54075e4	932.51752	77.29099
Totals : 5.94613e4 7772.05878							Totals : 5.90636e4 8084.73303							Totals : 5.87487e4 7602.20599						
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.54 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 45°C & 2.4 bar p_{SO₂} – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios			
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial	
SO ₂	O ₂	45°C	2.4 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	
wt%	wt%													
24.72	75.28				4.2311	1.6393	4.1953	1.5967	4.1455	1.6019	2.5810	2.6275	2.5879	

Table D.55 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 45°C & 2.4 bar p_{SO₂} – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	45°C	2.4 ± 0.1	0.9	0.857	3.0117	3.0659	3.0197	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%								75.07	24.93	75.41	24.59	75.12	24.88	75.20	24.80
24.72	75.28															

Table D.56 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 45°C & 2.4 bar p_{SO₂} – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report										Area Percent Report										Area Percent Report									
Sorted By : Signal										Sorted By : Signal										Sorted By : Signal									
Multiplier : 1.0000										Multiplier : 1.0000										Multiplier : 1.0000									
Dilution : 1.0000										Dilution : 1.0000										Dilution : 1.0000									
Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs									
Signal 1: TCD1 B,										Signal 1: TCD1 B,										Signal 1: TCD1 B,									
Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %			
1	0.900	BB S	0.0278	1.63930e4	7762.95459	27.92495				1	0.900	BB S	0.0272	1.59669e4	8022.94873	27.56741				1	0.898	BB S	0.0255	1.60194e4	7809.02393	27.87244			
2	8.339	BB	0.6303	4.23109e4	882.86310	72.07505				2	8.345	BB	0.6116	4.19526e4	877.15710	72.43259				2	8.346	BB	0.6144	4.14547e4	869.88165	72.12756			
Totals :										Totals :										Totals :									
Summed Peaks Report										Summed Peaks Report										Summed Peaks Report									

Table D.57 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 55°C & 2.4 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	55°C	2.4 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
24.72	75.28				3.5920	1.9184	3.5512	1.9251	3.5359	1.9268	1.8724	1.8447	1.8351

Table D.58 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 55°C & 2.4 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	55°C	2.4 ± 0.1	0.9	0.857	2.1848	2.1525	2.1413	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
24.72	75.28								68.60	31.40	68.28	31.72	68.17	31.83	68.35	31.65

Table D.59 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 55°C & 2.4 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report										Area Percent Report										Area Percent Report									
Sorted By : Signal										Sorted By : Signal										Sorted By : Signal									
Multiplier : 1.0000										Multiplier : 1.0000										Multiplier : 1.0000									
Dilution : 1.0000										Dilution : 1.0000										Dilution : 1.0000									
Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs									
Signal 1: TCD1 B,										Signal 1: TCD1 B,										Signal 1: TCD1 B,									
Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %			
1	0.896	BB S	0.0297	1.91838e4	8705.67773	34.81388				1	0.895	BB S	0.0298	1.92512e4	8189.34619	35.15329				1	0.895	BB S	0.0281	1.92675e4	9039.49219	35.27168			
2	8.446	BB	0.5818	3.59200e4	781.58740	65.18612				2	8.444	BB	0.5814	3.55124e4	774.43628	64.84671				2	8.452	BB	0.5911	3.53585e4	772.07648	64.72832			
Totals :										Totals :										Totals :									
							5.51038e4	9487.26514									5.47636e4	8963.78247									5.46261e4	9811.56866	
Summed Peaks Report										Summed Peaks Report										Summed Peaks Report									

Table D.60 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 15°C & 1.8 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	15°C	1.8 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
49.96	50.04				5.0928	0.6231	4.6591	0.5705	4.4062	0.5394	8.1733	8.1667	8.1687

Table D.61 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 15°C & 1.8 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	15°C	1.8 ± 0.1	0.9	0.857	9.5371	9.5294	9.5317	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
49.96	50.04								90.51	9.49	90.50	9.50	90.50	9.50	90.51	9.49

Table D.62 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 15°C & 1.8 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report										Area Percent Report										Area Percent Report									
Sorted By : Signal										Sorted By : Signal										Sorted By : Signal									
Multiplier : 1.0000										Multiplier : 1.0000										Multiplier : 1.0000									
Dilution : 1.0000										Dilution : 1.0000										Dilution : 1.0000									
Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs									
Signal 1: TCD1 B,										Signal 1: TCD1 B,										Signal 1: TCD1 B,									
Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %			
1	0.920	BB S	0.0230	6230.51807	3983.95166	10.90039				1	0.922	BB S	0.0201	5704.64258	3949.15991	10.90845				1	0.922	BB S	0.0206	5394.20361	3779.90356	10.90696			
2	8.233	BB	0.6410	5.09281e4	1012.83356	89.09961				2	8.290	BB	0.6304	4.65910e4	947.55011	89.09155				2	8.322	BB	0.6235	4.40623e4	909.62805	89.09304			
Totals :				5.71587e4	4996.78522					Totals :				5.22956e4	4896.71002					Totals :				4.94565e4	4689.53162				
Summed Peaks Report										Summed Peaks Report										Summed Peaks Report									

Table D.63 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 25°C & 1.8 bar p_{SO₂} – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	25°C	1.8 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
49.96	50.04				2.5206	0.2704	3.7676	0.3897	3.0343	0.3286	9.3217	9.6679	9.2340

Table D.64 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 25°C & 1.8 bar p_{SO₂} – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	1.8 ± 0.1	0.9	0.857	10.8772	11.2812	10.7748	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
49.96	50.04								91.58	8.42	91.86	8.14	91.51	8.49	91.65	8.35

Table D.65 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 25°C & 1.8 bar p_{SO₂} – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report										Area Percent Report										Area Percent Report									
Sorted By : Signal										Sorted By : Signal										Sorted By : Signal									
Multiplier : 1.0000										Multiplier : 1.0000										Multiplier : 1.0000									
Dilution : 1.0000										Dilution : 1.0000										Dilution : 1.0000									
Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs									
Signal 1: TCD1 B,										Signal 1: TCD1 B,										Signal 1: TCD1 B,									
Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %			
1	0.932	BB	0.0213	2704.02905	1912.80969	9.68847				1	0.927	BB S	0.0215	3897.32007	2730.68921	9.37451				1	0.929	BB S	0.0218	3285.60962	2254.96436	9.77029			
2	8.653	BB	0.5578	2.52057e4	593.56689	90.31153				2	8.426	BB	0.5892	3.76763e4	809.77008	90.62549				2	8.548	BB	0.5840	3.03430e4	686.07556	90.22971			
Totals :										Totals :										Totals :									
Summed Peaks Report										Summed Peaks Report										Summed Peaks Report									

Table D.66 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 35°C & 1.8 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	35°C	1.8 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
49.96	50.04				5.0055	0.9864	3.1954	0.6484	3.3231	0.6743	5.0745	4.9281	4.9282

Table D.67 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 35°C & 1.8 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	35°C	1.8 ± 0.1	0.9	0.857	5.9213	5.7504	5.7506	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
49.96	50.04								85.55	14.45	85.19	14.81	85.19	14.81	85.31	14.69

Table D.68 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 35°C & 1.8 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : Signal							Sorted By : Signal							Sorted By : Signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.907	BB S	0.0233	9864.36426	5974.31885	16.46273	1	0.917	BB S	0.0224	6483.71826	4117.95557	16.86812	1	0.916	BB S	0.0226	6742.93945	4222.96289	16.86853
2	8.190	BB	0.6426	5.00550e4	998.30182	83.53727	2	8.469	BB	0.5816	3.19540e4	712.55188	83.13188	2	8.441	BB	0.5910	3.32305e4	735.68604	83.13147
Totals : 5.99194e4 6972.62067							Totals : 3.84377e4 4830.50745							Totals : 3.99735e4 4958.64893						
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.69 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 45°C & 1.8 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	45°C	1.8 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
49.96	50.04				3.2844	0.8260	3.2363	0.8166	3.6515	0.9084	3.9763	3.9631	4.0197

Table D.70 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 45°C & 1.8 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	45°C	1.8 ± 0.1	0.9	0.857	4.6398	4.6244	4.6904	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
49.96	50.04								82.27	17.73	82.22	17.78	82.43	17.57	82.31	17.69

Table D.71 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 45°C & 1.8 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report										Area Percent Report										Area Percent Report									
Sorted By : Signal										Sorted By : Signal										Sorted By : Signal									
Multiplier : 1.0000										Multiplier : 1.0000										Multiplier : 1.0000									
Dilution : 1.0000										Dilution : 1.0000										Dilution : 1.0000									
Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs									
Signal 1: TCD1 B,										Signal 1: TCD1 B,										Signal 1: TCD1 B,									
Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %			
1	0.913	BB S	0.0228	8260.05957	5130.92725	20.09546				1	0.913	BB S	0.0224	8166.06689	5179.47900	20.14877				1	0.909	BB S	0.0214	9083.93359	5822.84229	19.92154			
2	8.461	BB	0.5771	3.28441e4	729.68158	79.90454				2	8.467	BB	0.5824	3.23628e4	721.60516	79.85123				2	8.386	BB	0.5597	3.65146e4	789.26862	80.07846			
Totals :										Totals :										Totals :									
Summed Peaks Report										Summed Peaks Report										Summed Peaks Report									

Table D.72 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 55°C & 1.8 bar p_{SO₂} – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	55°C	1.8 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
49.96	50.04				3.4958	1.0426	3.1466	0.9553	3.1415	0.9711	3.3530	3.2938	3.2350

Table D.73 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 55°C & 1.8 bar p_{SO₂} – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	55°C	1.8 ± 0.1	0.9	0.857	3.9124	3.8434	3.7748	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
49.96	50.04								79.64	20.36	79.35	20.65	79.06	20.94	79.35	20.65

Table D.74 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 55°C & 1.8 bar p_{SO₂} – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report										Area Percent Report										Area Percent Report									
Sorted By : Signal										Sorted By : Signal										Sorted By : Signal									
Multiplier : 1.0000										Multiplier : 1.0000										Multiplier : 1.0000									
Dilution : 1.0000										Dilution : 1.0000										Dilution : 1.0000									
Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs									
Signal 1: TCD1 B,										Signal 1: TCD1 B,										Signal 1: TCD1 B,									
Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %			
1	0.913	BB S	0.0232	1.04259e4	6096.67871	22.97267				1	0.915	BB S	0.0233	9552.94922	5759.90820	23.28889				1	0.913	BB S	0.0256	9711.12598	5452.29346	23.61321			
2	8.498	BB	0.6001	3.49582e4	764.23096	77.02733				2	8.550	BB	0.5791	3.14664e4	705.05273	76.71111				2	8.545	BB	0.5955	3.14147e4	703.30725	76.38679			
Totals :										Totals :										Totals :									
Summed Peaks Report										Summed Peaks Report										Summed Peaks Report									

Table D.75 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 15°C & 2.0 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	15°C	2.0 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%				3.0885	0.1924	3.0761	0.1993	3.0711	0.1957	16.0525	15.4345	15.6929
75.00	25.00												

Table D.76 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 15°C & 2.0 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	15°C	2.0 ± 0.1	0.9	0.857	18.7310	18.0099	18.3114	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%								94.93	5.07	94.74	5.26	94.82	5.18	94.83	5.17
75.00	25.00															

Table D.77 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 15°C & 2.0 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : Signal							Sorted By : Signal							Sorted By : Signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.930	BB	0.0244	1924.38733	1196.33691	5.86533	1	0.930	BB	0.0237	1992.56433	1180.20569	6.08353	1	0.930	BB	0.0241	1957.01587	1184.61987	5.99071
2	8.503	BB	0.5667	3.08851e4	694.60608	94.13467	2	8.505	BB	0.5775	3.07609e4	692.43250	93.91647	2	8.508	BB	0.5756	3.07105e4	691.68256	94.00929
Totals :				3.28095e4	1890.94299		Totals :				3.27534e4	1872.63818		Totals :				3.26675e4	1876.30243	
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.78 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 25°C & 2.0 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	25°C	2.0 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
75.00	25.00				3.9497	0.2225	3.3637	0.1986	3.7636	0.2184	17.7515	16.9371	17.2326

Table D.79 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 25°C & 2.0 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	2.0 ± 0.1	0.9	0.857	20.7135	19.7632	20.1081	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
75.00	25.00								95.39	4.61	95.18	4.82	95.26	4.74	95.28	4.72

Table D.80 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 25°C & 2.0 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : Signal							Sorted By : Signal							Sorted By : Signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.928	BB	0.0206	2225.48975	1567.84827	5.33399	1	0.930	BB	0.0208	1985.67676	1376.66101	5.57417	1	0.928	BB	0.0216	2184.14478	1588.71021	5.48508
2	8.361	BB	0.6056	3.94973e4	837.24847	94.66601	2	8.451	BB	0.5914	3.36371e4	741.78143	94.42583	2	8.380	BB	0.6025	3.76356e4	807.01202	94.51492
Totals : 4.17228e4 2405.09674							Totals : 3.56228e4 2118.44244							Totals : 3.98197e4 2395.72223						
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.81 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 35°C & 2.0 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	35°C	2.0 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
75.00	25.00				3.0413	0.2268	4.2188	0.2921	3.0484	0.2249	13.4096	14.4430	13.5545

Table D.82 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 35°C & 2.0 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	35°C	2.0 ± 0.1	0.9	0.857	15.6472	16.8530	15.8162	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
75.00	25.00								93.99	6.01	94.40	5.60	94.05	5.95	94.15	5.85

Table D.83 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 35°C & 2.0 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report										Area Percent Report										Area Percent Report									
Sorted By : Signal										Sorted By : Signal										Sorted By : Signal									
Multiplier : 1.0000										Multiplier : 1.0000										Multiplier : 1.0000									
Dilution : 1.0000										Dilution : 1.0000										Dilution : 1.0000									
Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs									
Signal 1: TCD1 B,										Signal 1: TCD1 B,										Signal 1: TCD1 B,									
Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %			
1	0.932	BB	0.0214	2267.78076	1594.95813	6.93914				1	0.929	BB S	0.0206	2921.39844	2153.95190	6.47631				1	0.932	BB	0.0210	2249.11060	1615.98584	6.87098			
2	8.549	BB	0.5670	3.04132e4	686.81030	93.06086				2	8.355	BB	0.6151	4.21876e4	880.32092	93.52369				2	8.535	BB	0.5904	3.04844e4	688.21106	93.12902			
Totals :										Totals :										Totals :									
							3.26810e4	2281.76843									4.51090e4	3034.27283									3.27335e4	2304.19690	
Summed Peaks Report										Summed Peaks Report										Summed Peaks Report									

Table D.84 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 45°C & 2.0 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	45°C	2.0 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
75.00	25.00				2.9457	0.2662	4.6857	0.3955	3.1626	0.2861	11.0657	11.8475	11.0542

Table D.85 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 45°C & 2.0 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	45°C	2.0 ± 0.1	0.9	0.857	12.9122	13.8244	12.8987	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
75.00	25.00								92.81	7.19	93.25	6.75	92.81	7.19	92.96	7.04

Table D.86 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 45°C & 2.0 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : Signal							Sorted By : Signal							Sorted By : Signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.928	BB	0.0214	2661.70312	1962.60522	8.28698	1	0.923	BB S	0.0206	3955.10571	2917.65088	7.78375	1	0.927	BB S	0.0213	2861.04639	2128.90015	8.29591
2	8.534	BB	0.5700	2.94574e4	670.65051	91.71302	2	8.250	BB	0.5920	4.68573e4	950.42834	92.21625	2	8.488	BB	0.5682	3.16264e4	708.14026	91.70409
Totals : 3.21191e4 2633.25574							Totals : 5.08124e4 3868.07922							Totals : 3.44874e4 2837.04041						
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.87 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 55°C & 2.0 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	55°C	2.0 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
75.00	25.00				3.8645	0.3270	3.7935	0.3223	3.8002	0.3222	11.8180	11.7701	11.7945

Table D.88 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 55°C & 2.0 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	55°C	2.0 ± 0.1	0.9	0.857	13.7900	13.7341	13.7626	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
75.00	25.00								93.24	6.76	93.21	6.79	93.23	6.77	93.23	6.77

Table D.89 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 55°C & 2.0 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report										Area Percent Report										Area Percent Report									
Sorted By : signal										Sorted By : signal										Sorted By : signal									
Multiplier : 1.0000										Multiplier : 1.0000										Multiplier : 1.0000									
Dilution : 1.0000										Dilution : 1.0000										Dilution : 1.0000									
Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs									
Signal 1: TCD1 B,										Signal 1: TCD1 B,										Signal 1: TCD1 B,									
Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %			
1	0.928	BB S	0.0214	3270.25757	2296.89355	7.80201				1	0.928	BB S	0.0212	3223.37817	2411.25439	7.83162				1	0.928	BB S	0.0198	3222.19531	2382.09082	7.81627			
2	8.408	BB	0.6058	3.86453e4	823.60425	92.19799				2	8.416	BB	0.6046	3.79351e4	812.61688	92.16838				2	8.409	BB	0.6036	3.80020e4	813.14288	92.18373			
Totals :										Totals :										Totals :									
				4.19156e4	3120.49780									4.11585e4	3223.87128									4.12242e4	3195.23370				
Summed Peaks Report										Summed Peaks Report										Summed Peaks Report									

Table D.90 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @ 15°C & 2.2 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	15°C	2.2 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
24.72	75.28				6.1369	0.4297	6.1357	0.4294	6.1118	0.4272	14.2818	14.2890	14.3066

Table D.91 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @ 15°C & 2.2 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	15°C	2.2 ± 0.1	1.0	0.857	16.6649	16.6733	16.6939	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
24.72	75.28								94.34	5.66	94.34	5.66	94.35	5.65	94.34	5.66

Table D.92 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @15°C & 2.2 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report										Area Percent Report										Area Percent Report									
Sorted By : Signal										Sorted By : Signal										Sorted By : Signal									
Multiplier : 1.0000										Multiplier : 1.0000										Multiplier : 1.0000									
Dilution : 1.0000										Dilution : 1.0000										Dilution : 1.0000									
Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs									
Signal 1: TCD1 B,										Signal 1: TCD1 B,										Signal 1: TCD1 B,									
Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %			
1	0.919	BB S	0.0194	4296.55273	3264.85376	6.54313				1	0.919	BB S	0.0198	4293.55176	3171.02930	6.54003				1	0.902	BB S	0.0185	4271.87305	3438.26807	6.53296			
2	8.033	BB	0.6703	6.13686e4	1157.94946	93.45687				2	8.037	BB	0.6861	6.13568e4	1158.03613	93.45997				2	7.941	BB	0.6787	6.11177e4	1152.46692	93.46704			
Totals :				6.56651e4	4422.80322					Totals :				6.56504e4	4329.06543					Totals :				6.53895e4	4590.73499				
Summed Peaks Report										Summed Peaks Report										Summed Peaks Report									

Table D.93 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @ 25°C & 2.2 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	25°C	2.2 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
24.72	75.28				5.8372	0.7009	5.8094	0.6969	5.8229	0.6978	8.3281	8.3361	8.3447

Table D.94 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @ 25°C & 2.2 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	2.2 ± 0.1	0.9	0.857	9.7178	9.7270	9.7371	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
24.72	75.28								90.67	9.33	90.68	9.32	90.69	9.31	90.68	9.32

Table D.95 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @ 25°C & 2.2 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : Signal							Sorted By : Signal							Sorted By : Signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.914	BB S	0.0198	7008.77979	4920.04248	10.71993	1	0.914	BB S	0.0232	6968.88965	4423.84229	10.71109	1	0.914	BB S	0.0221	6977.69678	4508.58496	10.70089
2	8.104	BB	0.6723	5.83721e4	1116.61682	89.28007	2	8.108	BB	0.6655	5.80935e4	1113.39429	89.28891	2	8.108	BB	0.6722	5.82290e4	1114.01379	89.29911
Totals :				6.53808e4	6036.65930		Totals :				6.50624e4	5537.23657		Totals :				6.52067e4	5622.59875	
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.96 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @ 35°C & 2.2 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	35°C	2.2 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
24.72	75.28				5.6183	0.8222	5.6090	0.8223	5.6005	0.8214	6.8333	6.8217	6.8182

Table D.97 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @ 35°C & 2.2 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	35°C	2.2 ± 0.1	0.9	0.857	7.9735	7.9600	7.9559	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
24.72	75.28								88.86	11.14	88.84	11.16	88.83	11.17	88.84	11.16

Table D.98 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @ 35°C & 2.2 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : Signal							Sorted By : Signal							Sorted By : Signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.912	BB S	0.0225	8221.77344	5186.88330	12.76577	1	0.911	BB S	0.0206	8222.52148	5501.57568	12.78530	1	0.912	BB S	0.0220	8213.52539	5325.82129	12.79001
2	8.143	BB	0.6557	5.61831e4	1087.16736	87.23423	2	8.141	BB	0.6531	5.60898e4	1085.69946	87.21470	2	8.139	BB	0.6640	5.60048e4	1084.60168	87.20999
Totals :				6.44048e4	6274.05066		Totals :				6.43123e4	6587.27515		Totals :				6.42183e4	6410.42297	
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.99 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @ 45°C & 2.2 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios			
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial	
SO ₂	O ₂	45°C	2.2 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	
wt%	wt%													
24.72	75.28				5.1240	1.0439	5.1089	1.0445	5.0864	1.0431	4.9085	4.8912	4.8762	

Table D.100 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @ 45°C & 2.2 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	45°C	2.2 ± 0.1	0.9	0.857	5.7276	5.7074	5.6899	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
24.72	75.28								85.14	14.86	85.09	14.91	85.05	14.95	85.09	14.91

Table D.101 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @ 45°C & 2.2 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : Signal							Sorted By : Signal							Sorted By : Signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	Width [min]	Area [25 uV*s]	Height [25 uV]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uV*s]	Height [25 uV]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uV*s]	Height [25 uV]	Area %
1	0.906	BB S	0.0222	1.04388e4	6407.84131	16.92449	1	0.906	BB S	0.0223	1.04453e4	6395.90674	16.97476	1	0.905	BB S	0.0235	1.04311e4	5776.77686	17.01781
2	8.178	BB	0.6420	5.12398e4	1015.88947	83.07551	2	8.179	BB	0.6389	5.10888e4	1012.81012	83.02524	2	8.182	BB	0.6438	5.08639e4	1009.62933	82.98219
Totals :				6.16786e4	7423.73077		Totals :				6.15341e4	7408.71686		Totals :				6.12950e4	6786.40619	
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.102 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @ 55°C & 2.2 bar p_{SO₂} – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	55°C	2.2 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
24.72	75.28				4.8314	1.3025	4.7865	1.2920	4.7532	1.2848	3.7093	3.7047	3.6996

Table D.103 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @ 55°C & 2.2 bar p_{SO₂} – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	55°C	2.2 ± 0.1	0.9	0.857	4.3283	4.3229	4.3169	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
24.72	75.28								81.23	18.77	81.21	18.79	81.19	18.81	81.21	18.79

Table D.104 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @ 55°C & 2.2 bar p_{SO₂} – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : Signal							Sorted By : Signal							Sorted By : Signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.904	BB S	0.0255	1.30251e4	6584.38281	21.23471	1	0.904	BB S	0.0264	1.29201e4	6743.65918	21.25531	1	0.904	BB S	0.0258	1.28477e4	6883.40234	21.27839
2	8.271	BB	0.6321	4.83135e4	972.92938	78.76529	2	8.271	BB	0.6401	4.78651e4	966.58936	78.74469	2	8.270	BB	0.6382	4.75315e4	961.73419	78.72161
Totals :				6.13386e4	7557.31219		Totals :				6.07852e4	7710.24854		Totals :				6.03792e4	7845.13654	
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.105 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 15°C & 1.6 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	15°C	1.6 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
49.96	50.04				4.4792	0.2300	6.0427	0.2825	4.9932	0.2399	19.4748	21.3901	20.8137

Table D.106 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 15°C & 1.6 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	15°C	1.6 ± 0.1	0.9	0.857	22.7244	24.9593	24.2867	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
49.96	50.04								95.78	4.22	96.15	3.85	96.05	3.95	95.99	4.01

Table D.107 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 15°C & 1.6 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : Signal							Sorted By : Signal							Sorted By : Signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.933	BB	0.0217	2300.06372	1585.43335	4.88421	1	0.929	BB S	0.0194	2824.87256	2140.39038	4.46611	1	0.931	BB	0.0205	2399.41357	1696.53687	4.58500
2	8.318	BB	0.6218	4.47917e4	921.02350	95.11579	2	8.111	BB	0.6659	6.04265e4	1145.27905	95.53389	2	8.234	BB	0.6422	4.99324e4	996.44196	95.41500
Totals : 4.70918e4 2506.45685							Totals : 6.32513e4 3285.66943							Totals : 5.23318e4 2692.97882						
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.108 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.6 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	25°C	1.6 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
49.96	50.04				4.8877	0.2775	4.8049	0.2735	4.6376	0.2647	17.6133	17.5682	17.5202

Table D.109 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.6 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	1.6± 0.1	0.9	0.857	20.5523	20.4996	20.4437	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
49.96	50.04								95.36	4.64	95.35	4.65	95.34	4.66	95.35	4.65

Table D.110 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.6 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : Signal							Sorted By : Signal							Sorted By : Signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.927	BB S	0.0205	2774.80688	2170.28149	5.37215	1	0.928	BB S	0.0192	2735.48657	2092.82886	5.38647	1	0.928	BB S	0.0203	2646.57544	1996.73303	5.39865
2	8.238	BB	0.6423	4.88769e4	981.95813	94.62785	2	8.251	BB	0.6286	4.80489e4	969.47083	94.61353	2	8.271	BB	0.6222	4.63763e4	944.95715	94.60135
Totals :				5.16517e4	3152.23962		Totals :				5.07844e4	3062.29968		Totals :				4.90229e4	2941.69019	
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.111 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 35°C & 1.6 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	35°C	1.6 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
49.96	50.04				6.1098	0.5002	4.4851	0.3771	4.2894	0.3624	12.2147	11.8937	11.8361

Table D.112 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 35°C & 1.6 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	35°C	1.6 ± 0.1	0.9	0.857	14.2529	13.8783	13.8111	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
49.96	50.04								93.44	6.56	93.28	6.72	93.25	6.75	93.32	6.68

Table D.113 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 35°C & 1.6 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : Signal							Sorted By : Signal							Sorted By : Signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.918	BB S	0.0223	5001.75293	3665.74683	7.56695	1	0.922	BB S	0.0212	3771.14990	2814.15576	7.75609	1	0.923	BB S	0.0201	3623.90405	2771.04297	7.79042
2	8.057	BB	0.6716	6.10982e4	1154.91833	92.43305	2	8.268	BB	0.6234	4.48506e4	920.87708	92.24391	2	8.295	BB	0.6225	4.28935e4	892.13068	92.20958
Totals : 6.61000e4 4820.66516							Totals : 4.86218e4 3735.03284							Totals : 4.65174e4 3663.17365						
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.114 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 45°C & 1.6 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	45°C	1.6 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
49.96	50.04				4.2084	0.4402	4.3455	0.4556	5.9558	0.6200	9.5602	9.5380	9.6061

Table D.115 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 45°C & 1.6 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	45°C	1.6 ± 0.1	0.9	0.857	11.1554	11.1295	11.2090	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
49.96	50.04								91.77	8.23	91.76	8.24	91.81	8.19	91.78	8.22

Table D.116 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 45°C & 1.6 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report										Area Percent Report										Area Percent Report									
Sorted By : Signal										Sorted By : Signal										Sorted By : Signal									
Multiplier : 1.0000										Multiplier : 1.0000										Multiplier : 1.0000									
Dilution : 1.0000										Dilution : 1.0000										Dilution : 1.0000									
Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs									
Signal 1: TCD1 B,										Signal 1: TCD1 B,										Signal 1: TCD1 B,									
Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %			
1	0.922	BB S	0.0212	4401.99756	3283.31396	9.46946				1	0.922	BB S	0.0206	4555.87451	3206.15991	9.48921				1	0.916	BB S	0.0227	6200.19678	4236.47559	9.42872			
2	8.328	BB	0.6111	4.20842e4	878.23407	90.53054				2	8.304	BB	0.6073	4.34553e4	898.76013	90.51079				2	8.098	BB	0.6745	5.95584e4	1133.75623	90.57128			
Totals :										Totals :										Totals :									
				4.64862e4	4161.54803									4.80111e4	4104.92004									6.57586e4	5370.23181				
Summed Peaks Report										Summed Peaks Report										Summed Peaks Report									

Table D.117 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 55°C & 1.6 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	55°C	1.6 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
49.96	50.04				4.0364	0.5746	4.3586	0.6130	3.8777	0.5548	7.0247	7.1103	6.9894

Table D.118 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 55°C & 1.6 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	55°C	1.6 ± 0.1	0.9	0.857	8.1969	8.2967	8.1556	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
49.96	50.04								89.13	10.87	89.24	10.76	89.08	10.92	89.15	10.85

Table D.119 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 55°C & 1.6 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : signal							Sorted By : signal							Sorted By : signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.919	BB S	0.0215	5746.27002	3837.05908	12.46192	1	0.916	BB S	0.0222	6130.26172	4300.11865	12.33056	1	0.919	BB S	0.0195	5548.10742	3975.91748	12.51682
2	8.338	BB	0.6179	4.03644e4	850.21442	87.53808	2	8.298	BB	0.6150	4.35857e4	900.70770	87.66944	2	8.370	BB	0.6103	3.87771e4	825.69635	87.48318
Totals : 4.61106e4 4687.27350							Totals : 4.97160e4 5200.82635							Totals : 4.43252e4 4801.61383						
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.120 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 15°C & 1.8 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	15°C	1.8 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
75.00	25.00				6.8974	0.0747	6.8868	0.0740	6.9084	0.0745	92.3347	93.0649	92.7302

Table D.121 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 15°C & 1.8 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	15°C	1.8 ± 0.1	0.9	0.857	107.7417	108.5938	108.2033	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
75.00	25.00								99.08	0.92	99.09	0.91	99.08	0.92	99.08	0.92

Table D.122 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 15°C & 1.8 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report										Area Percent Report										Area Percent Report									
Sorted By : Signal										Sorted By : Signal										Sorted By : Signal									
Multiplier : 1.0000										Multiplier : 1.0000										Multiplier : 1.0000									
Dilution : 1.0000										Dilution : 1.0000										Dilution : 1.0000									
Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs									
Signal 1: TCD1 B,										Signal 1: TCD1 B,										Signal 1: TCD1 B,									
Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %			
1	0.933	BB	0.0219	746.70526	535.38531	1.07100				1	0.933	BB	0.0209	739.56714	536.22534	1.06248				1	0.934	BB	0.0209	744.60333	540.58612	1.06633			
2	7.989	BB	0.6872	6.89739e4	1258.88647	98.92900				2	7.991	BB	0.6839	6.88681e4	1258.82715	98.93752				2	7.991	BB	0.7017	6.90843e4	1259.13635	98.93367			
Totals :										Totals :										Totals :									
				6.97206e4	1794.27179									6.96077e4	1795.05249									6.98289e4	1799.72247				
Summed Peaks Report										Summed Peaks Report										Summed Peaks Report									

Table D.123 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.8 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios			
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial	
SO ₂	O ₂	25°C	1.8 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	
wt%	wt%													
75.00	25.00				5.9159	0.1484	5.9729	0.1482	5.8810	0.1445	39.8646	40.3030	40.6990	

Table D.124 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.8 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	1.8 ± 0.1	0.9	0.857	46.5164	47.0280	47.4900	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
75.00	25.00								97.90	2.10	97.92	2.08	97.94	2.06	97.92	2.08

Table D.125 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.8 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : Signal							Sorted By : Signal							Sorted By : Signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %
1	0.931	BB	0.0212	1483.64966	1111.12512	2.44657	1	0.931	BB	0.0212	1481.69006	1105.73364	2.42062	1	0.931	BB	0.0213	1444.72253	1021.14685	2.39770
2	8.103	BB	0.6624	5.91585e4	1129.16687	97.55343	2	8.099	BB	0.6665	5.97294e4	1136.99182	97.57938	2	8.112	BB	0.6625	5.88098e4	1125.41187	97.60230
Totals :				6.06421e4	2240.29199		Totals :				6.12111e4	2242.72546		Totals :				6.02546e4	2146.55872	
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.126 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 35°C & 1.8 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	35°C	1.8 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
75.00	25.00				6.6534	0.1461	6.3272	0.1405	6.2873	0.1394	45.5400	45.0335	45.1026

Table D.127 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 35°C & 1.8 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	35°C	1.8 ± 0.1	0.9	0.857	53.1389	52.5478	52.6285	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
75.00	25.00								98.15	1.85	98.13	1.87	98.14	1.86	98.14	1.86

Table D.128 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 35°C & 1.8 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : signal							Sorted By : signal							Sorted By : signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.929	BB	0.0196	1460.60413	1148.32959	2.14812	1	0.929	BB	0.0196	1404.98816	1108.46509	2.17233	1	0.929	BB	0.0198	1394.19165	1147.53601	2.16939
2	7.988	BB	0.6848	6.65338e4	1228.16052	97.85188	2	8.034	BB	0.6838	6.32716e4	1184.81396	97.82767	2	8.037	BB	0.6799	6.28725e4	1178.74268	97.83061
Totals : 6.79944e4 2376.49011							Totals : 6.46766e4 2293.27905							Totals : 6.42667e4 2326.27869						
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.129 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 45°C & 1.8 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	45°C	1.8 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
75.00	25.00				4.1175	0.1803	5.0898	0.2106	4.1405	0.1779	22.8369	24.1566	23.2743

Table D.130 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 45°C & 1.8 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	45°C	1.8 ± 0.1	0.9	0.857	26.6475	28.1874	27.1579	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
75.00	25.00								96.38	3.62	96.57	3.43	96.45	3.55	96.47	3.53

Table D.131 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 45°C & 1.8 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report										Area Percent Report										Area Percent Report									
Sorted By : Signal										Sorted By : Signal										Sorted By : Signal									
Multiplier : 1.0000										Multiplier : 1.0000										Multiplier : 1.0000									
Dilution : 1.0000										Dilution : 1.0000										Dilution : 1.0000									
Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs									
Signal 1: TCD1 B,										Signal 1: TCD1 B,										Signal 1: TCD1 B,									
Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %			
1	0.930	BB	0.0201	1802.98926	1302.80762	4.19034				1	0.928	BB	0.0205	2106.49805	1563.07153	3.96984				1	0.930	BB	0.0222	1778.92615	1316.65222	4.11500			
2	1.838	BB	0.0682	48.47691	11.01071	0.11267				2	1.835	BB	0.0659	58.38995	13.42991	0.11004				2	1.837	BB	0.0678	46.56580	10.81260	0.10772			
3	8.331	BB	0.6329	4.11758e4	863.77313	95.69699				3	8.192	BB	0.6455	5.08976e4	1011.38818	95.92012				3	8.326	BB	0.6317	4.14048e4	866.71521	95.77728			
Totals :				4.30273e4	2177.59146					Totals :				5.30625e4	2587.88962					Totals :				4.32303e4	2194.18003				
Summed Peaks Report										Summed Peaks Report										Summed Peaks Report									

Table D.132 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 55°C & 1.8 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	55°C	1.8 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
75.00	25.00				4.7696	0.1990	4.2920	0.1826	4.1800	0.1811	23.8599	23.5049	23.0812

Table D.133 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 55°C & 1.8 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	55°C	1.8 ± 0.1	0.9	0.857	27.8412	27.4270	26.9325	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
75.00	25.00								96.53	3.47	96.48	3.52	96.42	3.58	96.48	3.52

Table D.134 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 55°C & 1.8 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report						Area Percent Report						Area Percent Report								
Sorted By : Signal						Sorted By : Signal						Sorted By : Signal								
Multiplier : 1.0000						Multiplier : 1.0000						Multiplier : 1.0000								
Dilution : 1.0000						Dilution : 1.0000						Dilution : 1.0000								
Use Multiplier & Dilution Factor with ISTDs						Use Multiplier & Dilution Factor with ISTDs						Use Multiplier & Dilution Factor with ISTDs								
Signal 1: TCD1 B,						Signal 1: TCD1 B,						Signal 1: TCD1 B,								
Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.930	BB	0.0211	1990.06299	1422.30933	4.00525	1	0.930	BB	0.0211	1825.91772	1303.02429	4.08065	1	0.930	BB	0.0212	1811.31763	1350.92444	4.15331
2	8.250	BB	0.6436	4.76963e4	962.75507	95.99475	2	8.314	BB	0.6258	4.29199e4	892.51227	95.91935	2	8.329	BB	0.6158	4.18001e4	874.83643	95.84669
Totals :				4.96864e4	2385.06439		Totals :				4.47458e4	2195.53656		Totals :				4.36115e4	2225.76086	
Summed Peaks Report						Summed Peaks Report						Summed Peaks Report								

Table D.135 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 25°C & 2.4 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	25°C	2.4 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
24.72	75.28				5.2629	1.0539	5.1690	1.0963	5.0881	1.1412	4.9937	4.7162	4.4586

Table D.136 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 25°C & 2.4 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	2.4 ± 0.1	0.9	0.857	5.8270	5.5032	5.2025	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
24.72	75.28								85.35	14.65	84.62	15.38	83.88	16.12	84.62	15.38

Table D.137 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 25°C & 2.4 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : Signal							Sorted By : Signal							Sorted By : Signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.907	BB S	0.0260	1.05392e4	5790.17041	16.68434	1	0.906	BB S	0.0219	1.09633e4	6561.76416	17.49834	1	0.906	BB S	0.0227	1.14123e4	6833.35156	18.32033
2	8.184	BB	0.6567	5.26292e4	1037.32458	83.31566	2	8.199	BB	0.6523	5.16903e4	1025.05835	82.50166	2	8.212	BB	0.6412	5.08809e4	1011.58734	81.67967
Totals :				6.31684e4	6827.49500		Totals :				6.26536e4	7586.82251		Totals :				6.22932e4	7844.93890	
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.138 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 25°C & 1.4 bar p_{SO₂} – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	25°C	1.4 ± 0.05	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
24.72	75.28				3.9260	1.1965	3.7659	1.1527	4.0770	1.2465	3.2812	3.2670	3.2708

Table D.139 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 25°C & 1.4 bar p_{SO₂} – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	1.4 ± 0.05	0.9	0.857	3.8287	3.8122	3.8165	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
24.72	75.28								79.29	20.71	79.22	20.78	79.24	20.76	79.25	20.75

Table D.140 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 25°C & 1.4 bar p_{SO₂} – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report										Area Percent Report										Area Percent Report									
Sorted By : Signal										Sorted By : Signal										Sorted By : Signal									
Multiplier : 1.0000										Multiplier : 1.0000										Multiplier : 1.0000									
Dilution : 1.0000										Dilution : 1.0000										Dilution : 1.0000									
Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs									
Signal 1: TCD1 B,										Signal 1: TCD1 B,										Signal 1: TCD1 B,									
Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %			
1	0.902	BB S	0.0242	1.19645e4	6642.29736	23.35716				1	0.902	BB S	0.0258	1.15265e4	6172.83887	23.43474				1	0.900	BB S	0.0236	1.24646e4	6849.23145	23.41461			
2	8.322	BB	0.5959	3.92596e4	834.80475	76.64284				2	8.350	BB	0.6013	3.76592e4	809.28900	76.56526				2	8.299	BB	0.6164	4.07697e4	858.53680	76.58539			
Totals :										Totals :										Totals :									
Summed Peaks Report										Summed Peaks Report										Summed Peaks Report									

Table D.141 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 25°C & 1.3 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	25°C	1.3 ± 0.05	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
24.72	75.28				3.8461	1.1282	3.6254	1.0680	3.6423	1.0699	3.4091	3.3946	3.4043

Table D.142 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 25°C & 1.3 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	1.3 ± 0.05	0.9	0.857	3.9779	3.9610	3.9724	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
24.72	75.28								79.91	20.09	79.84	20.16	79.89	20.11	79.88	20.12

Table D.143 Binary permeation of 25:75 (SO₂:O₂) in Nafion 117 @ 25°C & 1.3 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : Signal							Sorted By : Signal							Sorted By : Signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.906	BB S	0.0253	1.12821e4	6173.15527	22.68050	1	0.907	BB S	0.0233	1.06800e4	6189.63721	22.75539	1	0.907	BB S	0.0242	1.06986e4	6177.67090	22.70403
2	8.375	BB	0.6106	3.84614e4	820.90576	77.31950	2	8.409	BB	0.5940	3.62539e4	786.20990	77.24461	2	8.405	BB	0.5455	3.64233e4	788.28064	77.29597
Totals :				4.97435e4	6994.06104		Totals :				4.69339e4	6975.84711		Totals :				4.71219e4	6965.95154	
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.144 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 25°C & 1.8 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	25°C	1.8 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
49.96	50.04				2.5206	0.2704	3.7676	0.3897	3.0343	0.3286	9.3217	9.6679	9.2340

Table D.145 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 25°C & 1.8 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	1.8 ± 0.1	0.9	0.857	10.8772	11.2812	10.7748	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
49.96	50.04								91.58	8.42	91.86	8.14	91.51	8.49	91.65	8.35

Table D.146 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 25°C & 1.8 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report										Area Percent Report										Area Percent Report									
Sorted By : Signal										Sorted By : Signal										Sorted By : Signal									
Multiplier : 1.0000										Multiplier : 1.0000										Multiplier : 1.0000									
Dilution : 1.0000										Dilution : 1.0000										Dilution : 1.0000									
Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs									
Signal 1: TCD1 B,										Signal 1: TCD1 B,										Signal 1: TCD1 B,									
Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %			
1	0.932	BB	0.0213	2704.02905	1912.80969	9.68847				1	0.927	BB S	0.0215	3897.32007	2730.68921	9.37451				1	0.929	BB S	0.0218	3285.60962	2254.96436	9.77029			
2	8.653	BB	0.5578	2.52057e4	593.56689	90.31153				2	8.426	BB	0.5892	3.76763e4	809.77008	90.62549				2	8.548	BB	0.5840	3.03430e4	686.07556	90.22971			
Totals :										Totals :										Totals :									
							2.79098e4	2506.37659																					
Summed Peaks Report										Summed Peaks Report										Summed Peaks Report									

Table D.147 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 25°C & 1.2 bar p_{SO₂} – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	25°C	1.2 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
49.96	50.04				2.3628	0.2941	2.5734	0.3178	2.3897	0.3007	8.0340	8.0975	7.9471

Table D.148 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 25°C & 1.2 bar p_{SO₂} – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	1.2 ± 0.1	0.9	0.857	9.3746	9.4487	9.2732	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
49.96	50.04								90.36	9.64	90.43	9.57	90.27	9.73	90.35	9.65

Table D.149 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 25°C & 1.2 bar p_{SO₂} – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report										Area Percent Report										Area Percent Report									
Sorted By : Signal										Sorted By : Signal										Sorted By : Signal									
Multiplier : 1.0000										Multiplier : 1.0000										Multiplier : 1.0000									
Dilution : 1.0000										Dilution : 1.0000										Dilution : 1.0000									
Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs									
Signal 1: TCD1 B,										Signal 1: TCD1 B,										Signal 1: TCD1 B,									
Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %			
1	0.927	BB	0.0220	2941.23657	1994.43982	11.06994				1	0.927	BB S	0.0225	3177.54761	2089.61450	10.99067				1	0.926	BB S	0.0223	3007.37988	2001.77991	11.17804			
2	8.642	BB	0.5514	2.36283e4	564.60858	88.93006				2	8.598	BB	0.5696	2.57338e4	603.35370	89.00933				2	8.631	BB	0.5517	2.38970e4	569.76056	88.82196			
Totals :										Totals :										Totals :									
							2.65696e4	2559.04840									2.89113e4	2692.96820									2.69044e4	2571.54047	
Summed Peaks Report										Summed Peaks Report										Summed Peaks Report									

Table D.150 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 25°C & 1.0 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	25°C	1.0 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
49.96	50.04				2.3963	0.4157	2.5646	0.4392	2.5685	0.4403	5.7645	5.8393	5.8335

Table D.151 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 25°C & 1.0 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	1.0 ± 0.1	0.9	0.857	6.7264	6.8136	6.8069	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
49.96	50.04								87.06	12.94	87.20	12.80	87.19	12.81	87.15	12.85

Table D.152 Binary permeation of 50:50 (SO₂:O₂) in Nafion 117 @ 25°C & 1.0 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report										Area Percent Report										Area Percent Report									
Sorted By : signal										Sorted By : signal										Sorted By : signal									
Multiplier : 1.0000										Multiplier : 1.0000										Multiplier : 1.0000									
Dilution : 1.0000										Dilution : 1.0000										Dilution : 1.0000									
Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs									
Signal 1: TCD1 B,										Signal 1: TCD1 B,										Signal 1: TCD1 B,									
Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %			
1	0.925	BB S	0.0225	4157.26318	2734.96265	14.78388				1	0.924	BB S	0.0224	4391.95459	2911.40137	14.62130				1	0.924	BB S	0.0224	4402.62988	2918.31079	14.63272			
2	8.658	BB	0.5082	2.39630e4	570.75226	85.21612				2	8.623	BB	0.5155	2.56461e4	601.85559	85.37870				2	8.614	BB	0.5665	2.56849e4	603.07965	85.36728			
Totals :										Totals :										Totals :									
							2.81202e4	3305.71490									3.00381e4	3513.25696									3.00876e4	3521.39044	
Summed Peaks Report										Summed Peaks Report										Summed Peaks Report									

Table D.153 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 25°C & 2.0 bar p_{SO₂} – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	25°C	2.0 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
75.00	25.00				3.9497	0.2225	3.3637	0.1986	3.7636	0.2184	17.7515	16.9371	17.2326

Table D.154 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 25°C & 2.0 bar p_{SO₂} – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	2.0 ± 0.1	0.9	0.857	20.7135	19.7632	20.1081	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
75.00	25.00								95.39	4.61	95.18	4.82	95.26	4.74	95.28	4.72

Table D.155 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 25°C & 2.0 bar p_{SO₂} – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : Signal							Sorted By : Signal							Sorted By : Signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.928	BB	0.0206	2225.48975	1567.84827	5.33399	1	0.930	BB	0.0208	1985.67676	1376.66101	5.57417	1	0.928	BB	0.0216	2184.14478	1588.71021	5.48508
2	8.361	BB	0.6056	3.94973e4	837.24847	94.66601	2	8.451	BB	0.5914	3.36371e4	741.78143	94.42583	2	8.380	BB	0.6025	3.76356e4	807.01202	94.51492
Totals : 4.17228e4 2405.09674							Totals : 3.56228e4 2118.44244							Totals : 3.98197e4 2395.72223						
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.156 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 25°C & 1.5 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	25°C	1.5 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
75.00	25.00				6.0948	0.2227	5.9980	0.2190	5.9193	0.2138	27.3678	27.3881	27.6862

Table D.157 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 25°C & 1.5 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	1.5 ± 0.1	0.9	0.857	31.9344	31.9581	32.3059	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
75.00	25.00								96.96	3.04	96.97	3.03	97.00	3.00	96.98	3.02

Table D.158 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 25°C & 1.5 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report										Area Percent Report										Area Percent Report									
Sorted By : Signal										Sorted By : Signal										Sorted By : Signal									
Multiplier : 1.0000										Multiplier : 1.0000										Multiplier : 1.0000									
Dilution : 1.0000										Dilution : 1.0000										Dilution : 1.0000									
Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs									
Signal 1: TCD1 B,										Signal 1: TCD1 B,										Signal 1: TCD1 B,									
Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %			
1	0.927	BB	0.0197	2227.46143	1747.65710	3.52581				1	0.928	BB	0.0200	2190.31812	1678.05737	3.52311				1	0.928	BB	0.0200	2137.61475	1640.63025	3.48540			
2	8.086	BB	0.6653	6.09484e4	1154.79846	96.47419				2	8.096	BB	0.6710	5.99797e4	1140.76807	96.47689				2	8.106	BB	0.6636	5.91930e4	1132.04785	96.51460			
Totals :										Totals :										Totals :									
Summed Peaks Report										Summed Peaks Report										Summed Peaks Report									

Table D.159 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 25°C & 1.1 bar p_{SO₂} – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	25°C	1.1 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
75.00	25.00				2.7686	0.1505	3.3665	0.1705	2.8042	0.1500	18.3960	19.7449	18.6947

Table D.160 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 25°C & 1.1 bar p_{SO₂} – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	1.1 ± 0.1	0.9	0.857	21.4656	23.0395	21.8141	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
75.00	25.00								95.55	4.45	95.84	4.16	95.62	4.38	95.67	4.33

Table D.161 Binary permeation of 75:25 (SO₂:O₂) in Nafion 117 @ 25°C & 1.1 bar p_{SO₂} – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report										Area Percent Report										Area Percent Report									
Sorted By : Signal										Sorted By : Signal										Sorted By : Signal									
Multiplier : 1.0000										Multiplier : 1.0000										Multiplier : 1.0000									
Dilution : 1.0000										Dilution : 1.0000										Dilution : 1.0000									
Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs									
Signal 1: TCD1 B,										Signal 1: TCD1 B,										Signal 1: TCD1 B,									
Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %			
1	0.931	BB	0.0229	1505.40479	971.63580	5.15696				1	0.931	BB	0.0204	1705.40259	1213.23376	4.82154				1	0.931	BB	0.0219	1500.43262	1026.36414	5.07894			
2	8.561	BB	0.5790	2.76863e4	639.16730	94.84304				2	8.452	BB	0.5790	3.36651e4	742.95074	95.17846				2	8.551	BB	0.5653	2.80418e4	645.37268	94.92106			
Totals :										Totals :										Totals :									
							2.91917e4	1610.80310									3.53705e4	1956.18451									2.95422e4	1671.73682	
Summed Peaks Report										Summed Peaks Report										Summed Peaks Report									

Table D.162 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @ 25°C & 2.2 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	25°C	2.2 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
24.72	75.28				5.8372	0.7009	5.8094	0.6969	5.8229	0.6978	8.3281	8.3361	8.3447

Table D.163 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @ 25°C & 2.2 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	2.2 ± 0.1	0.9	0.857	9.7178	9.7270	9.7371	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
24.72	75.28								90.67	9.33	90.68	9.32	90.69	9.31	90.68	9.32

Table D.164 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @ 25°C & 2.2 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report										Area Percent Report										Area Percent Report									
Sorted By : Signal										Sorted By : Signal										Sorted By : Signal									
Multiplier : 1.0000										Multiplier : 1.0000										Multiplier : 1.0000									
Dilution : 1.0000										Dilution : 1.0000										Dilution : 1.0000									
Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs									
Signal 1: TCD1 B,										Signal 1: TCD1 B,										Signal 1: TCD1 B,									
Peak #	RetTime [min]	Type	Width [min]	Area [25 uV*s]	Height [25 uV]	Area %				Peak #	RetTime [min]	Type	Width [min]	Area [25 uV*s]	Height [25 uV]	Area %				Peak #	RetTime [min]	Type	Width [min]	Area [25 uV*s]	Height [25 uV]	Area %			
1	0.914	BB S	0.0198	7008.77979	4920.04248	10.71993				1	0.914	BB S	0.0232	6968.88965	4423.84229	10.71109				1	0.914	BB S	0.0221	6977.69678	4508.58496	10.70089			
2	8.104	BB	0.6723	5.83721e4	1116.61682	89.28007				2	8.108	BB	0.6655	5.80935e4	1113.39429	89.28891				2	8.108	BB	0.6722	5.82290e4	1114.01379	89.29911			
Totals :										Totals :										Totals :									
Summed Peaks Report										Summed Peaks Report										Summed Peaks Report									

Table D.165 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.8 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	25°C	1.8 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
24.72	75.28				5.1855	1.0634	3.9482	0.8090	3.6706	0.7511	4.8763	4.8803	4.8870

Table D.166 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.8 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	1.8 ± 0.1	0.9	0.857	5.6900	5.6947	5.7024	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
24.72	75.28								85.05	14.95	85.06	14.94	85.08	14.92	85.07	14.93

Table D.167 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.8 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : Signal							Sorted By : Signal							Sorted By : Signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.907	BB S	0.0260	1.06339e4	5863.05078	17.01715	1	0.913	BB S	0.0211	8089.50049	5261.94238	17.00508	1	0.914	BB S	0.0205	7511.44727	5063.28271	16.98763
2	8.189	BB	0.6411	5.18553e4	1025.55151	82.98285	2	8.365	BB	0.6097	3.94816e4	837.94727	82.99492	2	8.407	BB	0.5977	3.67057e4	794.12286	83.01237
Totals :				6.24892e4	6888.60229		Totals :				4.75711e4	6099.88965		Totals :				4.42172e4	5857.40558	
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.168 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.3 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios			
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial	
SO ₂	O ₂	25°C	1.3 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	
wt%	wt%													
24.72	75.28				4.4425	0.9057	2.7725	0.5924	2.9406	0.6239	4.9050	4.6801	4.7133	

Table D.169 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.3 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	1.3 ± 0.1	0.9	0.857	5.7235	5.4610	5.4997	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
24.72	75.28								85.13	14.87	84.52	15.48	84.61	15.39	84.75	15.25

Table D.170 Binary permeation of 25:75 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.3 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : Signal							Sorted By : Signal							Sorted By : Signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.910	BB S	0.0230	9056.54980	5550.67822	16.93405	1	0.918	BB S	0.0216	5924.00000	3932.40186	17.60535	1	0.917	BB S	0.0221	6239.00391	4029.72363	17.50298
2	8.270	BB	0.6218	4.44248e4	914.72412	83.06595	2	8.548	BB	0.5663	2.77249e4	639.83362	82.39465	2	8.518	BB	0.5229	2.94064e4	669.45251	82.49702
Totals : 5.34813e4 6465.40234							Totals : 3.36489e4 4572.23547							Totals : 3.56454e4 4699.17615						
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.171 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.6 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	25°C	1.6 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%				4.8877	0.2775	4.8049	0.2735	4.6376	0.2647	17.6133	17.5682	17.5202
49.96	50.04												

Table D.172 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.6 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	1.6 ± 0.1	0.9	0.857	20.5523	20.4996	20.4437	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%								95.36	4.64	95.35	4.65	95.34	4.66	95.35	4.65
49.96	50.04															

Table D.173 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.6 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : Signal							Sorted By : Signal							Sorted By : Signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.927	BB S	0.0205	2774.80688	2170.28149	5.37215	1	0.928	BB S	0.0192	2735.48657	2092.82886	5.38647	1	0.928	BB S	0.0203	2646.57544	1996.73303	5.39865
2	8.238	BB	0.6423	4.88769e4	981.95813	94.62785	2	8.251	BB	0.6286	4.80489e4	969.47083	94.61353	2	8.271	BB	0.6222	4.63763e4	944.95715	94.60135
Totals : 5.16517e4 3152.23962							Totals : 5.07844e4 3062.29968							Totals : 4.90229e4 2941.69019						
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.174 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.3 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	25°C	1.3 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
49.96	50.04				2.6922	0.2510	3.7692	0.3332	2.9632	0.2657	10.7259	11.3121	11.1524

Table D.175 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.3 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	1.3 ± 0.1	0.9	0.857	12.5156	13.1997	13.0133	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
49.96	50.04								92.60	7.40	92.96	7.04	92.86	7.14	92.81	7.19

Table D.176 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.3 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : Signal							Sorted By : Signal							Sorted By : Signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.930	BB	0.0221	2509.79053	1688.28589	8.52747	1	0.927	BB S	0.0218	3331.54565	2282.96338	8.12100	1	0.929	BB S	0.0210	2657.09814	1910.95764	8.22911
2	8.600	BB	0.5695	2.69220e4	624.30994	91.47253	2	8.414	BB	0.6159	3.76923e4	808.55743	91.87900	2	8.544	BB	0.5804	2.96319e4	672.57153	91.77089
Totals :				2.94318e4	2312.59583		Totals :				4.10238e4	3091.52081		Totals :				3.22890e4	2583.52917	
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.177 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.0 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	25°C	1.0 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
49.96	50.04				0.9370	0.1649	0.9153	0.1608	0.9156	0.1614	5.6822	5.6922	5.6729

Table D.178 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.0 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	1.0 ± 0.1	0.9	0.857	6.6304	6.6420	6.6194	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
49.96	50.04								86.89	13.11	86.91	13.09	86.88	13.12	86.89	13.11

Table D.179 Binary permeation of 50:50 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.0 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : signal							Sorted By : signal							Sorted By : signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.931	BB	0.0253	1649.06360	938.40552	14.96499	1	0.931	BB	0.0252	1608.36499	920.94342	14.94506	1	0.930	BB	0.0249	1614.45386	936.36847	14.98899
2	9.011	BB	0.4267	9370.41309	259.12698	85.03501	2	9.016	BB	0.4314	9153.48242	254.16470	85.05494	2	9.013	BB	0.4356	9156.47656	254.09445	85.01101
Totals : 1.10195e4 1197.53250							Totals : 1.07618e4 1175.10812							Totals : 1.07709e4 1190.46292						
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.180 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.8 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	25°C	1.8 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
75.00	25.00				5.9159	0.1484	5.9729	0.1482	5.8810	0.1445	39.8646	40.3030	40.6990

Table D.181 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.8 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	1.8 ± 0.1	0.9	0.857	46.5164	47.0280	47.4900	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
75.00	25.00								97.90	2.10	97.92	2.08	97.94	2.06	97.92	2.08

Table D.182 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.8 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : Signal							Sorted By : Signal							Sorted By : Signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.931	BB	0.0212	1483.64966	1111.12512	2.44657	1	0.931	BB	0.0212	1481.69006	1105.73364	2.42062	1	0.931	BB	0.0213	1444.72253	1021.14685	2.39770
2	8.103	BB	0.6624	5.91585e4	1129.16687	97.55343	2	8.099	BB	0.6665	5.97294e4	1136.99182	97.57938	2	8.112	BB	0.6625	5.88098e4	1125.41187	97.60230
Totals :				6.06421e4	2240.29199		Totals :				6.12111e4	2242.72546		Totals :				6.02546e4	2146.55872	
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.183 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.5 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	25°C	1.5 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
75.00	25.00				3.5389	0.1573	3.5485	0.1566	3.1170	0.1431	22.4978	22.6596	21.7820

Table D.184 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.5 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	1.5 ± 0.1	0.9	0.857	26.2518	26.4407	25.4165	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
75.00	25.00								96.33	3.67	96.36	3.64	96.21	3.79	96.30	3.70

Table D.185 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.5 bar pso₂ – GC area reports (1st, 2nd & 3rd trials)

Area Percent Report							Area Percent Report							Area Percent Report						
Sorted By : Signal							Sorted By : Signal							Sorted By : Signal						
Multiplier : 1.0000							Multiplier : 1.0000							Multiplier : 1.0000						
Dilution : 1.0000							Dilution : 1.0000							Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs							Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,							Signal 1: TCD1 B,							Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %	Peak #	RetTime [min]	Type	Width [min]	Area [25 uv*s]	Height [25 uv]	Area %
1	0.932	BB	0.0217	1573.09863	1141.59314	4.25597	1	0.932	BB	0.0213	1566.01562	1056.07275	4.22670	1	0.932	BB	0.0227	1431.14368	932.85040	4.38988
2	8.443	BB	0.5958	3.53891e4	770.64368	95.74403	2	8.433	BB	0.5792	3.54845e4	772.29327	95.77330	2	8.510	BB	0.5415	3.11698e4	700.50757	95.61012
Totals : 3.69622e4 1912.23682							Totals : 3.70505e4 1828.36603							Totals : 3.26010e4 1633.35797						
Summed Peaks Report							Summed Peaks Report							Summed Peaks Report						

Table D.186 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.1 bar pso₂ – Raw Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Permeate peak Areas (UVs) x 10 ⁻⁴						Area Ratios		
			Bar	Bar	1 st Trial		2nd Trial		3rd Trial		1st Trial	2nd Trial	3rd Trial
SO ₂	O ₂	25°C	1.1 ± 0.1	0.9	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}	A _{SO2} /A _{O2}
wt%	wt%												
75.00	25.00				2.3820	0.3659	1.9408	0.3092	2.5001	0.3857	6.5100	6.2768	6.4820

Table D.187 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.1 bar pso₂ – Calculated Data

Feed Composition		Temperature	SO ₂ Feed Partial Pressure	Total Downstream Pressure	Proportionality Constant	Permeate Composition Ratio (wt /wt)			Permeate Composition (wt %)							
			Bar	Bar	k	1st Trial	2nd Trial	3rd Trial	1 st Trial		2nd Trial		3rd Trial		Average	
SO ₂	O ₂	25°C	1.1 ± 0.1	0.9	0.857	7.5962	7.3242	7.5636	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂	SO ₂	O ₂
wt%	wt%															
75.00	25.00								88.37	11.63	87.99	12.01	88.32	11.68	88.23	11.77

Table D.188 Binary permeation of 75:25 (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.1 bar pso₂– GC area reports (1st, 2nd & 3rd trials)

Area Percent Report										Area Percent Report										Area Percent Report									
Sorted By : signal										Sorted By : signal										Sorted By : signal									
Multiplier : 1.0000										Multiplier : 1.0000										Multiplier : 1.0000									
Dilution : 1.0000										Dilution : 1.0000										Dilution : 1.0000									
Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs									
Signal 1: TCD1 B,										Signal 1: TCD1 B,										Signal 1: TCD1 B,									
Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %			
1	0.929	BB S	0.0205	3658.81592	2582.51758	13.31484				1	0.931	BB S	0.0218	3091.83813	2115.85327	13.74181				1	0.929	BB S	0.0220	3857.06860	2738.47095	13.36585			
2	8.688	BB	0.5528	2.38204e4	566.72015	86.68516				2	8.795	BB	0.5175	1.94077e4	480.62064	86.25819				2	8.686	BB	0.5591	2.50006e4	588.12152	86.63415			
Totals :										Totals :										Totals :									
Summed Peaks Report										Summed Peaks Report										Summed Peaks Report									

Table D.189 Binary flux results of 75:25 wt (SO₂:O₂) in Nafion 117 @ 15°C & 1.2 bar Δpso₂ – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar					
Molar %		Bar ± 0.1		°C		s					
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅
60.00	40.00	1.20	0.80	15 ± 1	1	0.00	162.00	266.99	312.61	391.25	471.61
60.00	40.00	1.20	0.80		2	0.00	115.47	186.26	311.48	385.48	508.17
60.00	40.00	1.20	0.80		3	0.00	108.58	182.59	297.56	430.51	501.34

Table D.190 Binary flux results of 75:25 wt (SO₂:O₂) in Nafion 117 @ 15°C & 1.2 bar Δpso₂ – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
60.00	40.00	1.20	0.80	15 ± 1	1	0.000185	0.01950	0.0193	90.17	9.83	0.0174	0.00190	177.80	6.30E-06	6.86E-07	9.33E-15	1.53E-15
60.00	40.00	1.20	0.80		2	0.000185	0.02000	0.0198	90.17	9.83	0.0179	0.00195	177.80	6.46E-06	7.04E-07	9.57E-15	1.57E-15
60.00	40.00	1.20	0.80		3	0.000185	0.01960	0.0194	90.17	9.83	0.0175	0.00191	177.80	6.33E-06	6.90E-07	9.38E-15	1.53E-15

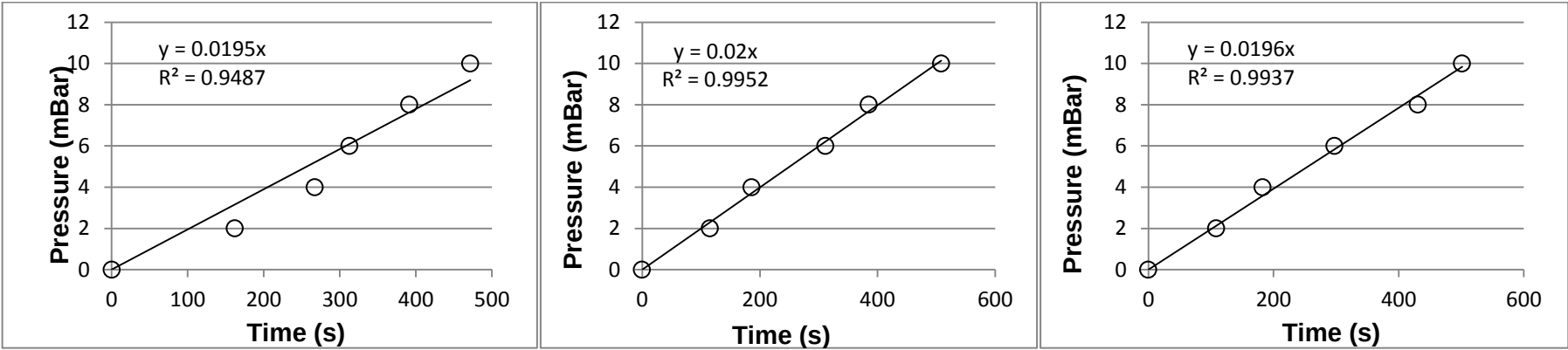


Figure D.57 Permeate pressure-time graphs for 75:25 wt (SO₂:O₂) in Nafion 117 @ 15°C & 1.2 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.191 Binary flux results of 75:25 wt (SO₂:O₂) in Nafion 117 @ 25°C & 1.2 bar Δp_{SO_2} – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per $\Delta p=2\text{mBar}$					
Molar %		Bar ± 0.1		°C		s					
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅
60.00	40.00	1.20	0.80	25 $\pm$ 1	1	0.00	85.74	187.38	220.21	288.96	391.97
60.00	40.00	1.20	0.80		2	0.00	66.18	187.42	213.45	291.52	385.10
60.00	40.00	1.20	0.80		3	0.00	62.88	169.73	210.38	299.05	377.19

Table D.192 Binary flux results of 75:25 wt (SO₂:O₂) in Nafion 117 @ 25°C & 1.2 bar Δp_{SO_2} – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$\Delta p/\Delta t_{\text{Total}}$	Permeate Composition		$(\Delta p/\Delta t)_{SO_2}$	$(\Delta p/\Delta t)_{O_2}$	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π_{SO_2}	Π_{O_2}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
60.00	40.00	1.20	0.80	25 $\pm$ 1	1	0.000185	0.02580	0.0256	90.99	9.01	0.0233	0.00231	177.80	8.14E-06	8.07E-07	1.21E-14	1.79E-15
60.00	40.00	1.20	0.80		2	0.000185	0.02620	0.0260	90.99	9.01	0.0237	0.00234	177.80	8.27E-06	8.19E-07	1.23E-14	1.82E-15
60.00	40.00	1.20	0.80		3	0.000185	0.02670	0.0265	90.99	9.01	0.0241	0.00239	177.80	8.43E-06	8.35E-07	1.25E-14	1.86E-15

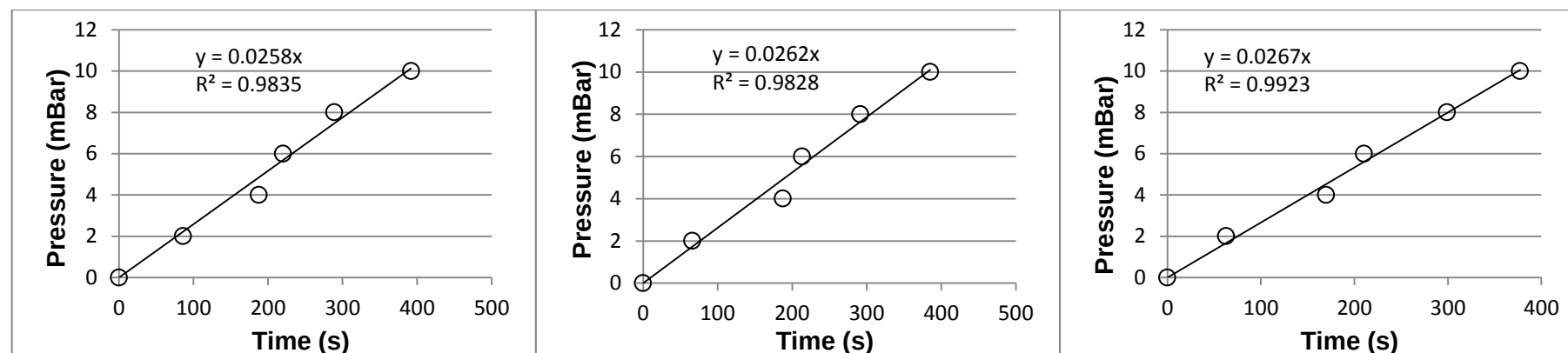


Figure D.58 Permeate pressure-time graphs for 75:25 wt (SO₂:O₂) in Nafion 117 @ 25°C & 1.2 bar Δp_{SO_2} , 1st, 2nd & 3rd trials

Table D.193 Binary flux results of 75:25 wt (SO₂:O₂) in Nafion 117 @ 35°C & 1.2 bar Δp_{SO₂} – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar					
Molar %		Bar ± 0.1		°C		s					
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅
60.00	40.00	1.20	0.80	35 ± 1	1	0.00	101.41	148.05	198.37	241.96	311.09
60.00	40.00	1.20	0.80		2	0.00	95.43	141.26	210.57	260.55	307.87
60.00	40.00	1.20	0.80		3	0.00	112.96	146.31	189.53	250.44	319.35

Table D.194 Binary flux results of 75:25 wt (SO₂:O₂) in Nafion 117 @ 35°C & 1.2 bar Δp_{SO₂} – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO₂}	(Δp/Δt) _{O₂}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO₂}	Π _{O₂}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
60.00	40.00	1.20	0.80	35 ± 1	1	0.000185	0.0310	0.0308	88.94	11.06	0.0274	0.00341	177.80	9.27E-06	1.15E-06	1.37E-14	2.56E-15
60.00	40.00	1.20	0.80		2	0.000185	0.0304	0.0302	88.94	11.06	0.0269	0.00334	177.80	9.09E-06	1.13E-06	1.35E-14	2.51E-15
60.00	40.00	1.20	0.80		3	0.000185	0.0304	0.0302	88.94	11.06	0.0269	0.00334	177.80	9.09E-06	1.13E-06	1.35E-14	2.51E-15

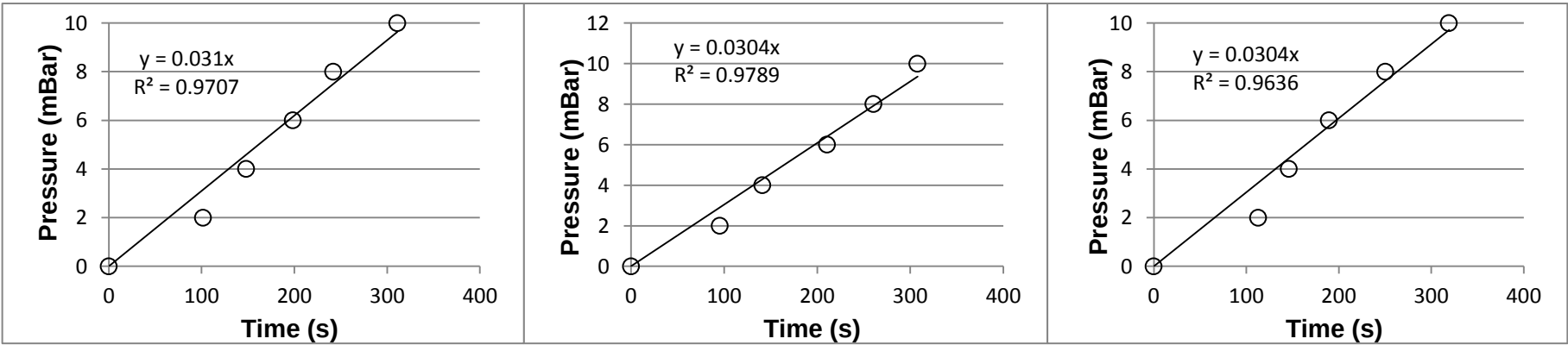


Figure D.59 Permeate pressure-time graphs for 75:25 wt (SO₂:O₂) in Nafion 117 @ 35°C & 1.2 bar Δp_{SO₂}, 1st, 2nd & 3rd trials

Table D.195 Binary flux results of 75:25 wt (SO₂:O₂) in Nafion 117 @ 45°C & 1.2 bar Δpso₂ – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar					
Molar %		Bar ± 0.1		°C		s					
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅
60.00	40.00	1.20	0.80	45 ± 1	1	0.00	46.98	117.73	171.69	228.00	287.55
60.00	40.00	1.20	0.80		2	0.00	53.21	114.64	169.49	236.28	281.02
60.00	40.00	1.20	0.80		3	0.00	58.76	109.1	181.2	225.66	279.66

Table D.196 Binary flux results of 75:25 wt (SO₂:O₂) in Nafion 117 @ 45°C & 1.2 bar Δpso₂ – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
60.00	40.00	1.20	0.80	45 ± 1	1	0.000185	0.03490	0.0347	86.84	13.16	0.0301	0.00457	177.80	9.87E-06	1.50E-06	1.46E-14	3.32E-15
60.00	40.00	1.20	0.80		2	0.000185	0.03500	0.0348	86.84	13.16	0.0302	0.00458	177.80	9.9E-06	1.50E-06	1.470E-14	3.33E-15
60.00	40.00	1.20	0.80		3	0.000185	0.0352	0.0350	86.84	13.16	0.0304	0.00461	177.80	9.96E-06	1.51E-06	1.48E-14	3.35E-15

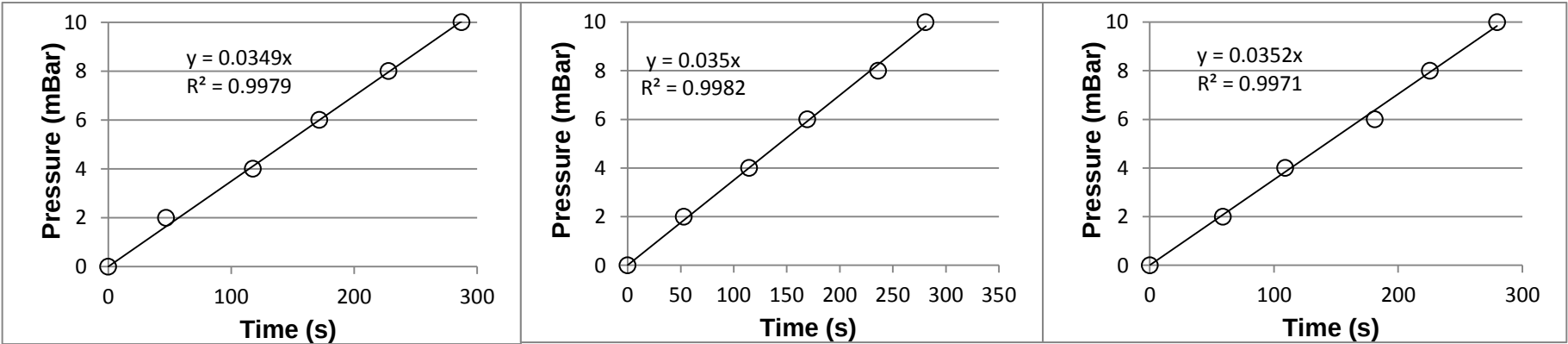


Figure D.60 Permeate pressure-time graphs for 75:25 wt (SO₂:O₂) in Nafion 117 @ 45°C & 1.2 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.197 Binary flux results of 75:25 wt (SO₂:O₂) in Nafion 117 @ 55°C & 1.2 bar Δpso₂ – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar					
Molar %		Bar ± 0.1		°C		s					
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅
60.00	40.00	1.20	0.80	55 ± 1	1	0.00	39.29	88.35	135.16	166.32	237.41
60.00	40.00	1.20	0.80		2	0.00	45.35	102.91	143.93	155.86	236.25
60.00	40.00	1.20	0.80		3	0.00	39.79	88.28	122.27	160.22	230.19

Table D.198 Binary flux results of 75:25 wt (SO₂:O₂) in Nafion 117 @ 55°C & 1.2 bar Δpso₂ – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
60.00	40.00	1.20	0.80	55 ± 1	1	0.000185	0.04430	0.0441	87.31	12.69	0.0385	0.00560	177.80	1.22E-05	1.78E-06	1.81E-14	3.95E-15
60.00	40.00	1.20	0.80		2	0.000185	0.04380	0.0436	87.31	12.69	0.0381	0.00553	177.80	1.21E-05	1.76E-06	1.79E-14	3.9E-15
60.00	40.00	1.20	0.80		3	0.000185	0.04610	0.0459	87.31	12.69	0.0401	0.00583	177.80	1.27E-05	1.85E-06	1.89E-14	4.11E-15

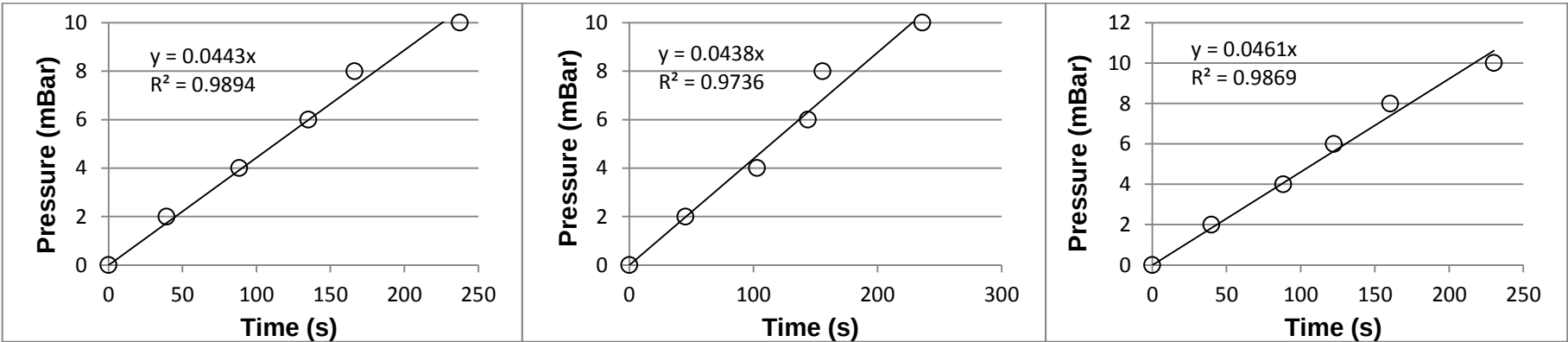


Figure D.61 Permeate pressure-time graphs for 75:25 wt (SO₂:O₂) in Nafion 117 @ 55°C & 1.2 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.199 Binary flux results of 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 15°C & 1.0 bar Δp_{so₂} – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Permeate Δt per Δp=2mBar				
Molar %		Bar ± 0.1		°C		s				
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄
60.00	40.00	1.00	0.67	15 ± 1	1	0.00	202.55	543.25	713.40	889.87
60.00	40.00	1.00	0.67		2	0.00	201.42	510.1	690.6	920.23
60.00	40.00	1.00	0.67		3	0.00	152.41	312.87	612.96	1070.43

Table D.200 Binary flux results of 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 15°C & 1.0 bar Δp_{so₂} – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO₂}	(Δp/Δt) _{O₂}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO₂}	Π _{O₂}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂	± 1	Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
60.00	40.00	1.00	0.67	15	1	0.000185	0.00850	0.0083	98.18	1.82	0.0082	0.00015	75.00	2.95E-06	5.46E-08	2.21E-15	6.14E-17
60.00	40.00	1.00	0.67		2	0.000185	0.00860	0.0084	98.18	1.82	0.0083	0.00015	75.00	2.99E-06	5.52E-08	2.24E-15	6.21E-17
60.00	40.00	1.00	0.67		3	0.000185	0.00840	0.0082	98.18	1.82	0.0081	0.00015	75.00	2.92E-06	5.39E-08	2.19E-15	6.07E-17

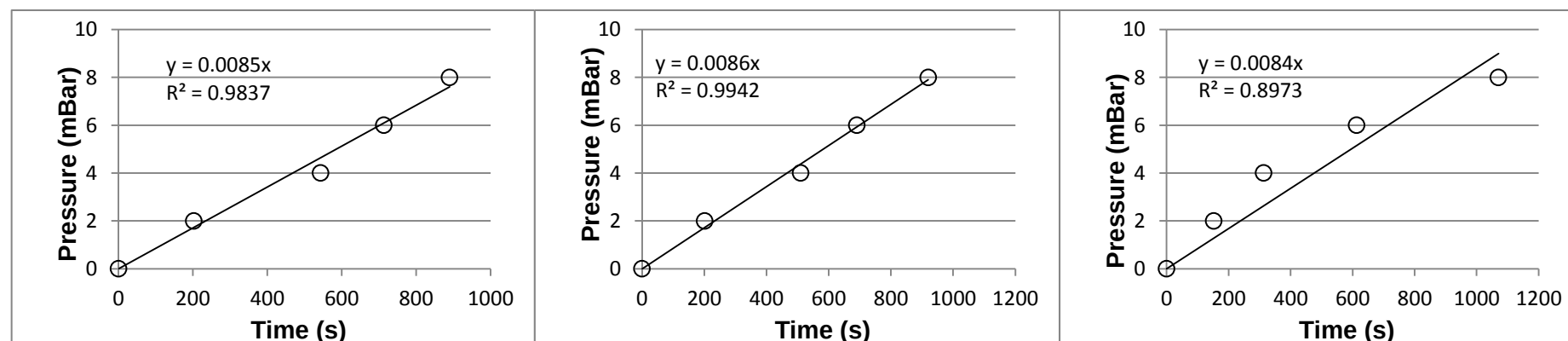


Figure D.62 Permeate pressure-time graphs for 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 15°C & 1.0 bar Δp_{so₂}, 1st, 2nd & 3rd trials

Table D.201 Binary flux results of 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.0 bar Δpso₂ – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar				
Molar %		Bar ± 0.1		°C		s				
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄
60.00	40.00	1.00	0.67	25 ± 1	1	0.00	83.24	190.74	273.56	408.04
60.00	40.00	1.00	0.67		2	0.00	83.19	198.30	289.87	396.86
60.00	40.00	1.00	0.67		3	0.00	84.80	202.85	288.18	395.46

Table D.202 Binary flux results of 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.0 bar Δpso₂ – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{total}	Permeate Composition		(Δp/Δt) _{SO₂}	(Δp/Δt) _{O₂}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO₂}	Π _{O₂}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
60.00	40.00	1.00	0.67	25 ± 1	1	0.000185	0.02050	0.0203	95.92	4.08	0.0195	0.00083	75.00	6.81E-06	2.90E-07	5.11E-15	3.26E-16
60.00	40.00	1.00	0.67		2	0.000185	0.02040	0.0202	95.92	4.08	0.0194	0.00082	75.00	6.78E-06	2.88E-07	5.08E-15	3.24E-16
60.00	40.00	1.00	0.67		3	0.000185	0.02040	0.0202	95.92	4.08	0.0194	0.00082	75.00	6.78E-06	2.88E-07	5.08E-15	3.24E-16

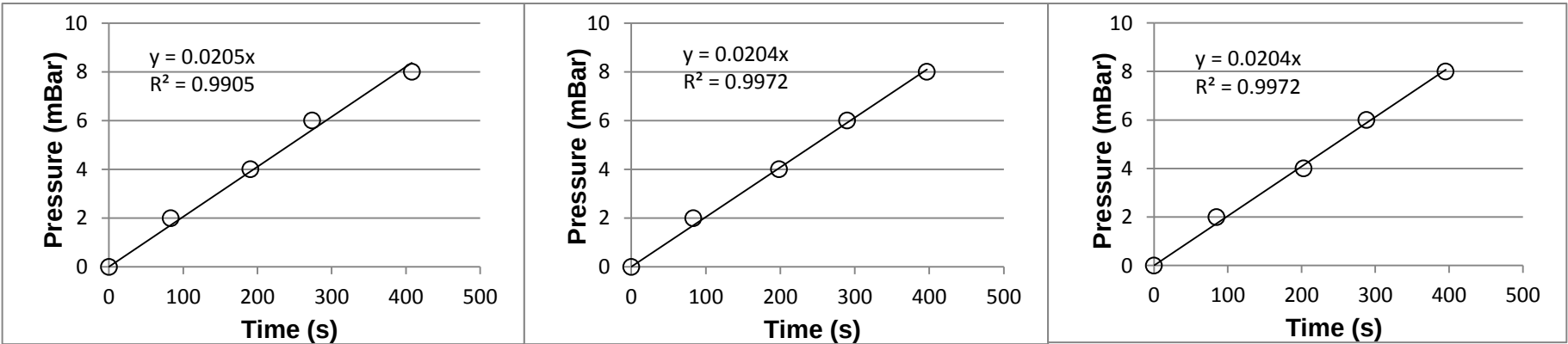


Figure D.63 Permeate pressure-time graphs for 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.0 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.203 Binary flux results of 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 35°C & 1.0 bar Δpso₂ – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar				
Molar %		Bar ± 0.1		°C		s				
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄
60.00	40.00	1.00	0.67	35 ± 1	1	0.00	74.20	157.34	227.88	278.59
60.00	40.00	1.00	0.67		2	0.00	69.72	133.07	213.39	275.80
60.00	40.00	1.00	0.67		3	0.00	58.83	130.84	214.75	290.52

Table D.204 Binary flux results of 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 35°C & 1.0 bar Δpso₂ – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm	mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂							
60.00	40.00	1.00	0.67	35 ± 1	1	0.000185	0.02740	0.0272	96.35	3.65	0.0262	0.00099	75.00	8.86E-06	3.36E-07	6.65E-15	3.78E-16
60.00	40.00	1.00	0.67		2	0.000185	0.02880	0.0286	96.35	3.65	0.0276	0.00104	75.00	9.32E-06	3.53E-07	6.99E-15	3.97E-16
60.00	40.00	1.00	0.67		3	0.000185	0.02820	0.0280	96.35	3.65	0.0270	0.00102	75.00	9.13E-06	3.46E-07	6.84E-15	3.89E-16

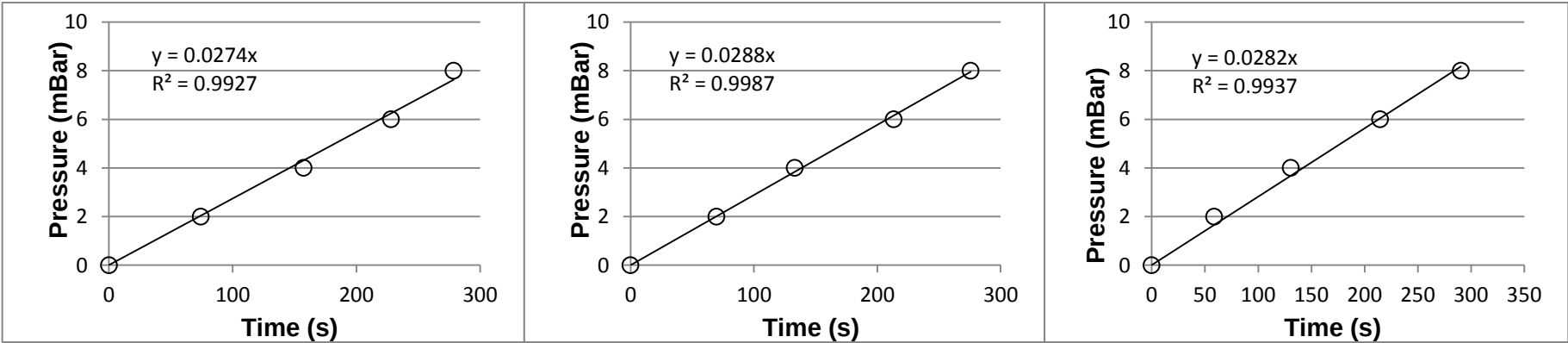


Figure D.64 Permeate pressure-time graphs for 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 35°C & 1.0 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.205 Binary flux results of 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 45°C & 1.0 bar Δpso₂ – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar					
Molar %		Bar ± 0.1		°C		s					
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅
60.00	40.00	1.00	0.67	45 ± 1	1	0.00	45.38	87.68	164.75	223.44	332.19
60.00	40.00	1.00	0.67		2	0.00	55.84	123.89	193.98	210.16	301.95
60.00	40.00	1.00	0.67		3	0.00	61.24	110.30	187.50	241.57	296.97

Table D.206 Binary flux results of 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 45°C & 1.0 bar Δpso₂ – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
60.00	40.00	1.00	0.67	45 ± 1	1	0.000185	0.03320	0.0330	93.18	6.82	0.0308	0.00225	75.00	1.01E-05	7.38E-07	7.55E-15	8.30E-16
60.00	40.00	1.00	0.67		2	0.000185	0.03380	0.0336	93.18	6.82	0.0313	0.00229	75.00	1.03E-05	7.51E-07	7.69E-15	8.45E-16
60.00	40.00	1.00	0.67		3	0.000185	0.03340	0.0332	93.18	6.82	0.0309	0.00227	75.00	1.01E-05	7.42E-07	7.60E-15	8.35E-16

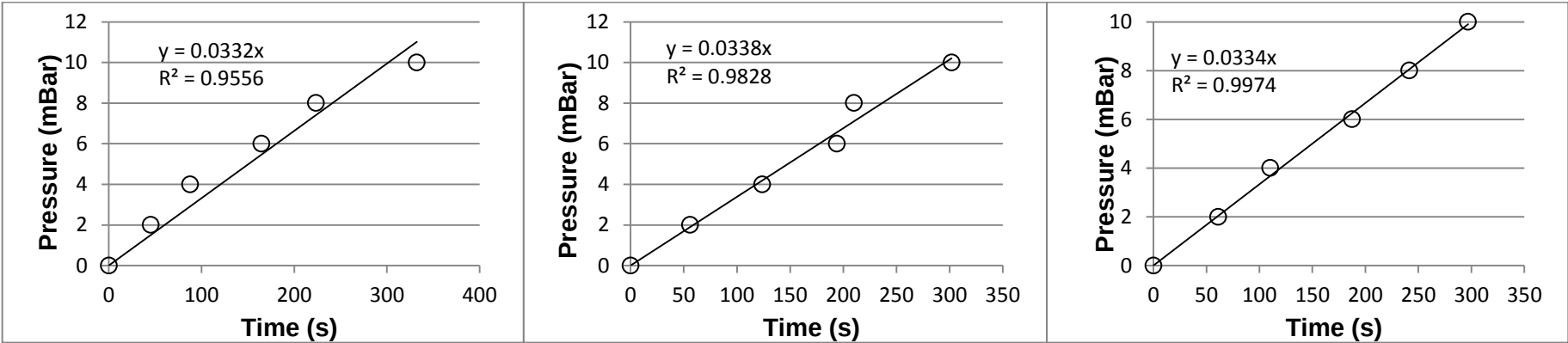


Figure D.65 Permeate pressure-time graphs for 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 45°C & 1.0 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.207 Binary flux results of 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 55°C & 1.0 bar Δp_{so₂} – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar					
Molar %		Bar ± 0.1		°C		s					
SO ₂	O ₂	SO ₂	O ₂	± 1	Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅
60.00	40.00	1.00	0.67	55	1	0.00	31.06	94.43	136.01	212.77	282.26
60.00	40.00	1.00	0.67		2	0.00	29.25	93.58	129.67	235.38	286.99
60.00	40.00	1.00	0.67		3	0.00	35.27	96.73	137.93	196.91	292.56

Table D.208 Binary flux results of 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 55°C & 1.0 bar Δp_{so₂} – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO₂}	(Δp/Δt) _{O₂}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO₂}	Π _{O₂}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
60.00	40.00	1.00	0.67	55 ± 1	1	0.000185	0.03770	0.0375	93.20	6.80	0.0350	0.00255	75.00	1.11E-05	8.10E-07	8.32E-15	9.12E-16
60.00	40.00	1.00	0.67		2	0.000185	0.0363	0.0361	93.20	6.80	0.0337	0.00246	75.00	1.07E-05	7.80E-07	8.01E-15	8.78E-16
60.00	40.00	1.00	0.67		3	0.000185	0.03760	0.0374	93.20	6.80	0.0349	0.00255	75.00	1.11E-05	8.08E-07	8.30E-15	9.09E-16

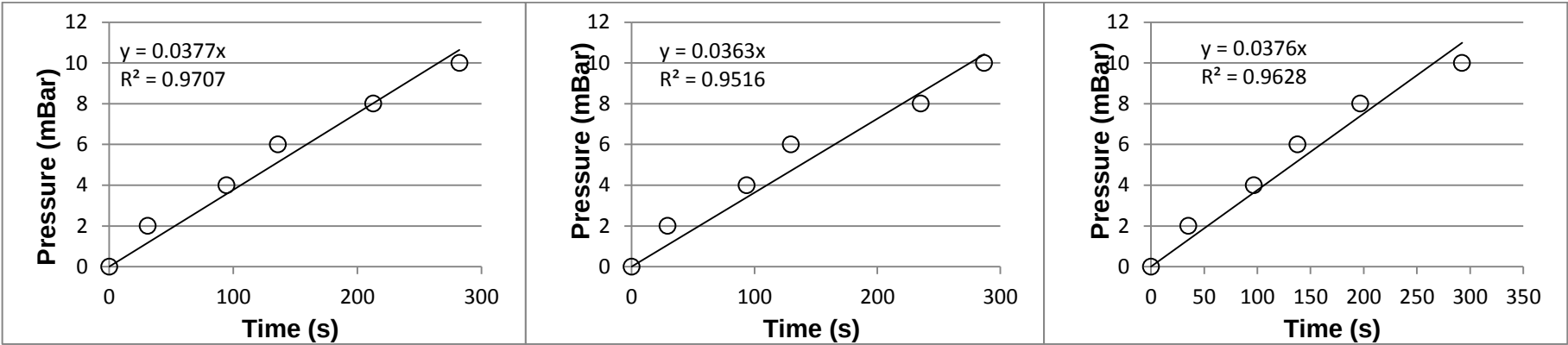


Figure D.66 Permeate pressure-time graphs for 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 55°C & 1.0 bar Δp_{so₂}, 1st, 2nd & 3rd trials

Table D.209 Binary flux results of 50:50 wt (SO₂:O₂) in Nafion 117 @ 15°C & 1.1 bar Δpso₂ – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar							
Molar %		Bar ± 0.1		°C		s							
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅	t ₆	t ₇
33.30	66.70	1.10	2.20	15 ± 1	1	0.00	84.15	151.23	219.81	292.56	347.94	438.47	540.37
33.30	66.70	1.10	2.20		2	0.00	70.49	138.97	205.64	287.18	338.61	420.13	584.99
33.30	66.70	1.10	2.20		3	0.00	111.28	146.53	223.90	314.87	351.39	464.71	551.00

Table D.210 Binary flux results of 50:50 wt (SO₂:O₂) in Nafion 117 @ 15°C & 1.1 bar Δpso₂ – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO₂}	(Δp/Δt) _{O₂}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO₂}	Π _{O₂}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
33.30	66.70	1.10	2.20	15 ± 1	1	0.000185	0.02700	0.0268	82.66	17.34	0.0222	0.00465	177.80	8.01E-06	1.68E-06	1.30E-14	1.36E-15
33.30	66.70	1.10	2.20		2	0.000185	0.02660	0.0264	82.66	17.34	0.0218	0.00458	177.80	7.89E-06	1.66E-06	1.28E-14	1.34E-15
33.30	66.70	1.10	2.20		3	0.000185	0.02600	0.0258	82.66	17.34	0.0213	0.00448	177.80	7.71E-06	1.62E-06	1.25E-14	1.31E-15

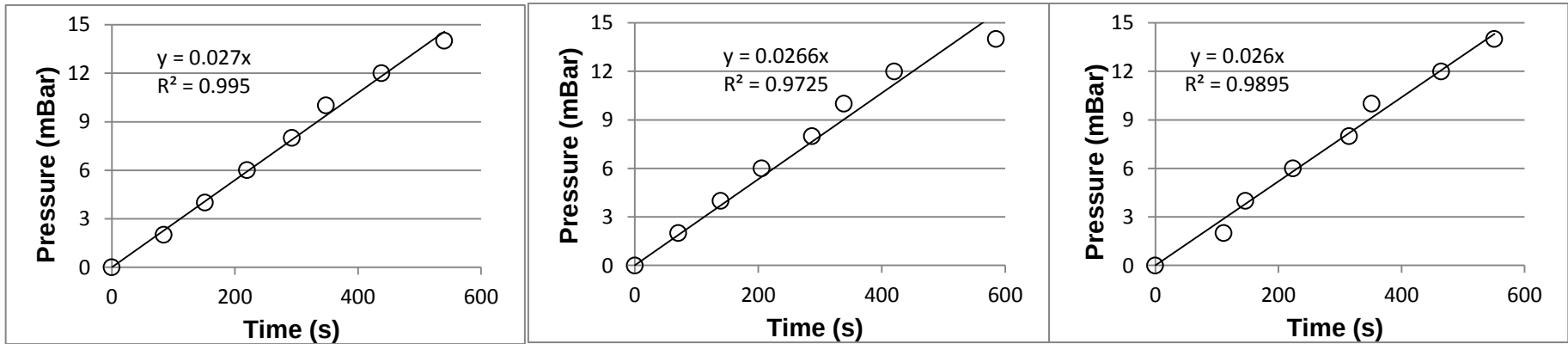


Figure D.67 Permeate pressure-time graphs for 50:50 wt (SO₂:O₂) in Nafion 117 @ 15°C & 1.1 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.211 Binary flux results of 50:50 wt (SO₂:O₂) in Nafion 117 @ 25°C & 1.1 bar Δpso₂ – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar						
Molar %		Bar ± 0.1		°C		s						
SO ₂	O ₂	SO ₂	O ₂	± 1	Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅	t ₆
33.30	66.70	1.10	2.20	25	1	0.00	65.72	147.28	198.19	279.45	331.04	376.53
33.30	66.70	1.10	2.20		2	0.00	41.03	135.18	174.62	257.00	301.48	381.08
33.30	66.70	1.10	2.20		3	0.00	46.54	156.77	187.02	269.55	349.12	357.70

Table D.212 Binary flux results of 50:50 wt (SO₂:O₂) in Nafion 117 @ 25°C & 1.1 bar Δpso₂ – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{so2}	(Δp/Δt) _{o2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{so2}	Π _{o2}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
33.30	66.70	1.10	2.20	25 ± 1	1	0.000185	0.03030	0.0301	84.58	15.42	0.0255	0.00464	177.80	8.90E-06	1.62E-06	1.44E-14	1.31E-15
33.30	66.70	1.10	2.20		2	0.000185	0.03210	0.0319	84.58	15.42	0.0270	0.00492	177.80	9.43E-06	1.72E-06	1.52E-14	1.39E-15
33.30	66.70	1.10	2.20		3	0.000185	0.03070	0.0305	84.58	15.42	0.0258	0.00470	177.80	9.02E-06	1.64E-06	1.46E-14	1.33E-15

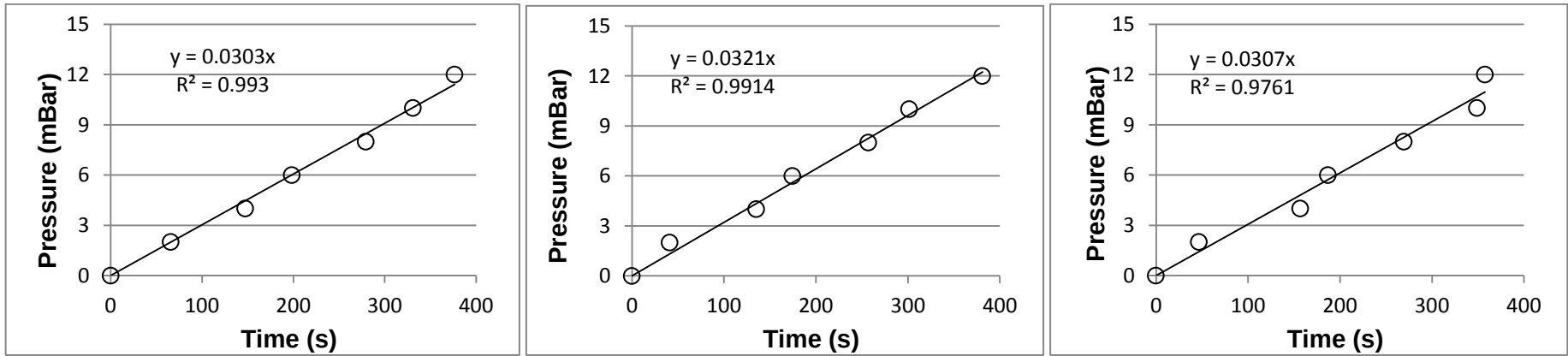


Figure D.68 Permeate pressure-time graphs for 50:50 wt (SO₂:O₂) in Nafion 117 @ 25°C & 1.1 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.213 Binary flux results of 50:50 wt (SO₂:O₂) in Nafion 117 @ 35°C & 1.1 bar Δpso₂ – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar						
Molar %		Bar ± 0.1		°C		s						
SO ₂	O ₂	SO ₂	O ₂	± 1	Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅	t ₆
33.30	66.70	1.10	2.20	35	1	0.00	49.45	110.37	161.23	203.59	242.67	299.10
33.30	66.70	1.10	2.20		2	0.00	55.91	98.71	142.34	186.99	254.79	303.54
33.30	66.70	1.10	2.20		3	0.00	43.24	108.91	157.34	178.66	263.89	311.27

Table D.214 Binary flux results of 50:50 wt (SO₂:O₂) in Nafion 117 @ 35°C & 1.1 bar Δpso₂ – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
33.30	66.70	1.10	2.20	35 ± 1	1	0.000185	0.03970	0.0395	74.38	25.62	0.0294	0.01012	177.80	9.94E-06	3.42E-06	1.61E-14	2.76E-15
33.30	66.70	1.10	2.20		2	0.000185	0.04020	0.0400	74.38	25.62	0.0298	0.01025	177.80	1.01E-05	3.47E-06	1.63E-14	2.80E-15
33.30	66.70	1.10	2.20		3	0.000185	0.03910	0.0389	74.38	25.62	0.0289	0.00997	177.80	9.79E-06	3.37E-06	1.58E-14	2.72E-15

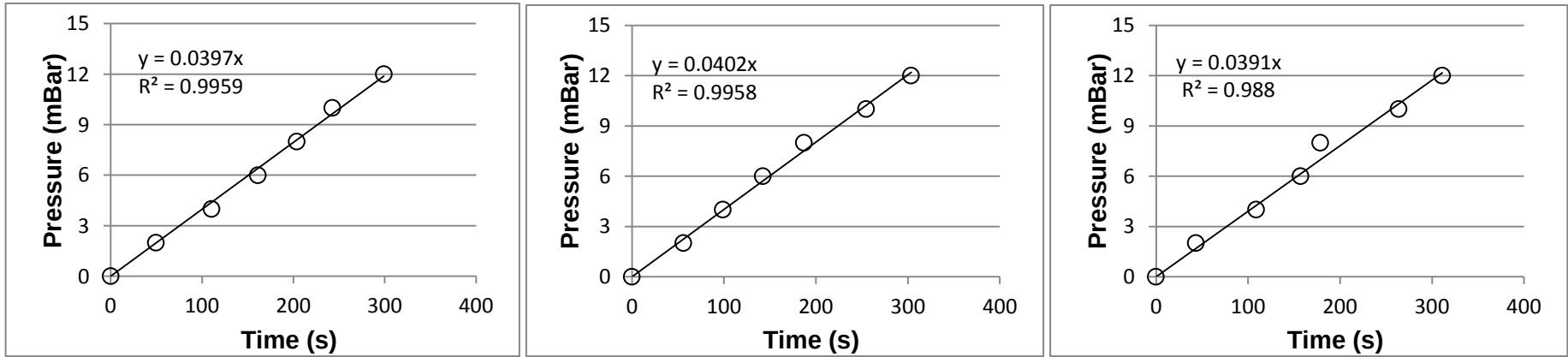


Figure D.69 Permeate pressure-time graphs for 50:50 wt (SO₂:O₂) in Nafion 117 @ 35°C & 1.1 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.215 Binary flux results of 50:50 wt (SO₂:O₂) in Nafion 117 @ 45°C & 1.1 bar Δpso₂ – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar						
Molar %		Bar ± 0.1		°C		s						
SO ₂	O ₂	SO ₂	O ₂	± 1	Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅	t ₆
33.30	66.70	1.10	2.20	45	1	0.00	50.36	70.36	103.06	135.48	197.09	247.04
33.30	66.70	1.10	2.20		2	0.00	40.52	68.32	95.85	147.53	205.48	233.10
33.30	66.70	1.10	2.20		3	0.00	45.68	80.31	125.78	153.54	185.88	226.71

Table D.216 Binary flux results of 50:50 wt (SO₂:O₂) in Nafion 117 @ 45°C & 1.1 bar Δpso₂ – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
33.30	66.70	1.10	2.20	45 ± 1	1	0.000185	0.05150	0.0513	69.93	30.07	0.0359	0.01543	177.80	1.18E-05	5.05E-06	1.90E-14	4.08E-15
33.30	66.70	1.10	2.20		2	0.000185	0.05200	0.0518	69.93	30.07	0.0362	0.01558	177.80	1.19E-05	5.10E-06	1.92E-14	4.12E-15
33.30	66.70	1.10	2.20		3	0.000185	0.05210	0.0519	69.93	30.07	0.0363	0.01561	177.80	1.19E-05	5.11E-06	1.92E-14	4.12E-15

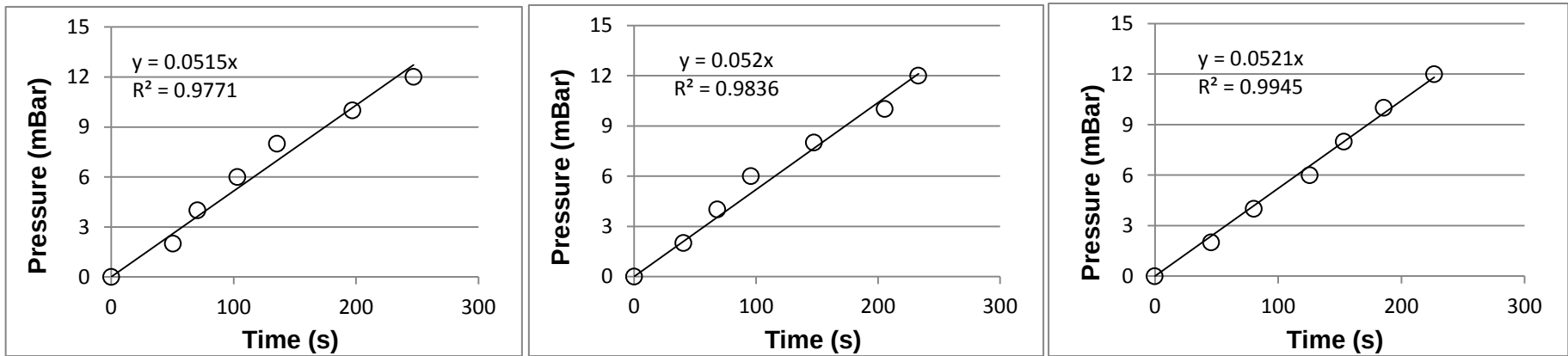


Figure D.70 Permeate pressure-time graphs for 50:50 wt (SO₂:O₂) in Nafion 117 @ 45°C & 1.1 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.217 Binary flux results of 50:50 wt (SO₂:O₂) in Nafion 117 @ 55°C & 1.1 bar Δpso₂ – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar						
Molar %		Bar ± 0.1		°C		s						
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅	t ₆
33.30	66.70	1.10	2.20	55 ± 1	1	0.00	34.99	63.66	87.68	123.46	141.40	210.31
33.30	66.70	1.10	2.20		2	0.00	41.03	66.63	91.37	118.96	154.55	205.45
33.30	66.70	1.10	2.20		3	0.00	46.54	66.40	95.78	117.54	158.18	206.09

Table D.218 Binary flux results of 50:50 wt (SO₂:O₂) in Nafion 117 @ 55°C & 1.1 bar Δpso₂ – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{so2}	Π _{o2}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
33.30	66.70	1.10	2.20	55 ± 1	1	0.000185	0.06250	0.0623	65.77	34.23	0.0410	0.02133	177.80	1.30E-05	6.77E-06	2.10E-14	5.46E-15
33.30	66.70	1.10	2.20		2	0.000185	0.06190	0.0617	65.77	34.23	0.0406	0.02112	177.80	1.29E-05	6.71E-06	2.08E-14	5.41E-15
33.30	66.70	1.10	2.20		3	0.000185	0.06110	0.0609	65.77	34.23	0.0401	0.02085	177.80	1.27E-05	6.62E-06	2.06E-14	5.34E-15

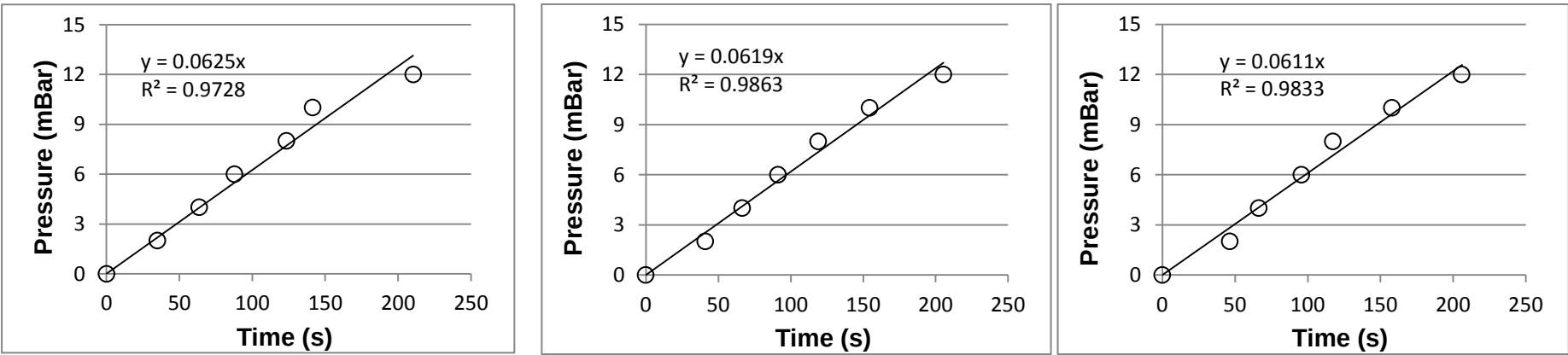


Figure D.71 Permeate pressure-time graphs for 50:50 wt (SO₂:O₂) in Nafion 117 @ 55°C & 1.1 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.219 Binary flux results of 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 15°C & 0.8 bar Δp_{so₂} – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar				
Molar %		Bar ± 0.1		°C		s				
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄
33.30	66.70	0.80	1.60	15 ± 1	1	0.00	134.76	340.21	566.47	673.73
33.30	66.70	0.80	1.60		2	0.00	158.06	368.00	574.77	690.45
33.30	66.70	0.80	1.60		3	0.00	128.58	355.58	527.96	658.52

Table D.220 Binary flux results of 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 15°C & 0.8 bar Δp_{so₂} – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO₂}	(Δp/Δt) _{O₂}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO₂}	Π _{O₂}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
33.30	66.70	0.80	1.60	15 ± 1	1	0.000185	0.01150	0.0113	92.29	7.71	0.0104	0.00087	75.00	3.78E-06	3.15E-07	3.54E-15	1.48E-16
33.30	66.70	0.80	1.60		2	0.000185	0.01110	0.0109	92.29	7.71	0.0101	0.00084	75.00	3.64E-06	3.04E-07	3.41E-15	1.42E-16
33.30	66.70	0.80	1.60		3	0.000185	0.01180	0.0116	92.29	7.71	0.0107	0.00090	75.00	3.88E-06	3.24E-07	3.63E-15	1.51E-16

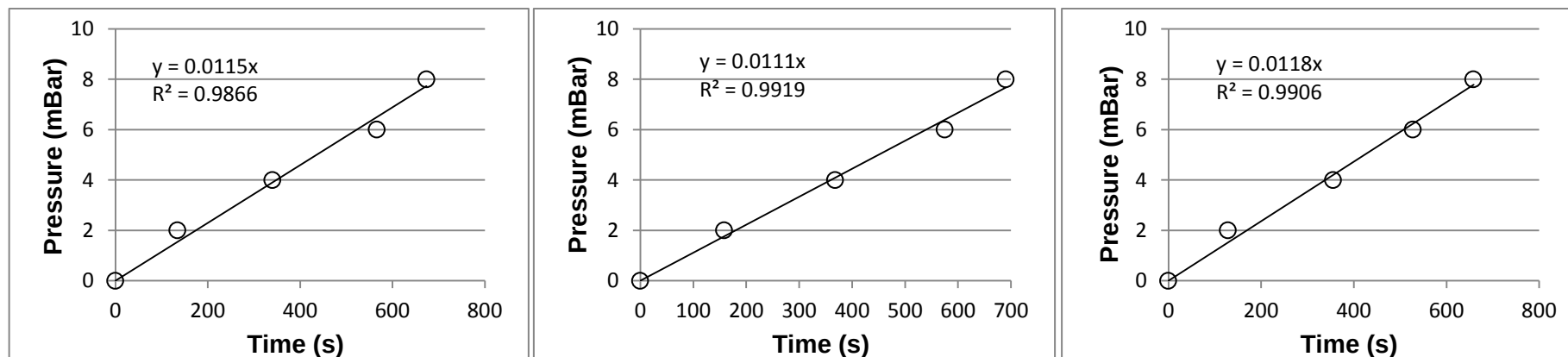


Figure D.72 Permeate pressure-time graphs for 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 15°C & 0.8 bar Δp_{so₂}, 1st, 2nd & 3rd trials

Table D.221 Binary flux results of 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.8 bar Δpso₂ – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar				
Molar %		Bar ± 0.1		°C		s				
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄
33.30	66.70	0.80	1.60	25 ± 1	1	0.00	138.77	265.38	420.11	471.07
33.30	66.70	0.80	1.60		2	0.00	121.76	238.78	392.96	488.79
33.30	66.70	0.80	1.60		3	0.00	111.45	186.37	410.3	498.34

Table D.222 Binary flux results of 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.8 bar Δpso₂ – Calculated Data

Upstream Composition n		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
33.30	66.70	0.80	1.60	25 ± 1	1	0.000185	0.01560	0.0154	91.11	8.89	0.0140	0.00137	75.00	4.91E-06	4.79E-07	4.60E-15	2.24E-16
33.30	66.70	0.80	1.60		2	0.000185	0.01610	0.0159	91.11	8.89	0.0145	0.00141	75.00	5.07E-06	4.94E-07	4.75E-15	2.31E-16
33.30	66.70	0.80	1.60		3	0.000185	0.01600	0.0158	91.11	8.89	0.0144	0.00141	75.00	5.03E-06	4.91E-07	4.72E-15	2.30E-16

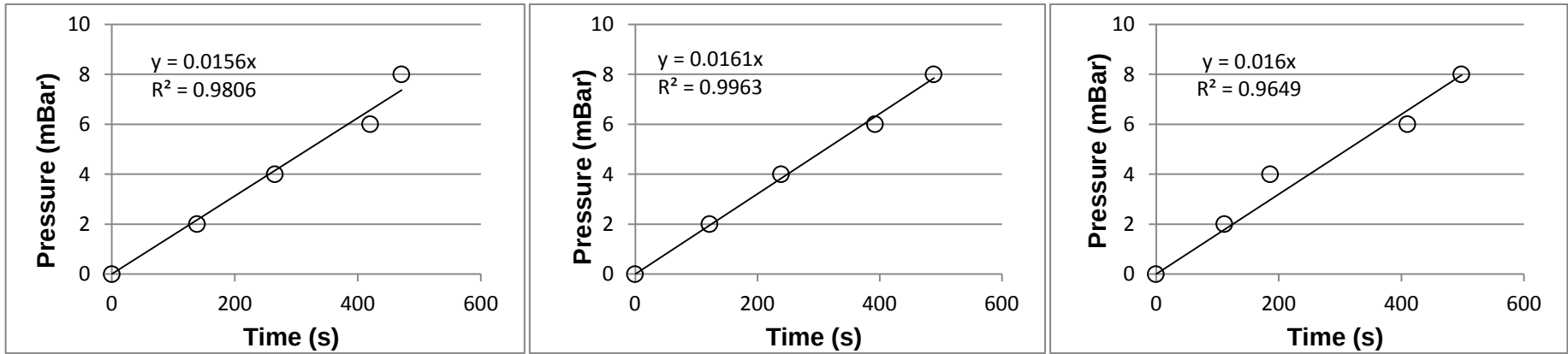


Figure D.73 Permeate pressure-time graphs for 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.8 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.223 Binary flux results of 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 35°C & 0.8 bar Δpso₂ – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar				
Molar %		Bar ± 0.1		°C		s				
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄
33.30	66.70	0.80	1.60	35 ± 1	1	0.00	94.08	170.65	291.79	370.00
33.30	66.70	0.80	1.60		2	0.00	105.47	191.57	276.21	350.45
33.30	66.70	0.80	1.60		3	0.00	98.61	142.24	290.68	341.69

Table D.224 Binary flux results of 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 35°C & 0.8 bar Δpso₂ – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{total}	Permeate Composition		(Δp/Δt) _{so2}	(Δp/Δt) _{o2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{so2}	Π _{o2}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
33.30	66.70	0.80	1.60	35 ± 1	1	0.000185	0.02150	0.0213	87.48	12.52	0.0186	0.00267	75.00	6.30E-06	9.02E-07	5.91E-15	4.22E-16
33.30	66.70	0.80	1.60		2	0.000185	0.02200	0.0218	87.48	12.52	0.0191	0.00273	75.00	6.45E-06	9.23E-07	6.05E-15	4.32E-16
33.30	66.70	0.80	1.60		3	0.000185	0.02270	0.0225	87.48	12.52	0.0197	0.00282	75.00	6.66E-06	9.53E-07	6.24E-15	4.46E-16

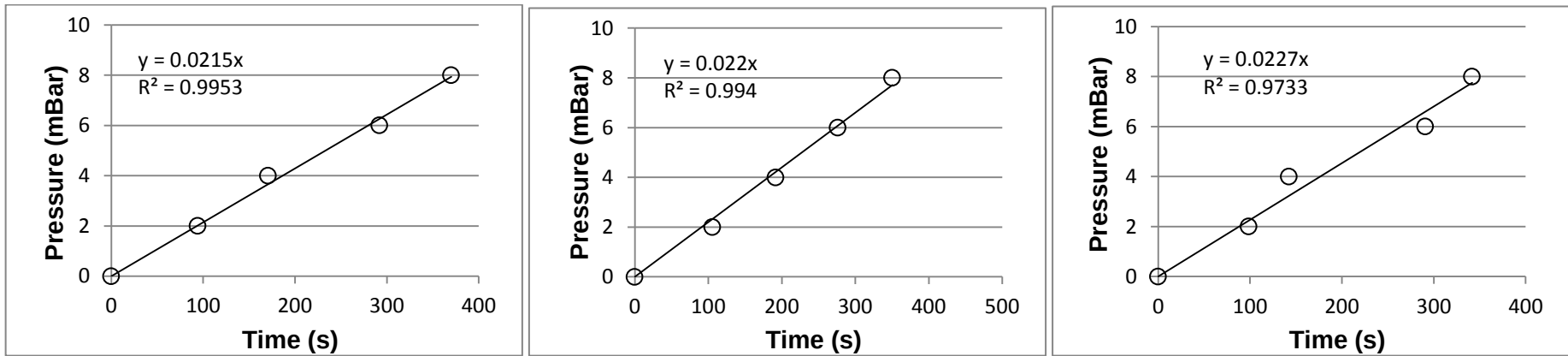


Figure D.74 Permeate pressure-time graphs for 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 35°C & 0.8 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.225 Binary flux results of 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 45°C & 0.8 bar Δpso₂ – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar					
Molar %		Bar ± 0.1		°C		s					
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅
33.30	66.70	0.80	1.60	45 ± 1	1	0.00	77.98	159.04	230.58	312.58	
33.30	66.70	0.80	1.60		2	0.00	75.92	152.86	214.25	276.63	411.24
33.30	66.70	0.80	1.60		3	0.00	90.20	148.10	230.33	308.24	404.71

Table D.226 Binary flux results of 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 45°C & 0.8 bar Δpso₂ – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm	mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂							
33.30	66.70	0.80	1.60	45 ± 1	1	0.000185	0.02570	0.0255	84.81	15.19	0.0216	0.00388	75.00	7.09E-06	1.27E-06	6.64E-15	5.94E-16
33.30	66.70	0.80	1.60		2	0.000185	0.02610	0.0259	84.81	15.19	0.0220	0.00394	75.00	7.20E-06	1.29E-06	6.75E-15	6.03E-16
33.30	66.70	0.80	1.60		3	0.000185	0.02540	0.0252	84.81	15.19	0.0214	0.00383	75.00	7.00E-06	1.25E-06	6.56E-15	5.87E-16

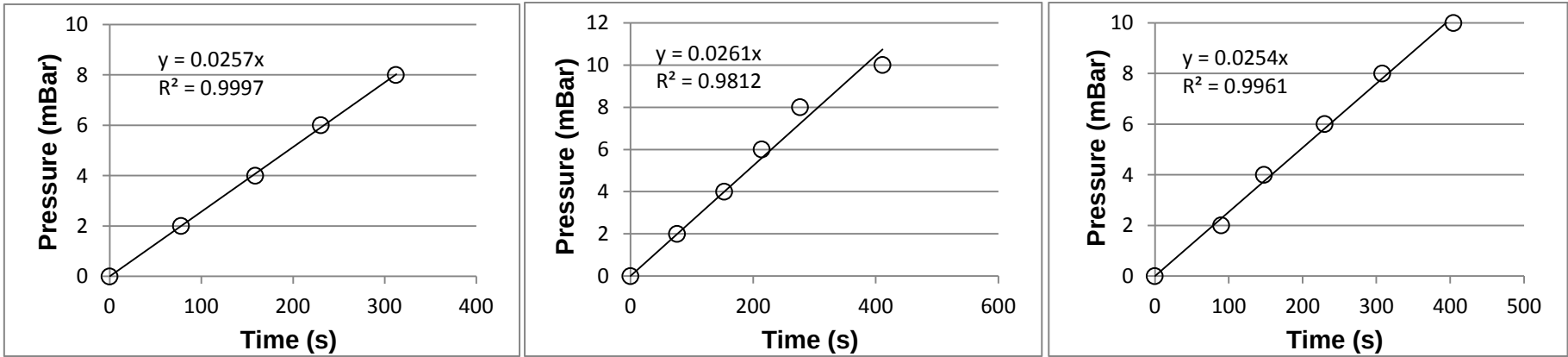


Figure D.75 Permeate pressure-time graphs for 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 45°C & 0.8 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.227 Binary flux results of 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 55°C & 0.8 bar Δpso₂ – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar					
Molar %		Bar ± 0.1		°C		s					
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅
33.30	66.70	0.80	1.60	55 ± 1	1	0.00	55.88	101.89	176.10	235.19	326.26
33.30	66.70	0.80	1.60		2	0.00	91.98	134.38	164.11	221.99	290.43
33.30	66.70	0.80	1.60		3	0.00	69.97	107.12	208.58	240.86	300.12

Table D.228 Binary flux results of 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 55°C & 0.8 bar Δpso₂ – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm	mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂							
33.30	66.70	0.80	1.60	55 ± 1	1	0.000185	0.03260	0.0324	80.42	19.58	0.0261	0.00635	75.00	8.28E-06	2.01E-06	7.76E-15	9.43E-16
33.30	66.70	0.80	1.60		2	0.000185	0.03410	0.0339	80.42	19.58	0.0273	0.00664	75.00	8.66E-06	2.11E-06	8.12E-15	9.87E-16
33.30	66.70	0.80	1.60		3	0.000185	0.03240	0.0322	80.42	19.58	0.0259	0.00631	75.00	8.23E-06	2.00E-06	7.71E-15	9.37E-16

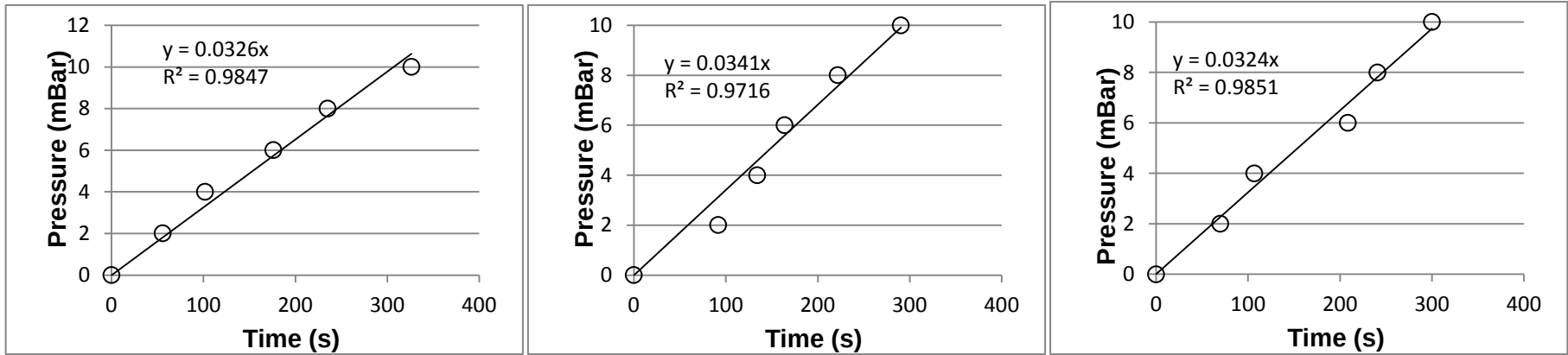


Figure D.76 Permeate pressure-time graphs for 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 55°C & 0.8 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.229 Binary flux results of 25:75 wt (SO₂:O₂) in Nafion 117 @ 15°C & 1.2 bar Δp_{so₂} – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar				
Molar %		Bar		°C		s				
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄
14.10	85.90	1.20	7.31	15 ± 1	1	0.00	103.87	221.36	328.93	387.21
14.10	85.90	1.20	7.31		2	0.00	110.49	230.42	333.47	416.39
14.10	85.90	1.20	7.31		3	0.00	97.43	244.99	321.60	422.81

Table D.230 Binary flux results of 25:75 wt (SO₂:O₂) in Nafion 117 @ 15°C & 1.2 bar Δp_{so₂} – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Run	Temp	Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{so₂}	(Δp/Δt) _{o₂}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{so₂}	Π _{o₂}
Molar %		Bar			°C	mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂						SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
14.10	85.90	1.20	7.31	1	15 ± 1	0.000185	0.01940	0.0192	72.37	27.63	0.0139	0.00531	177.80	5.03E-06	1.92E-06	7.45E-15	4.67E-16
14.10	85.90	1.20	7.31	2		0.000185	0.01850	0.0183	72.37	27.63	0.0133	0.00506	177.80	4.79E-06	1.83E-06	7.10E-15	4.45E-16
14.10	85.90	1.20	7.31	3		0.000185	0.01840	0.0182	72.37	27.63	0.0132	0.00503	177.80	4.77E-06	1.82E-06	7.06E-15	4.43E-16

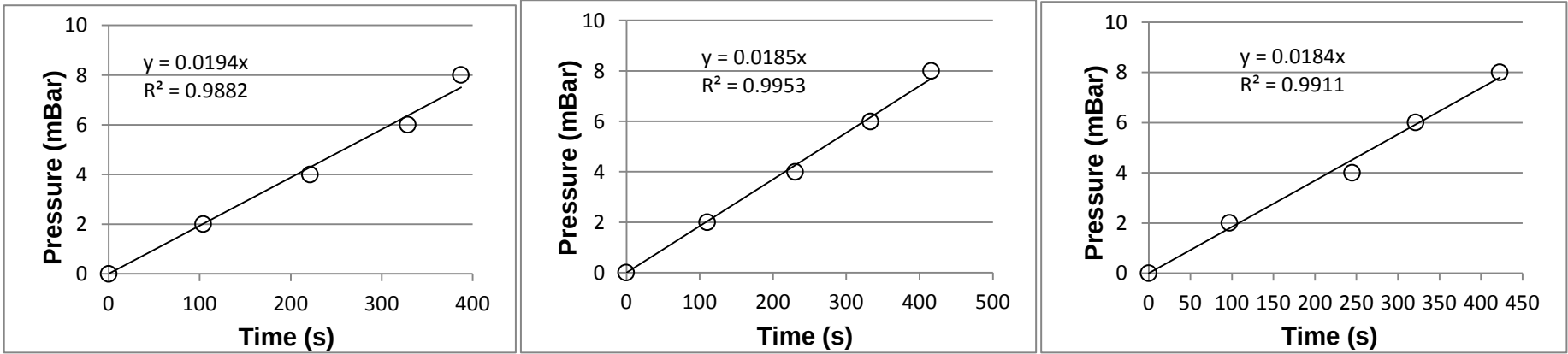


Figure D.77 Permeate pressure-time graphs for 25:75 wt (SO₂:O₂) in Nafion 117 @ 15°C & 1.2 bar Δp_{so₂}, 1st, 2nd & 3rd trials

Table D.231 Binary flux results of 25:75 wt (SO₂:O₂) in Nafion 117 @ 25°C & 1.2 bar Δp_{SO_2} – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per $\Delta p=2\text{mBar}$				
Molar %		Bar		°C		s				
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄
14.10	85.90	1.20	7.31	25 ± 1	1	0.00	29.74	130.18	181.98	234.64
14.10	85.90	1.20	7.31		2	0.00	65.86	121.20	181.10	243.59
14.10	85.90	1.20	7.31		3	0.00	67.74	106.29	190.38	231.08

Table D.232 Binary flux results of 25:75 wt (SO₂:O₂) in Nafion 117 @ 25°C & 1.2 bar Δp_{SO_2} – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Run	Temp	$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$\Delta p/\Delta t_{\text{total}}$	Permeate Composition		$(\Delta p/\Delta t)_{SO_2}$	$(\Delta p/\Delta t)_{O_2}$	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π_{SO_2}	Π_{O_2}
Molar %		Bar			°C	mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm	mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
SO ₂	O ₂	SO ₂	O ₂						SO ₂	O ₂							
14.10	85.90	1.20	7.31	1	25 ± 1	0.000185	0.03350	0.0333	68.33	31.67	0.0228	0.01055	177. 0	7.95E-06	3.69E-06	1.18E-14	8.97E-16
14.10	85.90	1.20	7.31	2		0.000185	0.03290	0.0327	68.33	31.67	0.0224	0.01036	177.80	7.81E-06	3.62E-06	1.16E-14	8.81E-16
14.10	85.90	1.20	7.31	3		0.000185	0.03370	0.0335	68.33	31.67	0.0229	0.01061	177.80	8.00E-06	3.71E-06	1.19E-14	9.02E-16

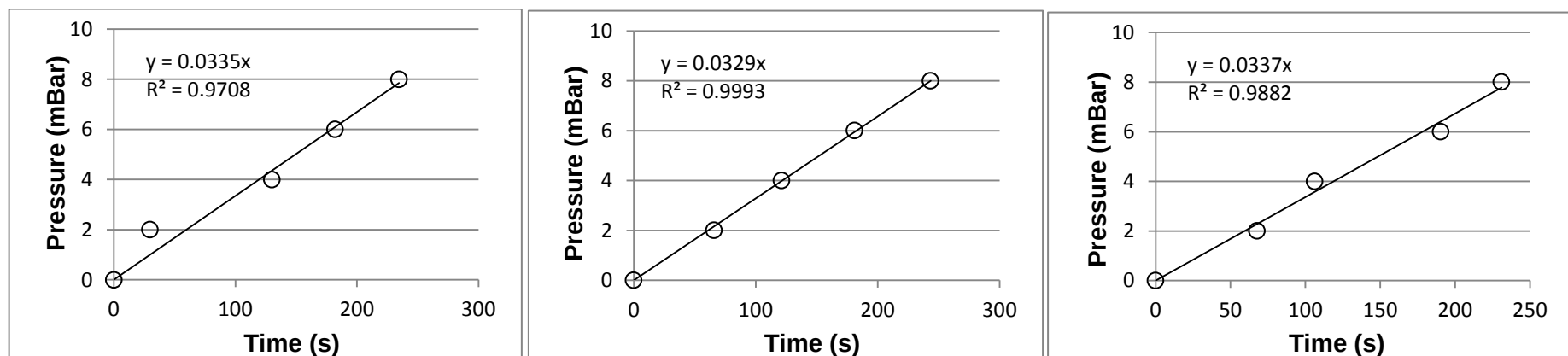


Figure D.78 Permeate pressure-time graphs for 25:75 wt (SO₂:O₂) in Nafion 117 @ 25°C & 1.2 bar Δp_{SO_2} , 1st, 2nd & 3rd trials

Table D.233 Binary flux results of 25:75 wt (SO₂:O₂) in Nafion 117 @ 35°C & 1.2 bar Δp_{SO_2} – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per $\Delta p=2\text{mBar}$					
Molar %		Bar		°C		s					
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅
14.10	85.90	1.20	7.31	35 ± 1	1	0.00	39.27	80.29	129.54	182.59	207.28
14.10	85.90	1.20	7.31		2	0.00	35.66	77.60	119.21	190.19	215.99
14.10	85.90	1.20	7.31		3	0.00	43.03	81.41	109.25	179.45	210.16

Table D.234 Binary flux results of 25:75 wt (SO₂:O₂) in Nafion 117 @ 35°C & 1.2 bar Δp_{SO_2} – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$\Delta p/\Delta t_{\text{Total}}$	Permeate Composition		$(\Delta p/\Delta t)_{SO_2}$	$(\Delta p/\Delta t)_{O_2}$	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π_{SO_2}	Π_{O_2}
Molar %		Bar		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm	mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂							
14.10	85.90	1.20	7.31	35 ± 1	1	0.000185	0.04660	0.0464	62.82	37.18	0.0292	0.01726	177.80	9.86E-06	5.83E-06	1.46E-14	1.42E-15
14.10	85.90	1.20	7.31		2	0.000185	0.04580	0.0456	62.82	37.18	0.0287	0.01696	177.80	9.69E-06	5.73E-06	1.44E-14	1.39E-15
14.10	85.90	1.20	7.31		3	0.000185	0.04760	0.0474	62.82	37.18	0.0298	0.01763	177.80	1.01E-05	5.96E-06	1.49E-14	1.45E-15

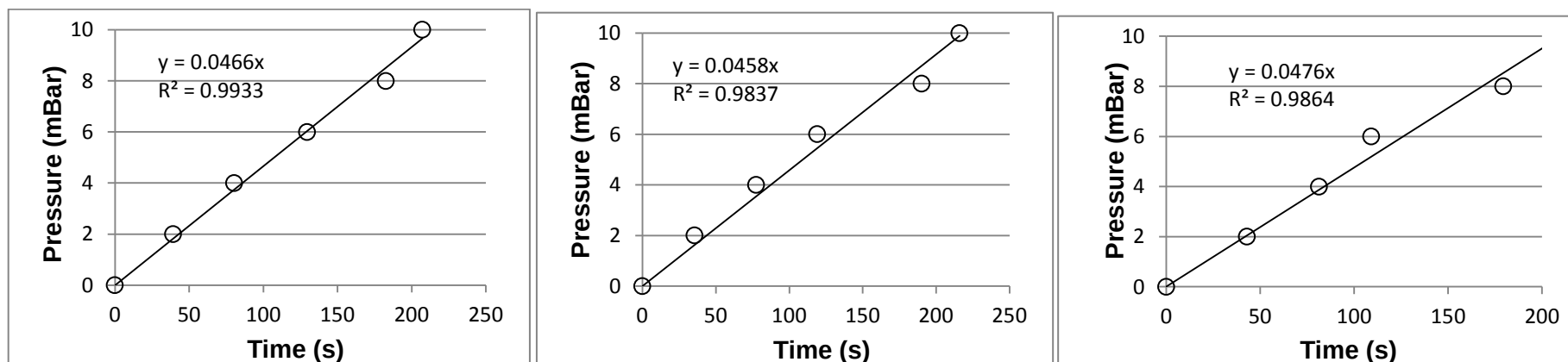


Figure D.79 Permeate pressure-time graphs for 25:75 wt (SO₂:O₂) in Nafion 117 @ 35°C & 1.2 bar Δp_{SO_2} , 1st, 2nd & 3rd trials

Table D.235 Binary flux results of 25:75 wt (SO₂:O₂) in Nafion 117 @ 45°C & 1.2 bar Δp_{SO_2} – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per $\Delta p=2\text{mBar}$					
Molar %		Bar		°C		s					
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅
14.10	85.90	1.20	7.31	45 ± 1	1	0.00	43.34	65.75	111.46	142.64	189.76
14.10	85.90	1.20	7.31		2	0.00	39.62	57.49	95.43	139.60	185.11
14.10	85.90	1.20	7.31		3	0.00	46.63	76.83	103.25	129.78	178.06

Table D.236 Binary flux results of 25:75 wt (SO₂:O₂) in Nafion 117 @ 45°C & 1.2 bar Δp_{SO_2} – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$\Delta p/\Delta t_{\text{Total}}$	Permeate Composition		$(\Delta p/\Delta t)_{SO_2}$	$(\Delta p/\Delta t)_{O_2}$	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π_{SO_2}	Π_{O_2}
Molar %		Bar		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
14.10	85.90	1.20	7.31	45 ± 1	1	0.000185	0.05410	0.0539	55.86	44.14	0.0301	0.02380	177.80	9.86E-06	7.79E-06	1.46E-14	1.90E-15
14.10	85.90	1.20	7.31		2	0.000185	0.05680	0.0566	55.86	44.14	0.0316	0.02499	177.80	1.04E-05	8.18E-06	1.53E-14	1.99E-15
14.10	85.90	1.20	7.31		3	0.000185	0.05710	0.0569	55.86	44.14	0.0318	0.02512	177.80	1.04E-05	8.23E-06	1.54E-14	2.00E-15

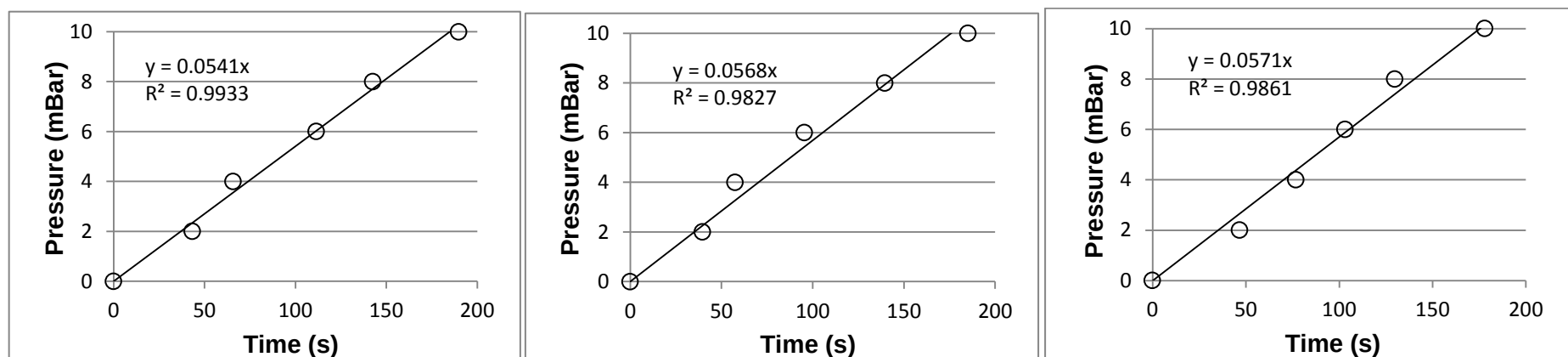


Figure D.80 Permeate pressure-time graphs for 25:75 wt (SO₂:O₂) in Nafion 117 @ 45°C & 1.2 bar Δp_{SO_2} , 1st, 2nd & 3rd trials

Table D.237 Binary flux results of 25:75 wt (SO₂:O₂) in Nafion 117 @ 55°C & 1.2 bar Δpso₂ – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar					
Molar %		Bar		°C		s					
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅
14.10	85.90	1.20	7.31	55 ± 1	1	0.00	26.13	44.28	71.67	92.91	110.38
14.10	85.90	1.20	7.31		2	0.00	37.22	51.52	69.56	88.97	109.33
14.10	85.90	1.20	7.31		3	0.00	26.54	46.91	62.40	90.08	112.96

Table D.238 Binary flux results of 25:75 wt (SO₂:O₂) in Nafion 117 @ 55°C & 1.2 bar Δpso₂ – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
14.10	85.90	1.20	7.31	55 ± 1	1	0.000185	0.08770	0.0875	47.44	52.56	0.0415	0.04600	177.80	1.32E-05	1.46E-05	1.95E-14	3.55E-15
14.10	85.90	1.20	7.31		2	0.000185	0.08710	0.0869	47.44	52.56	0.0412	0.04569	177.80	1.31E-05	1.45E-05	1.94E-14	3.53E-15
14.10	85.90	1.20	7.31		3	0.000185	0.08910	0.0889	47.44	52.56	0.0422	0.04674	177.80	1.34E-05	1.48E-05	1.98E-14	3.61E-15

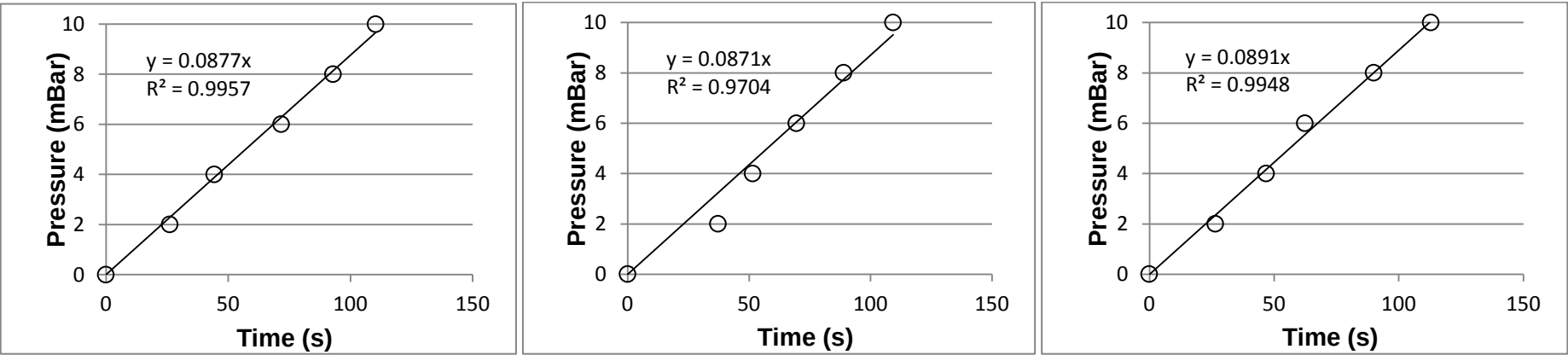


Figure D.81 Permeate pressure-time graphs for 25:75 wt (SO₂:O₂) in Nafion 117 @ 55°C & 1.2 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.239 Binary flux results of 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 15°C & 1.2 bar Δp_{so₂} – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar					
Molar %		Bar		°C		s					
SO ₂	O ₂	SO ₂	O ₂	± 1	Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅
14.10	85.90	1.20	7.31	15	1	0.00	160.31	280.09	460.37	680.53	
14.10	85.90	1.20	7.31		2	0.00	138.66	260.56	450.37	670.51	
14.10	85.90	1.20	7.31		3	0.00	149.23	247.75	467.49	643.48	

Table D.240 Binary flux results of 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 15°C & 1.2 bar Δp_{so₂} – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO₂}	(Δp/Δt) _{O₂}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO₂}	Π _{O₂}
Molar %		Bar		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
14.10	85.90	1.20	7.31	15 ± 1	1	0.000185	0.01240	0.0122	86.14	13.86	0.0105	0.00169	75.00	3.80E-06	6.12E-07	2.38E-15	6.28E-17
14.10	85.90	1.20	7.31		2	0.000185	0.01270	0.0125	86.14	13.86	0.0108	0.00173	75.00	3.90E-06	6.27E-07	2.44E-15	6.43E-17
14.10	85.90	1.20	7.31		3	0.000185	0.01290	0.0127	86.14	13.86	0.0110	0.00176	75.00	3.96E-06	6.37E-07	2.47E-15	6.54E-17

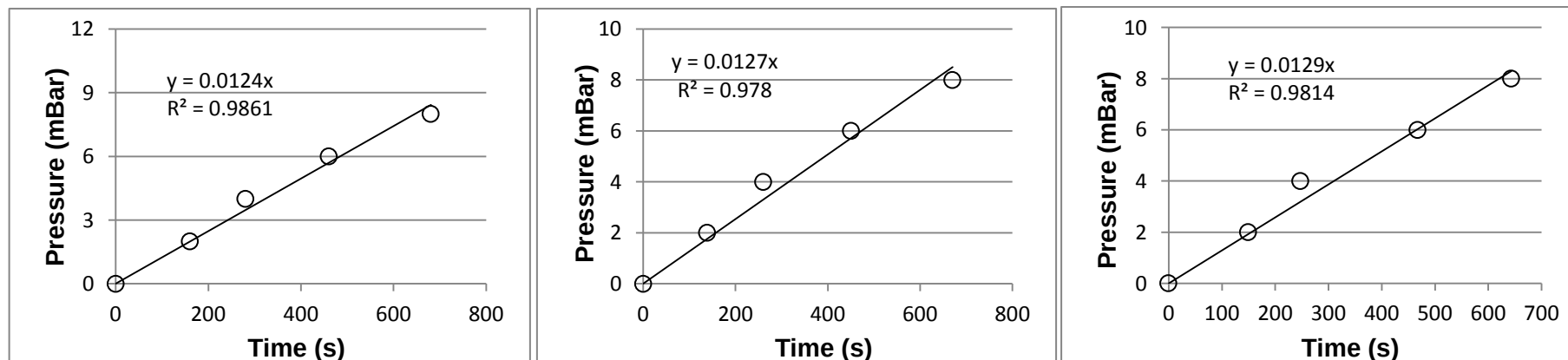


Figure D.82 Permeate pressure-time graphs for 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 15°C & 1.2 bar Δp_{so₂}, 1st, 2nd & 3rd trials

Table D.241 Binary flux results of 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.2 bar Δpso₂ – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar					
Molar %		Bar		°C		s					
SO ₂	O ₂	SO ₂	O ₂	± 1	Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅
14.10	85.90	1.20	7.31	25	1	0.00	125.33	308.98	444.96	532.88	670.32
14.10	85.90	1.20	7.31		2	0.00	110.76	289.48	398.94	573.21	719.41
14.10	85.90	1.20	7.31		3	0.00	206.21	268.45	387.48	555.41	

Table D.242 Binary flux results of 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.2 bar Δpso₂ – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm	mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂							
14.10	85.90	1.20	7.31	25 ± 1	1	0.000185	0.01450	0.0143	81.07	18.93	0.0116	0.00271	75.00	4.05E-06	9.47E-07	2.53E-15	9.72E-17
14.10	85.90	1.20	7.31		2	0.000185	0.01410	0.0139	81.07	18.93	0.0113	0.00263	75.00	3.94E-06	9.21E-07	2.46E-15	9.44E-17
14.10	85.90	1.20	7.31		3	0.000185	0.01440	0.0142	81.07	18.93	0.0115	0.00269	75.00	4.03E-06	9.40E-07	2.52E-15	9.65E-17

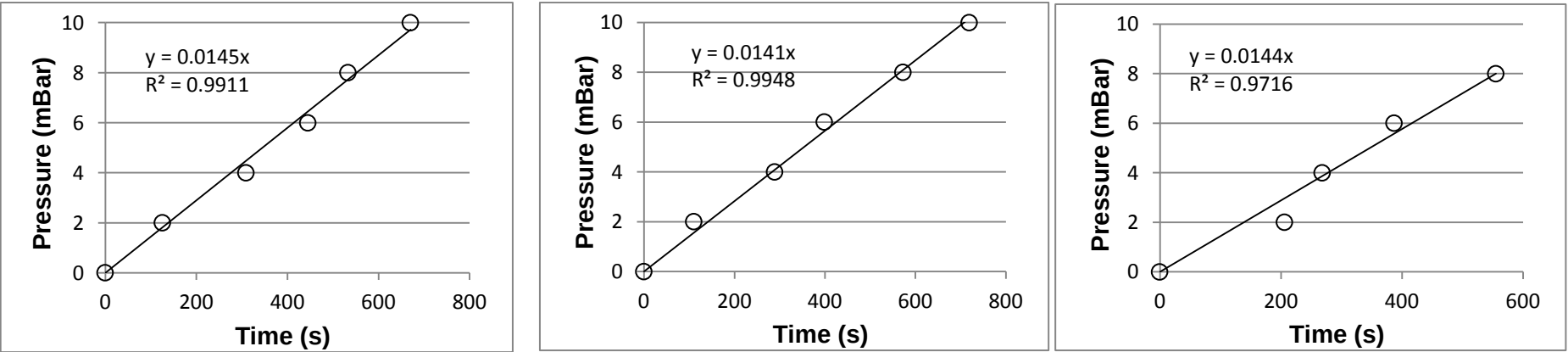


Figure D.83 Permeate pressure-time graphs for 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.2 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.243 Binary flux results of 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 35°C & 1.2 bar Δpso₂ – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar						
Molar %		Bar		°C		s						
SO ₂	O ₂	SO ₂	O ₂	± 1	Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅	t ₆
14.10	85.90	1.20	7.31	35	1	0.00	56.86	121.39	173.54	253.50	280.14	
14.10	85.90	1.20	7.31		2	0.00	68.84	108.67	166.71	240.79	273.92	
14.10	85.90	1.20	7.31		3	0.00	44.14	88.05	163.02	227.35	291.43	367.21

Table D.244 Binary flux results of 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 35°C & 1.2 bar Δpso₂ – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
14.10	85.90	1.20	7.31	35 ± 1	1	0.000185	0.03390	0.0337	75.99	24.01	0.0256	0.00809	75.00	8.66E-06	2.74E-06	5.41E-15	2.81E-16
14.10	85.90	1.20	7.31		2	0.000185	0.03520	0.0350	75.99	24.01	0.0266	0.00841	75.00	9.00E-06	2.84E-06	5.62E-15	2.92E-16
14.10	85.90	1.20	7.31		3	0.000185	0.03430	0.0341	75.99	24.01	0.0259	0.00819	75.00	8.76E-06	2.77E-06	5.48E-15	2.84E-16

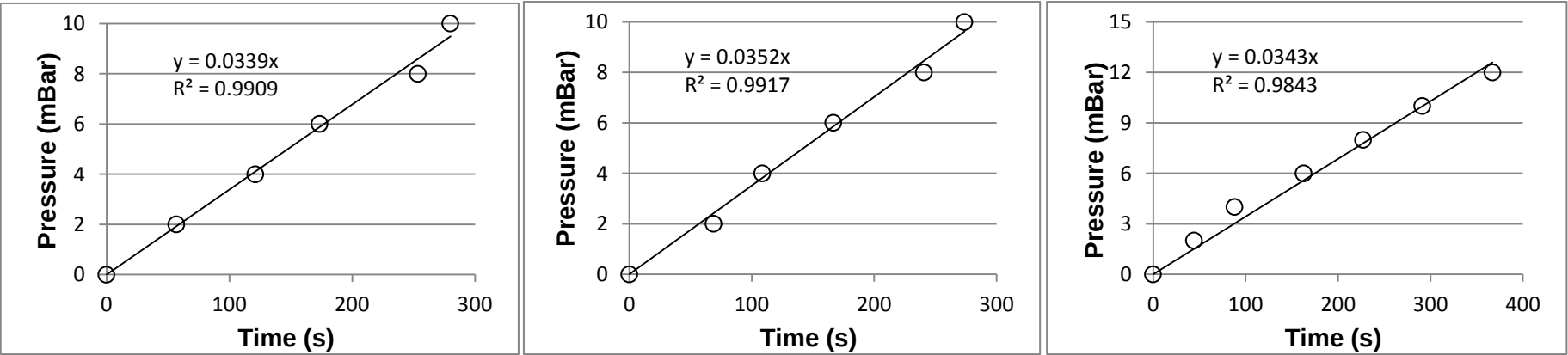


Figure D.84 Permeate pressure-time graphs for 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 35°C & 1.2 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.245 Binary flux results of 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 45°C & 1.2 bar Δpso₂ – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar					
Molar %		Bar		°C		s					
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅
14.10	85.90	1.20	7.31	45 ± 1	1	0.00	32.65	89.24	134.01	174.18	210.12
14.10	85.90	1.20	7.31		2	0.00	48.17	69.74	120.45	180.55	213.07
14.10	85.90	1.20	7.31		3	0.00	44.17	78.89	120.78	163.95	206.14

Table D.246 Binary flux results of 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 45°C & 1.2 bar Δpso₂ – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
14.10	85.90	1.20	7.31	45 ± 1	1	0.000185	0.04650	0.0463	70.92	29.08	0.0328	0.01347	75.00	1.08E-05	4.41E-06	6.72E-15	4.52E-16
14.10	85.90	1.20	7.31		2	0.000185	0.04690	0.0467	70.92	29.08	0.0331	0.01359	75.00	1.08E-05	4.45E-06	6.78E-15	4.56E-16
14.10	85.90	1.20	7.31		3	0.000185	0.04890	0.0487	70.92	29.08	0.0345	0.01417	75.00	1.13E-05	4.64E-06	7.07E-15	4.76E-16

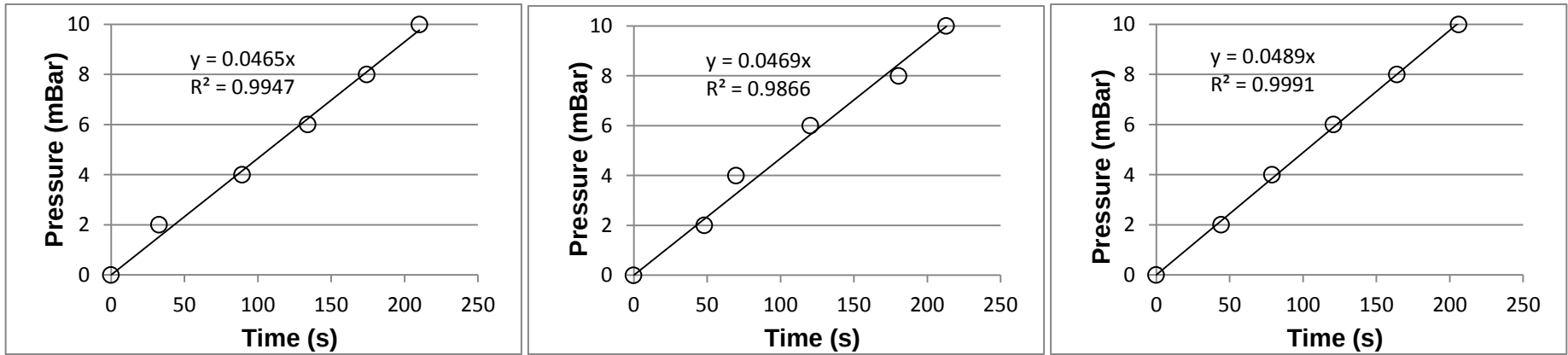


Figure D.85 Permeate pressure-time graphs for 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 45°C & 1.2 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.247 Binary flux results of 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 55°C & 1.2 bar Δpso₂ – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar					
Molar %		Bar		°C		s					
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅
14.10	85.90	1.20	7.31	55 ± 1	1	0.00	32.36	62.30	93.92	114.25	151.33
14.10	85.90	1.20	7.31		2	0.00	18.45	59.46	85.12	120.36	164.86
14.10	85.90	1.20	7.31		3	0.00	31.27	74.62	91.57	124.15	146.66

Table D.248 Binary flux results of 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 55°C & 1.2 bar Δpso₂ – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
14.10	85.90	1.20	7.31	55 ± 1	1	0.000185	0.06650	0.0663	65.84	34.16	0.0437	0.02265	75.00	1.39E-05	7.19E-06	8.66E-15	7.38E-16
14.10	85.90	1.20	7.31		2	0.000185	0.06440	0.0642	65.84	34.16	0.0423	0.02193	75.00	1.34E-05	6.96E-06	8.39E-15	7.14E-16
14.10	85.90	1.20	7.31		3	0.000185	0.06500	0.0648	65.84	34.16	0.0427	0.02214	75.00	1.35E-05	7.03E-06	8.47E-15	7.21E-16

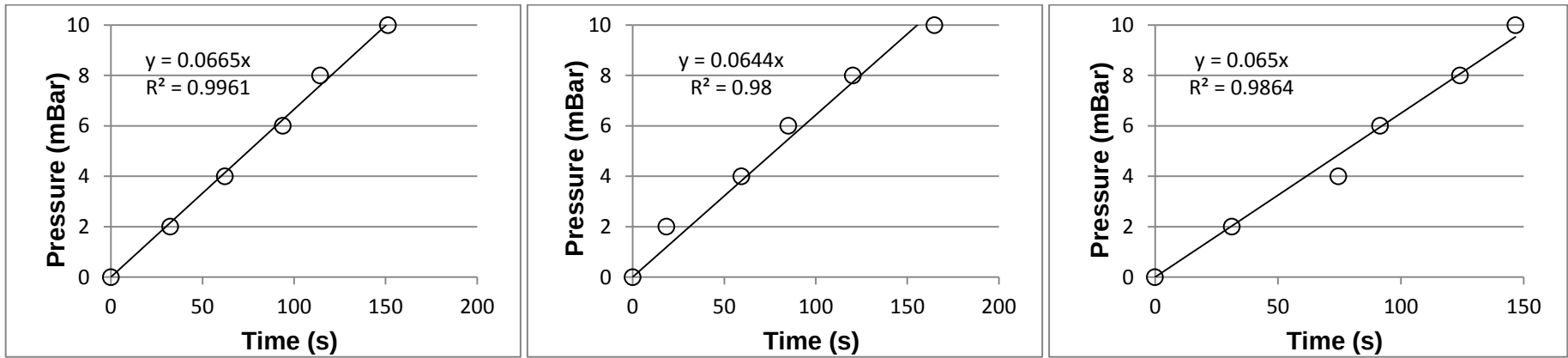


Figure D.86 Permeate pressure-time graphs for 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 55°C & 1.2 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.249 Binary flux results of 75:25 wt (SO₂:O₂) in Nafion 117 @ 25°C & 1.2 bar Δpso₂ – Raw Data

Feed Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar					
Molar %		Bar ± 0.1		°C		s					
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅
60.00	40.00	1.20	0.80	25 ± 1	1	0.00	85.74	187.38	220.21	288.96	391.97
60.00	40.00	1.20	0.80		2	0.00	66.18	187.42	213.45	291.52	385.10
60.00	40.00	1.20	0.80		3	0.00	62.88	169.73	210.38	299.05	377.19

Table D.250 Binary flux results of 75:25 wt (SO₂:O₂) in Nafion 117 @ 25°C & 1.2 bar Δpso₂ – Calculated Data

Feed Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
60.00	40.00	1.20	0.80	25 ± 1	1	0.000185	0.02580	0.0256	90.99	9.01	0.0233	0.00231	177.80	8.14E-06	8.07E-07	1.21E-14	1.79E-15
60.00	40.00	1.20	0.80		2	0.000185	0.02620	0.0260	90.99	9.01	0.0237	0.00234	177.80	8.27E-06	8.19E-07	1.23E-14	1.82E-15
60.00	40.00	1.20	0.80		3	0.000185	0.02670	0.0265	90.99	9.01	0.0241	0.00239	177.80	8.43E-06	8.35E-07	1.25E-14	1.86E-15

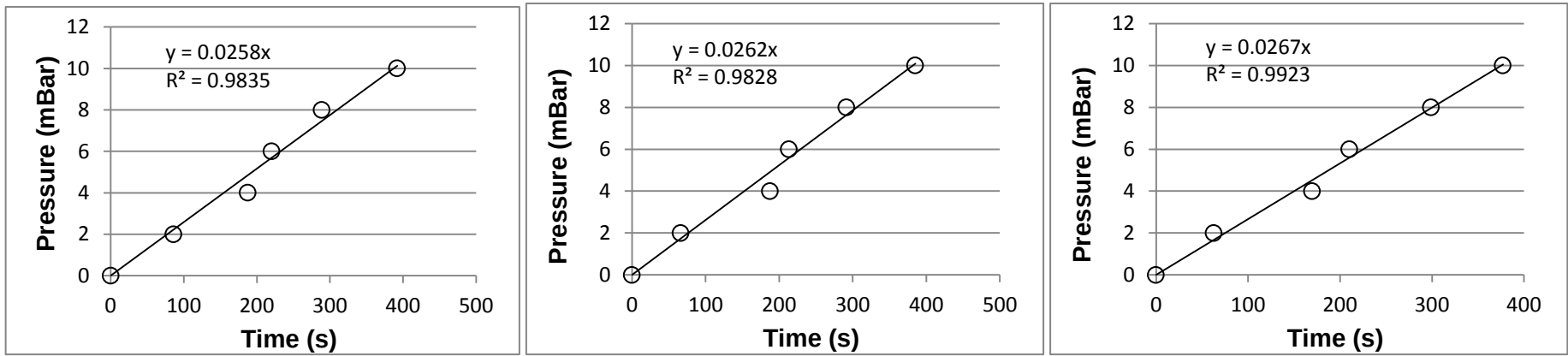


Figure D.87 Permeate pressure-time graphs for 75:25 wt (SO₂:O₂) in Nafion 117 @ 25°C & 1.2 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.251 Binary flux results of 75:25 wt (SO₂:O₂) in Nafion 117 @ 25°C & 0.7 bar Δp_{so₂} – Raw Data

Feed Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar					
Molar %		Bar ± 0.1		°C		s					
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅
60.00	40.00	0.70	0.47	25 ± 1	1	0.00	185.59	307.67	471.76	615.25	745.97
60.00	40.00	0.70	0.47		2	0.00	172.34	295.74	543.25	653.81	765.21
60.00	40.00	0.70	0.47		3	0.00	109.99	320.16	468.70	682.97	771.65

Table D.252 Binary flux results of 75:25 wt (SO₂:O₂) in Nafion 117 @ 25°C & 0.7 bar Δp_{so₂} – Calculated Data

Feed Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO₂}	(Δp/Δt) _{O₂}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO₂}	Π _{O₂}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
60.00	40.00	0.70	0.47	25 ± 1	1	0.000185	0.01310	0.0129	94.13	5.87	0.0122	0.00076	177.80	4.25E-06	2.65E-07	1.08E-14	1.01E-15
60.00	40.00	0.70	0.47		2	0.000185	0.01240	0.0122	94.13	5.87	0.0115	0.00072	177.80	4.02E-06	2.51E-07	1.02E-14	9.55E-16
60.00	40.00	0.70	0.47		3	0.000185	0.01250	0.0123	94.13	5.87	0.0116	0.00072	177.80	4.05E-06	2.53E-07	1.03E-14	9.63E-16

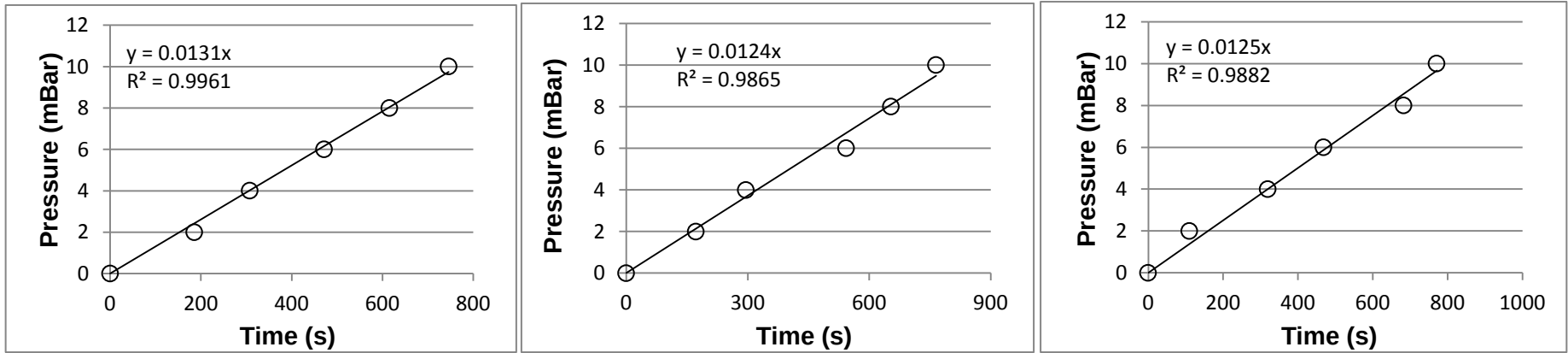


Figure D.88 Permeate pressure-time graphs for 75:25 wt (SO₂:O₂) in Nafion 117 @ 25°C & 0.7 bar Δp_{so₂}, 1st, 2nd & 3rd trials

Table D.253 Binary flux results of 75:25 wt (SO₂:O₂) in Nafion 117 @ 25°C & 0.3 bar Δpso₂ – Raw Data

Feed Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar				
Molar %		Bar ± 0.1		°C		s				
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄
60.00	40.00	0.30	0.20	25 ± 1	1	0.00	392.95	825.77	1218.15	1668.44
60.00	40.00	0.30	0.20		2	0.00	493.89	774.42	1220.43	1701.71
60.00	40.00	0.30	0.20		3	0.00	209.65	717.18	1360.74	1803.41

Table D.254 Binary flux results of 75:25 wt (SO₂:O₂) in Nafion 117 @ 25°C & 0.3 bar Δpso₂ – Calculated Data

Feed Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
60.00	40.00	0.30	0.20	25 ± 1	1	0.000185	0.00480	0.0046	91.70	8.30	0.0042	0.00038	177.80	1.48E-06	1.34E-07	8.76E-15	1.19E-15
60.00	40.00	0.30	0.20		2	0.000185	0.00480	0.0046	91.70	8.30	0.0042	0.00038	177.80	1.48E-06	1.34E-07	8.76E-15	1.19E-15
60.00	40.00	0.30	0.20		3	0.000185	0.00460	0.0044	91.70	8.30	0.0040	0.00037	177.80	1.41E-06	1.28E-07	8.38E-15	1.14E-15

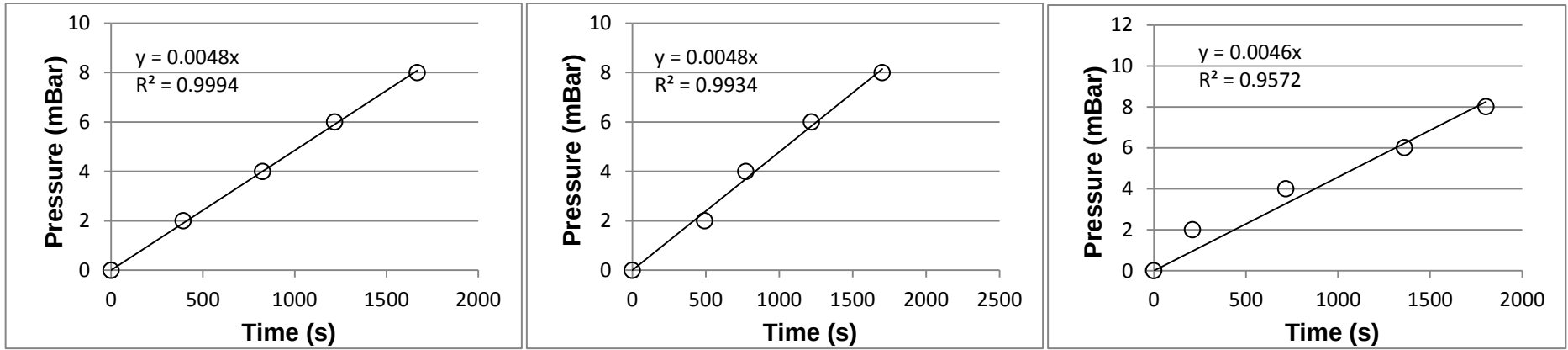


Figure D.89 Permeate pressure-time graphs for 75:25 wt (SO₂:O₂) in Nafion 117 @ 25°C & 0.3 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.255 Binary flux results of 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.0 bar Δpso₂ – Raw Data

Feed Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar				
Molar %		Bar		°C		s				
SO ₂	O ₂	SO ₂	O ₂	± 1	Run	t ₀	t ₁	t ₂	t ₃	t ₄
60.00	40.00	1.00	0.67	25	1	0.00	83.24	190.74	273.56	408.04
60.00	40.00	1.00	0.67		2	0.00	83.19	198.30	289.87	396.86
60.00	40.00	1.00	0.67		3	0.00	84.80	202.85	288.18	395.46

Table D.256 Binary flux results of 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.0 bar Δpso₂ – Calculated Data

Feed Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
60.00	40.00	1.00	0.67	25 ± 1	1	0.000185	0.02050	0.0203	95.92	4.08	0.0195	0.00083	75.00	6.81E-06	2.90E-07	5.11E-15	3.26E-16
60.00	40.00	1.00	0.67		2	0.000185	0.02040	0.0202	95.92	4.08	0.0194	0.00082	75.00	6.78E-06	2.88E-07	5.08E-15	3.24E-16
60.00	40.00	1.00	0.67		3	0.000185	0.02040	0.0202	95.92	4.08	0.0194	0.00082	75.00	6.78E-06	2.88E-07	5.08E-15	3.24E-16

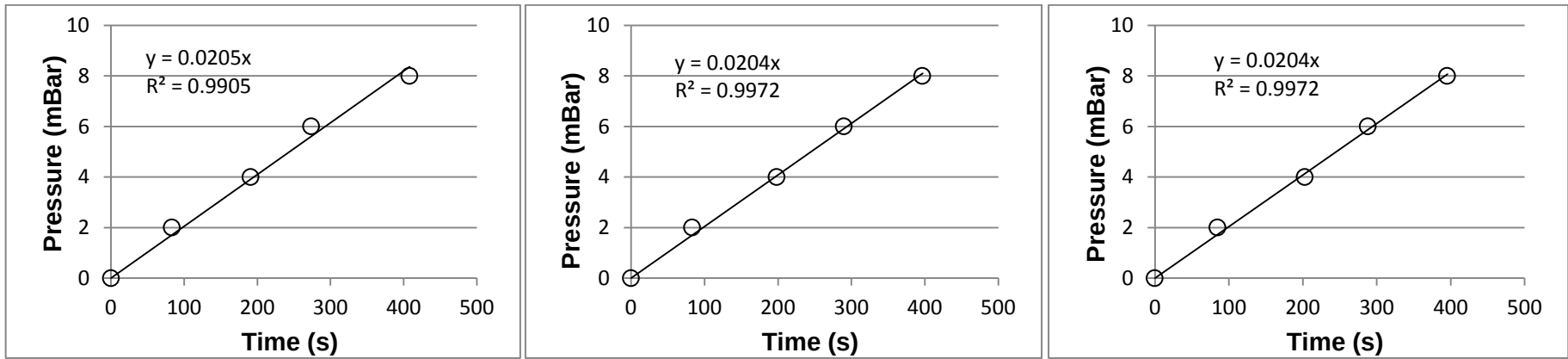


Figure D.90 Permeate pressure-time graphs for 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.0 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.257 Binary flux results of 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.7 bar Δpso₂ – Raw Data

Feed Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar				
Molar %		Bar		°C		s				
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄
60.00	40.00	0.70	0.47	25 ± 1	1	0.00	176.31	347.10	501.71	
60.00	40.00	0.70	0.47		2	0.00	135.67	394.46	550.96	680.59
60.00	40.00	0.70	0.47		3	0.00	122.30	288.72	450.90	726.52

Table D.258 Binary flux results of 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.7 bar Δpso₂ – Calculated Data

Feed Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm	mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂							
60.00	40.00	0.70	0.47	25 ± 1	1	0.000185	0.01180	0.0116	92.86	7.14	0.0108	0.00083	75.00	3.77E-06	2.90E-07	4.04E-15	4.65E-16
60.00	40.00	0.70	0.47		2	0.000185	0.01130	0.0111	92.86	7.14	0.0103	0.00079	75.00	3.61E-06	2.77E-07	3.86E-15	4.45E-16
60.00	40.00	0.70	0.47		3	0.000185	0.01200	0.0118	92.86	7.14	0.0110	0.00084	75.00	3.83E-06	2.95E-07	4.11E-15	4.73E-16

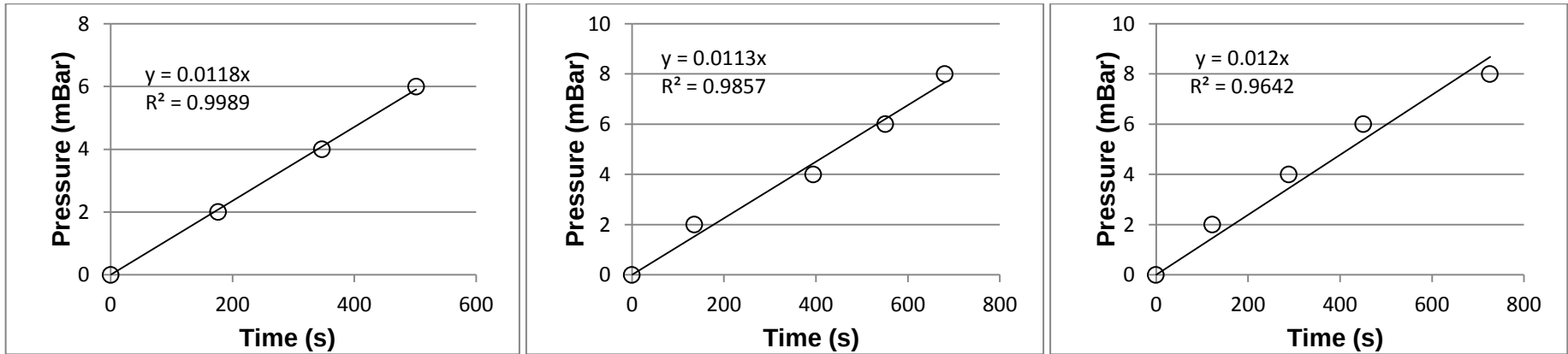


Figure D.91 Permeate pressure-time graphs for 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.7 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.259 Binary flux results of 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.4 bar Δpso₂ – Raw Data

Feed Composition		Trans-Membrane Partial Pressure		Temp		Permeate Δt per Δp=2mBar				
Molar %		Bar		°C		s				
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄
60.00	40.00	0.40	0.27	25 ± 1	1	0.00	310.61	631.70	950.43	1141.20
60.00	40.00	0.40	0.27		2	0.00	267.86	599.70	971.55	1087.01
60.00	40.00	0.40	0.27		3	0.00	346.69	584.11	938.97	1094.34

Table D.260 Binary flux results of 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.4 bar Δpso₂ – Calculated Data

Feed Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
60.00	40.00	0.40	0.27	25 ± 1	1	0.000185	0.00670	0.0065	78.93	21.07	0.0051	0.00137	75.00	1.80E-06	4.80E-07	3.37E-15	1.35E-15
60.00	40.00	0.40	0.27		2	0.000185	0.00680	0.0066	78.93	21.07	0.0052	0.00139	75.00	1.82E-06	4.87E-07	3.42E-15	1.37E-15
60.00	40.00	0.40	0.27		3	0.000185	0.00690	0.0067	78.93	21.07	0.0053	0.00141	75.00	1.85E-06	4.94E-07	3.47E-15	1.39E-15

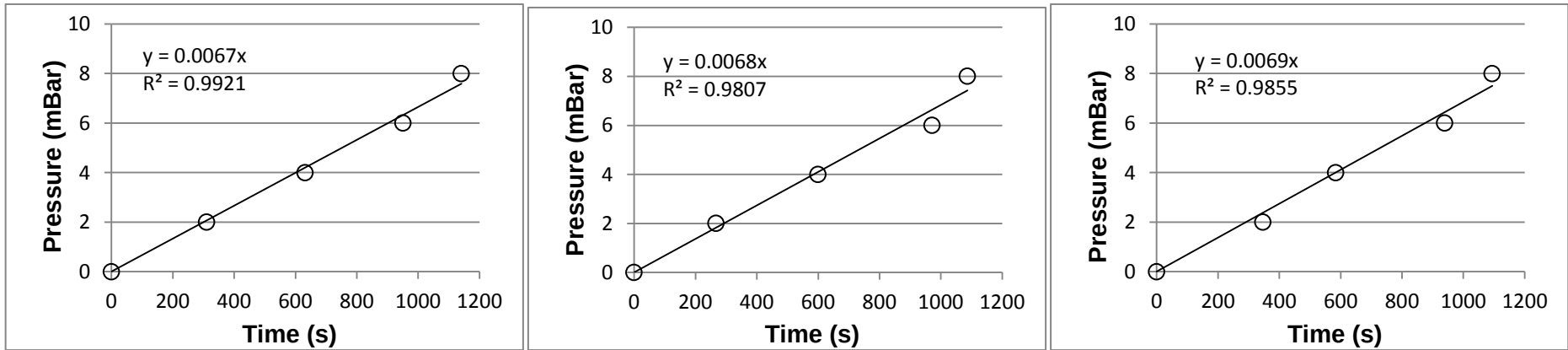


Figure D.92 Permeate pressure-time graphs for 75:25 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.4 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.261 Binary flux results of 50:50 wt (SO₂:O₂) in Nafion 117 @ 25°C & 1.1 bar Δp_{so₂} – Raw Data

Feed Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar						
Molar %		Bar ± 0.1		°C		s						
SO ₂	O ₂	SO ₂	O ₂	± 1	Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅	t ₆
33.30	66.70	1.10	2.20	25	1	0.00	65.72	147.28	198.19	279.45	331.04	376.53
33.30	66.70	1.10	2.20		2	0.00	41.03	135.18	174.62	257.00	301.48	381.08
33.30	66.70	1.10	2.20		3	0.00	46.54	156.77	187.02	269.55	349.12	357.70

Table D.262 Binary flux results of 50:50 wt (SO₂:O₂) in Nafion 117 @ 25°C & 1.1 bar Δp_{so₂} – Calculated Data

Feed Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{so₂}	(Δp/Δt) _{o₂}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{so₂}	Π _{o₂}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
33.30	66.70	1.10	2.20	25 ± 1	1	0.000185	0.03030	0.0301	84.58	15.42	0.0255	0.00464	177.80	8.90E-06	1.62E-06	1.44E-14	1.31E-15
33.30	66.70	1.10	2.20		2	0.000185	0.03210	0.0319	84.58	15.42	0.0270	0.00492	177.80	9.43E-06	1.72E-06	1.52E-14	1.39E-15
33.30	66.70	1.10	2.20		3	0.000185	0.03070	0.0305	84.58	15.42	0.0258	0.00470	177.80	9.02E-06	1.64E-06	1.46E-14	1.33E-15

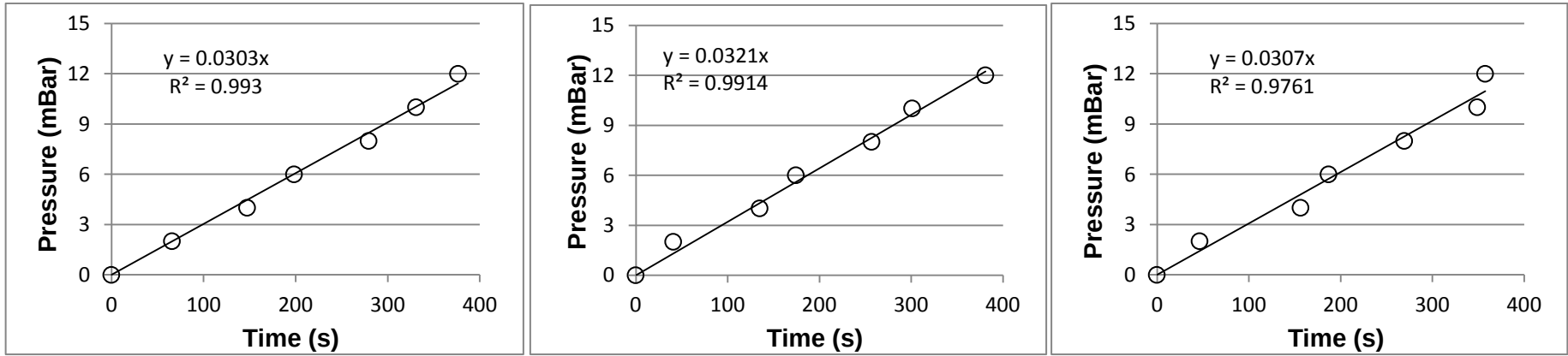


Figure D.93 Permeate pressure-time graphs for 50:50 wt (SO₂:O₂) in Nafion 117 @ 25°C & 1.1 bar Δp_{so₂}, 1st, 2nd & 3rd trials

Table D.263 Binary flux results of 50:50 wt (SO₂:O₂) in Nafion 117 @ 25°C & 0.5 bar Δpso₂ – Raw Data

Feed Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar					
Molar %		Bar ± 0.1		°C		s					
SO ₂	O ₂	SO ₂	O ₂	± 1	Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅
33.30	66.70	0.50	1.00	25	1	0.00	181.36	301.36	575.01	680.36	
33.30	66.70	0.50	1.00		2	0.00	212.46	330.63	507.42	663.87	
33.30	66.70	0.50	1.00		3	0.00	148.41	375.52	532.44	731.08	850.32

Table D.264 Binary flux results of 50:50 wt (SO₂:O₂) in Nafion 117 @ 25°C & 0.5 bar Δpso₂ – Calculated Data

Feed Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO₂}	(Δp/Δt) _{O₂}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO₂}	Π _{O₂}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
33.30	66.70	0.50	1.00	25 ± 1	1	0.000185	0.01140	0.0112	82.40	17.60	0.0092	0.00197	177.80	3.23E-06	6.90E-07	1.15E-14	1.22E-15
33.30	66.70	0.50	1.00		2	0.000185	0.01180	0.0116	82.40	17.60	0.0096	0.00204	177.80	3.34E-06	7.14E-07	1.19E-14	1.27E-15
33.30	66.70	0.50	1.00		3	0.000185	0.01140	0.0112	82.40	17.60	0.0092	0.00197	177.80	3.23E-06	6.90E-07	1.15E-14	1.22E-15

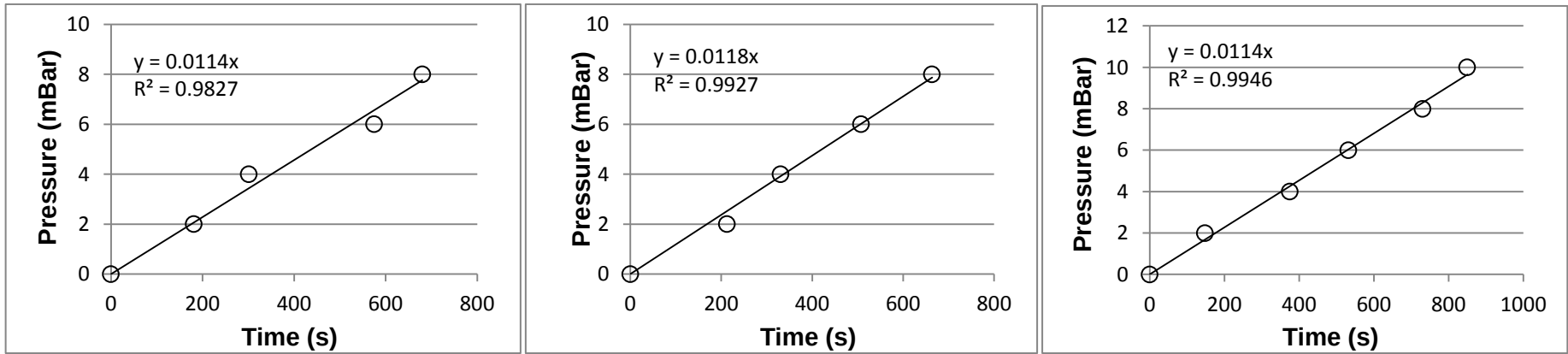


Figure D.94 Permeate pressure-time graphs for 50:50 wt (SO₂:O₂) in Nafion 117 @ 25°C & 0.5 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.265 Binary flux results of 50:50 wt (SO₂:O₂) in Nafion 117 @ 25°C & 0.3 bar Δp_{SO₂} – Raw Data

Feed Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar				
Molar %		Bar ± 0.1		°C		s				
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄
33.30	66.70	0.30	0.60	25 ± 1	1	0.00	390.11	750.46	1020.59	1301.66
33.30	66.70	0.30	0.60		2	0.00	330.56	690.23	998.07	1260.41
33.30	66.70	0.30	0.60		3	0.00	370.45	722.44	1032.94	1312.58

Table D.266 Binary flux results of 50:50 wt (SO₂:O₂) in Nafion 117 @ 25°C & 0.3 bar Δp_{SO₂} – Calculated Data

Feed Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
33.30	66.70	0.30	0.60	25 ± 1	1	0.000185	0.00590	0.0057	77.23	22.77	0.0044	0.00130	177.80	1.54E-06	4.55E-07	9.14E-15	1.35E-15
33.30	66.70	0.30	0.60		2	0.000185	0.00610	0.0059	77.23	22.77	0.0046	0.00135	177.80	1.60E-06	4.71E-07	9.46E-15	1.39E-15
33.30	66.70	0.30	0.60		3	0.000185	0.00590	0.0057	77.23	22.77	0.0044	0.00130	177.80	1.54E-06	4.55E-07	9.14E-15	1.35E-15

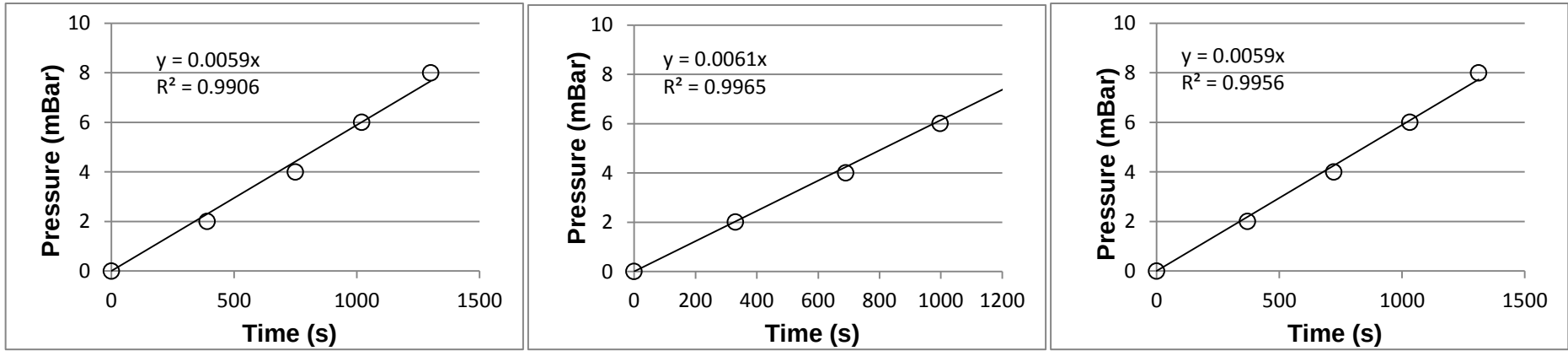


Figure D.95 Permeate pressure-time graphs for 50:50 wt (SO₂:O₂) in Nafion 117 @ 25°C & 0.3 bar Δp_{SO₂}, 1st, 2nd & 3rd trials

Table D.267 Binary flux results of 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.8 bar Δpso₂ – Raw Data

Feed Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar				
Molar %		Bar ± 0.1		°C		s				
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄
33.30	66.70	0.80	1.60	25 ± 1	1	0.00	138.77	265.38	420.11	471.07
33.30	66.70	0.80	1.60		2	0.00	121.76	238.78	392.96	488.79
33.30	66.70	0.80	1.60		3	0.00	111.45	186.37	410.3	498.34

Table D.268 Binary flux results of 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.8 bar Δpso₂ – Calculated Data

Feed Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
33.30	66.70	0.80	1.60	25 ± 1	1	0.000185	0.01560	0.0154	91.11	8.89	0.0140	0.00137	75.00	4.91E-06	4.79E-07	4.60E-15	2.24E-16
33.30	66.70	0.80	1.60		2	0.000185	0.01610	0.0159	91.11	8.89	0.0145	0.00141	75.00	5.07E-06	4.94E-07	4.75E-15	2.31E-16
33.30	66.70	0.80	1.60		3	0.000185	0.01600	0.0158	91.11	8.89	0.0144	0.00141	75.00	5.03E-06	4.91E-07	4.72E-15	2.30E-16

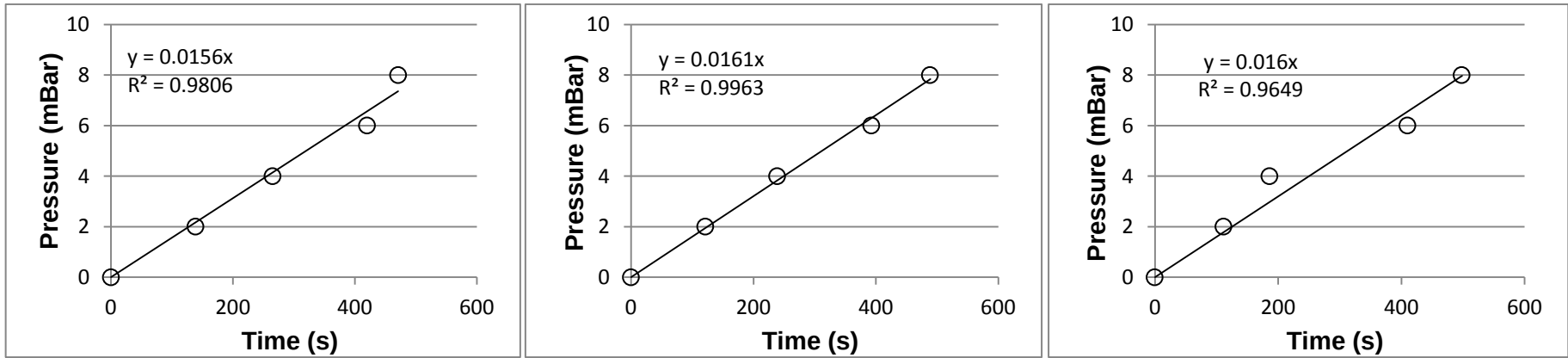


Figure D.96 Permeate pressure-time graphs for 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.8 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.269 Binary flux results of 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.6 bar Δpso₂ – Raw Data

Feed Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar				
Molar %		Bar ± 0.1		°C		s				
SO ₂	O ₂	SO ₂	O ₂	± 1	Run	t ₀	t ₁	t ₂	t ₃	t ₄
33.30	66.70	0.60	1.20	25	1	0.00	158.14	440.14	635.38	905.24
33.30	66.70	0.60	1.20		2	0.00	254.81	387.94	724.93	918.34
33.30	66.70	0.60	1.20		3	0.00	171.21	390.54	659.12	921.6

Table D.270 Binary flux results of 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.6 bar Δpso₂ – Calculated Data

Feed Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
33.30	66.70	0.60	1.20	25 ± 1	1	0.000185	0.00910	0.0089	86.58	13.42	0.0077	0.00120	75.00	2.70E-06	4.18E-07	3.37E-15	2.61E-16
33.30	66.70	0.60	1.20		2	0.000185	0.00870	0.0085	86.58	13.42	0.0074	0.00114	75.00	2.58E-06	3.99E-07	3.22E-15	2.49E-16
33.30	66.70	0.60	1.20		3	0.000185	0.00900	0.0088	86.58	13.42	0.0076	0.00118	75.00	2.67E-06	4.13E-07	3.33E-15	2.58E-16

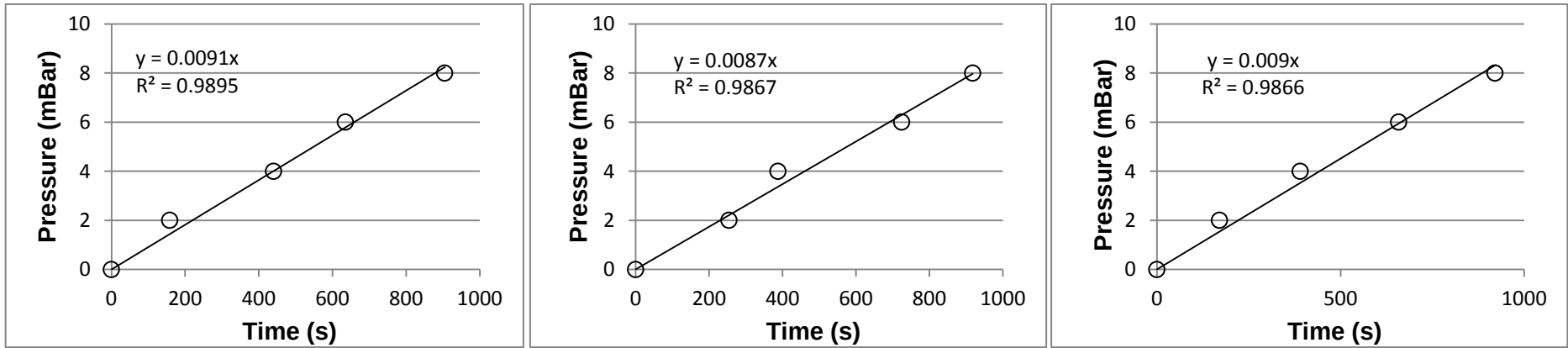


Figure D.97 Permeate pressure-time graphs for 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.6 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.271 Binary flux results of 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.3 bar Δpso₂ – Raw Data

Feed Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar				
Molar %		Bar ± 0.1		°C		s				
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄
33.30	66.70	0.30	0.60	25 ± 1	1	0.00	401.28	881.78	1149.73	1524.74
33.30	66.70	0.30	0.60		2	0.00	423.16	920.56	1224.68	1555.82
33.30	66.70	0.30	0.60		3	0.00	419.57	904.22	1179.36	1490.66

Table D.272 Binary flux results of 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.3 bar Δpso₂ – Calculated Data

Feed Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO2}	(Δp/Δt) _{O2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO2}	Π _{O2}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
33.30	66.70	0.30	0.60	25 ± 1	1	0.000185	0.00510	0.0049	76.83	23.17	0.0038	0.00114	75.00	1.32E-06	3.98E-07	3.30E-15	4.97E-16
33.30	66.70	0.30	0.60		2	0.000185	0.00490	0.0047	76.83	23.17	0.0036	0.00109	75.00	1.27E-06	3.82E-07	3.16E-15	4.76E-16
33.30	66.70	0.30	0.60		3	0.000185	0.00510	0.0049	76.83	23.17	0.0038	0.00114	75.00	1.32E-06	3.98E-07	3.30E-15	4.97E-16

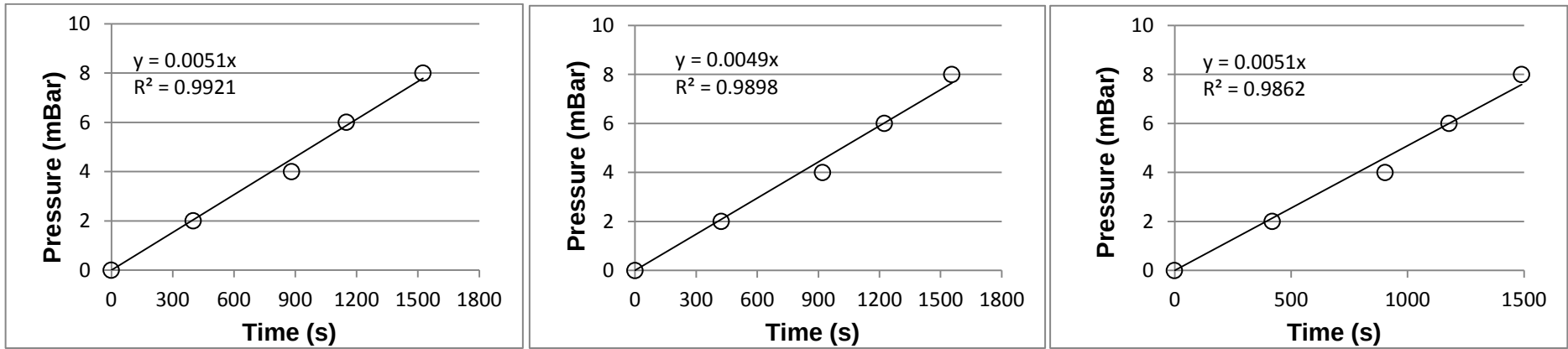


Figure D.98 Permeate pressure-time graphs for 50:50 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.3 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.273 Binary flux results of 25:75 wt (SO₂:O₂) in Nafion 117 @ 25°C & 1.2 bar Δp_{SO₂} – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar				
Molar %		Bar		°C		s				
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄
14.10	85.90	1.20	7.31	25 ± 1	1	0.00	29.74	130.18	181.98	234.64
14.10	85.90	1.20	7.31		2	0.00	65.86	121.20	181.10	243.59
14.10	85.90	1.20	7.31		3	0.00	67.74	106.29	190.38	231.08

Table D.274 Binary flux results of 25:75 wt (SO₂:O₂) in Nafion 117 @ 25°C & 1.2 bar Δp_{SO₂} – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Run	Temp	Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO₂}	(Δp/Δt) _{O₂}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO₂}	Π _{O₂}
Molar %		Bar			°C	mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂						SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
14.10	85.90	1.20	7.31	1	25 ± 1	0.000185	0.03350	0.0333	68.33	31.67	0.0228	0.01055	177.80	7.95E-06	3.69E-06	1.18E-14	8.97E-16
14.10	85.90	1.20	7.31	2		0.000185	0.03290	0.0327	68.33	31.67	0.0224	0.01036	177.80	7.81E-06	3.62E-06	1.16E-14	8.81E-16
14.10	85.90	1.20	7.31	3		0.000185	0.03370	0.0335	68.33	31.67	0.0229	0.01061	177.80	8.00E-06	3.71E-06	1.19E-14	9.02E-16

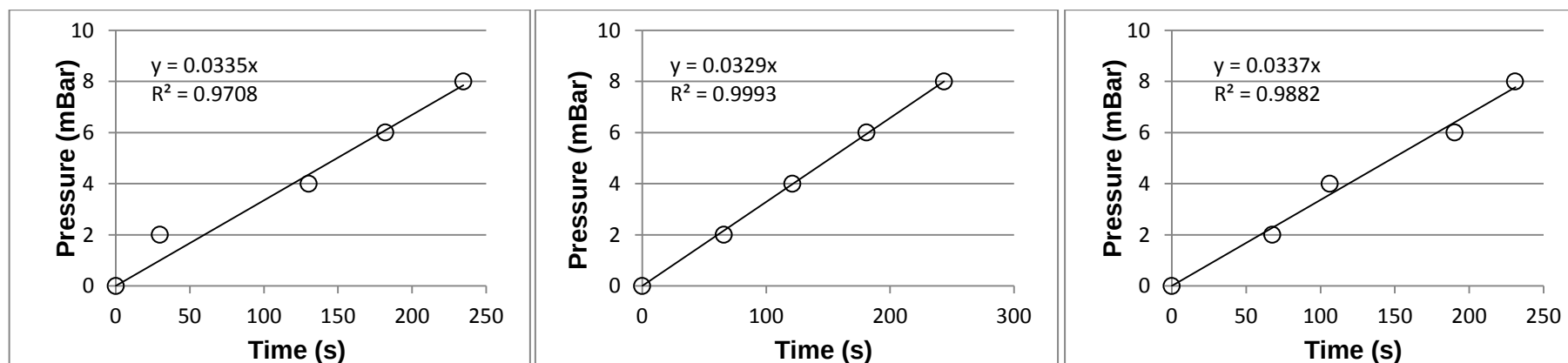


Figure D.99 Permeate pressure-time graphs for 25:75 wt (SO₂:O₂) in Nafion 117 @ 25°C & 1.2 bar Δp_{SO₂}, 1st, 2nd & 3rd trials

Table D.275 Binary flux results of 25:75 wt (SO₂:O₂) in Nafion 117 @ 25°C & 0.8 bar Δpso₂ – Raw Data

Feed Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar				
Molar %		Bar ± 0.1		°C		s				
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄
14.10	85.90	0.80	4.87	25 ± 1	1	0.00	137.89	276.31	324.39	459.68
14.10	85.90	0.80	4.87		2	0.00	127.60	248.76	329.87	469.41
14.10	85.90	0.80	4.87		3	0.00	100.74	254.62	301.84	487.77

Table D.276 Binary flux results of 25:75 wt (SO₂:O₂) in Nafion 117 @ 25°C & 0.8 bar Δpso₂ – Calculated Data

Feed Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{so2}	(Δp/Δt) _{o2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{so2}	Π _{o2}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
14.10	85.90	0.80	4.87	25 ± 1	1	0.000185	0.01700	0.0168	65.63	34.37	0.0110	0.0058	177.80	3.86E-06	2.02E-06	8.57E-15	7.37E-16
14.10	85.90	0.80	4.87		2	0.000185	0.01710	0.0169	65.63	34.37	0.0111	0.0058	177.80	3.88E-06	2.03E-06	8.62E-15	7.41E-16
14.10	85.90	0.80	4.87		3	0.000185	0.01720	0.0170	65.63	34.37	0.0112	0.0058	177.80	3.90E-06	2.04E-06	8.67E-15	7.45E-16

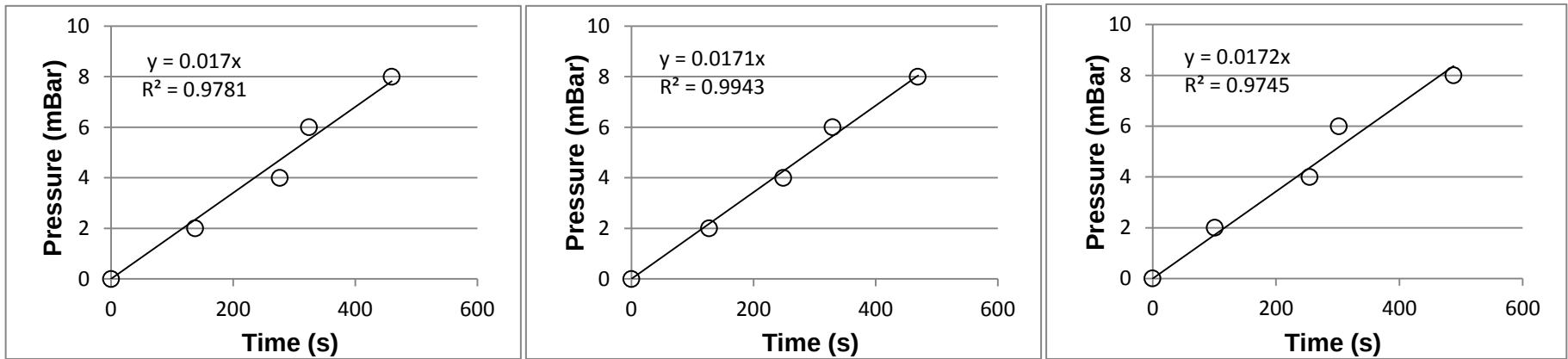


Figure D.100 Permeate pressure-time graphs for 25:75 wt (SO₂:O₂) in Nafion 117 @ 25°C & 0.8 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.277 Binary flux results of 25:75 wt (SO₂:O₂) in Nafion 117 @ 25°C & 0.3 bar Δpso₂ – Raw Data

Feed Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar				
Molar %		Bar ± 0.1		°C		s				
SO ₂	O ₂	SO ₂	O ₂	± 1	Run	t ₀	t ₁	t ₂	t ₃	t ₄
14.10	85.90	0.30	1.83	25	1	0.00	359.94	756.92	875.92	1368.40
14.10	85.90	0.30	1.83		2	0.00	301.72	711.94	1001.56	1395.64
14.10	85.90	0.30	1.83		3	0.00	288.30	553.38	943.04	1400.02

Table D.278 Binary flux results of 25:75 wt (SO₂:O₂) in Nafion 117 @ 25°C & 0.3 bar Δpso₂ – Calculated Data

Feed Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{so2}	(Δp/Δt) _{o2}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{so2}	Π _{o2}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
14.10	85.90	0.30	1.83	25 ± 1	1	0.000185	0.0060	0.0058	61.53	38.47	0.0036	0.0022	177.80	1.25E-06	7.82E-07	7.41E-15	7.60E-16
14.10	85.90	0.30	1.83		2	0.000185	0.0058	0.0056	61.53	38.47	0.0035	0.0022	177.80	1.21E-06	7.55E-07	7.15E-15	7.34E-16
14.10	85.90	0.30	1.83		3	0.000185	0.0061	0.0059	61.53	38.47	0.0036	0.0023	177.80	1.27E-06	7.95E-07	7.54E-15	7.73E-16

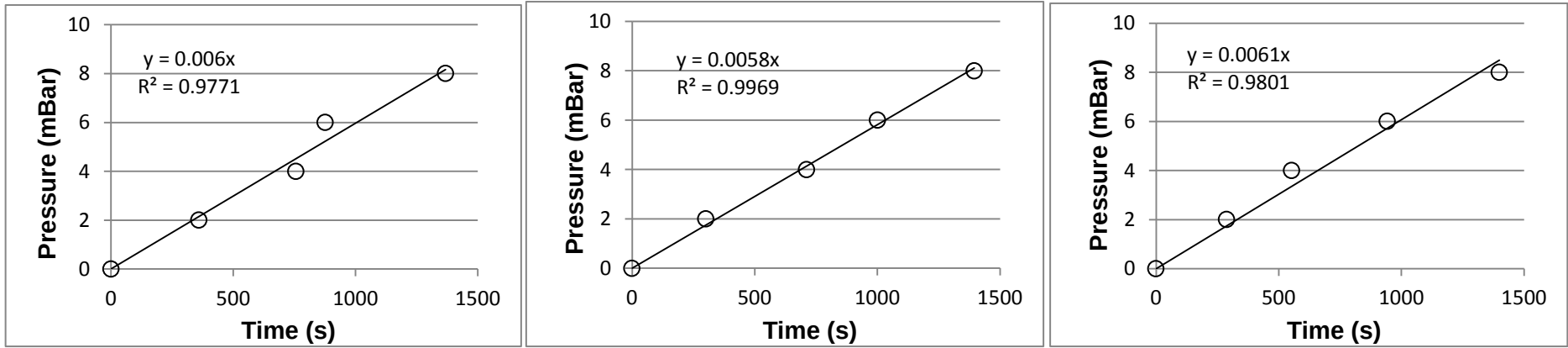


Figure D.101 Permeate pressure-time graphs for 25:75 wt (SO₂:O₂) in Nafion 117 @ 25°C & 0.3 bar Δpso₂, 1st, 2nd & 3rd trials

Table D.279 Binary flux results of 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.2 bar Δp_{so₂} – Raw Data

Upstream Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per Δp=2mBar					
Molar %		Bar		°C		s					
SO ₂	O ₂	SO ₂	O ₂	± 1	Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅
14.10	85.90	1.20	7.31	25	1	0.00	125.33	308.98	444.96	532.88	670.32
14.10	85.90	1.20	7.31		2	0.00	110.76	289.48	398.94	573.21	719.41
14.10	85.90	1.20	7.31		3	0.00	206.21	268.45	387.48	555.41	

Table D.280 Binary flux results of 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.2 bar Δp_{so₂} – Calculated Data

Upstream Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{Total}	Permeate Composition		(Δp/Δt) _{SO₂}	(Δp/Δt) _{O₂}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{SO₂}	Π _{O₂}
Molar %		Bar		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
14.10	85.90	1.20	7.31	25 ± 1	1	0.000185	0.01450	0.0143	81.07	18.93	0.0116	0.00271	75.00	4.05E-06	9.47E-07	2.53E-15	9.72E-17
14.10	85.90	1.20	7.31		2	0.000185	0.01410	0.0139	81.07	23.10	0.0113	0.00321	75.00	3.94E-06	1.12E-06	2.46E-15	1.15E-16
14.10	85.90	1.20	7.31		3	0.000185	0.01440	0.0142	81.07	23.10	0.0115	0.00328	75.00	4.03E-06	1.15E-06	2.52E-15	1.18E-16

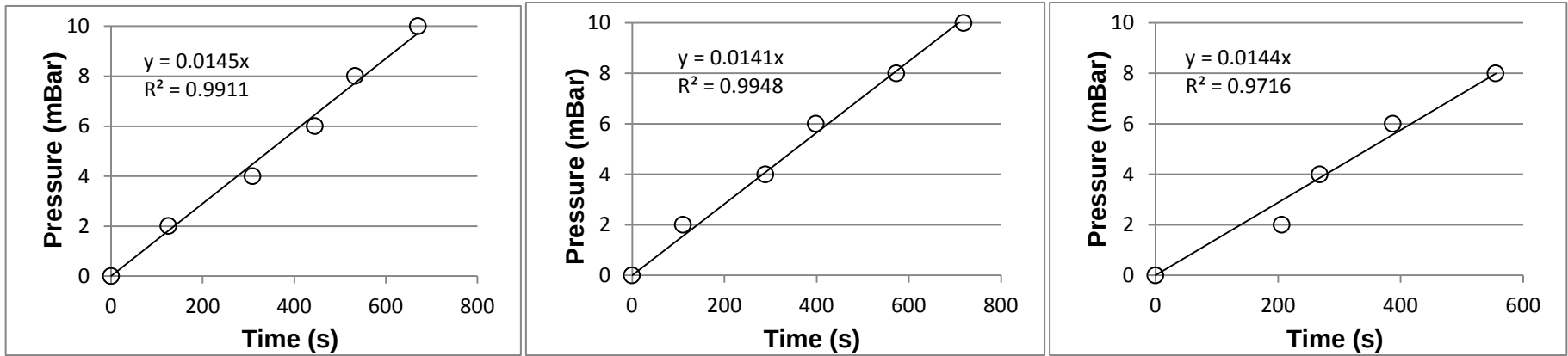


Figure D.102 Permeate pressure-time graphs for 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 1.2 bar Δp_{so₂}, 1st, 2nd & 3rd trials

Table D.281 Binary flux results of 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.7 bar Δp_{SO_2} – Raw Data

Feed Composition		Trans-Membrane Partial Pressure		Temperature		Permeate Δt per $\Delta p=2\text{mBar}$					
Molar %		Bar ± 0.1		°C		s					
SO ₂	O ₂	SO ₂	O ₂	$\pm$	Run	t ₀	t ₁	t ₂	t ₃	t ₄	t ₅
14.10	85.90	0.70	4.26	25	1	0.00	307.89	500.67	760.56	900.67	1220.37
14.10	85.90	0.70	4.26		2	0.00	323.57	523.46	801.27	920.71	1250.63
14.10	85.90	0.70	4.26		3	0.00	290.65	480.69	738.34	890.75	1209.56

Table D.282 Binary flux results of 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.7 bar Δp_{SO_2} – Calculated Data

Feed Composition		Trans-Membrane Partial Pressure		Temp		$\Delta p/\Delta t_{\text{leak}}$	$\Delta p/\Delta t_{\text{ss}}$	$\Delta p/\Delta t_{\text{Total}}$	Permeate Composition		$(\Delta p/\Delta t)_{SO_2}$	$(\Delta p/\Delta t)_{O_2}$	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π_{SO_2}	Π_{O_2}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
14.10	85.90	0.70	4.26	25 $\pm$	1	0.000185	0.00820	0.0080	74.25	25.75	0.0060	0.0021	75.00	2.08E-06	7.21E-07	2.23E-15	1.27E-16
14.10	85.90	0.70	4.26		2	0.000185	0.00800	0.0078	74.25	25.75	0.0058	0.0020	75.00	2.03E-06	7.03E-07	2.17E-15	1.24E-16
14.10	85.90	0.70	4.26		3	0.000185	0.00840	0.0082	74.25	25.75	0.0061	0.0021	75.00	2.13E-06	7.39E-07	2.28E-15	1.30E-16

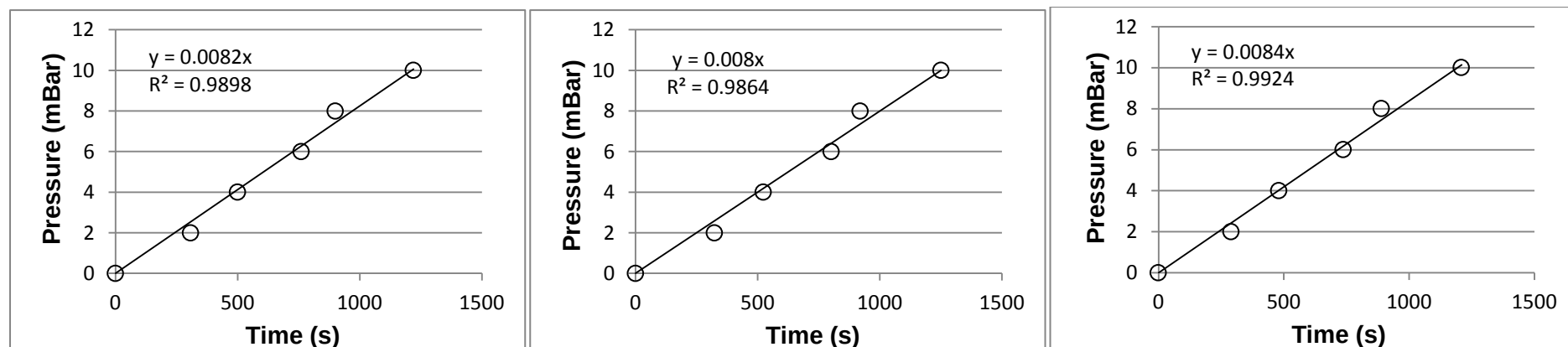


Figure D.103 Permeate pressure-time graphs for 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.7 bar Δp_{SO_2} , 1st, 2nd & 3rd trials

Table D.283 Binary flux results of 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.3 bar Δp_{so₂} – Raw Data

Feed Composition		Trans-Membrane Partial Pressure		Temp		Permeate Δt per Δp=2mBar				
Molar %		Bar ± 0.1		°C		s				
SO ₂	O ₂	SO ₂	O ₂		Run	t ₀	t ₁	t ₂	t ₃	t ₄
14.10	85.90	0.30	1.83	25 ± 1	1	0.00	590.74	1302.51	1795.46	2390.89
14.10	85.90	0.30	1.83		2	0.00	717.28	1280.32	1845.29	2250.77
14.10	85.90	0.30	1.83		3	0.00	579.56	1194.17	1760.64	2340.37

Table D.284 Binary flux results of 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.3 bar Δp_{so₂} – Calculated Data

Feed Composition		Trans-Membrane Partial Pressure		Temp		Δp/Δt _{leak}	Δp/Δt _{ss}	Δp/Δt _{total}	Permeate Composition		(Δp/Δt) _{so₂}	(Δp/Δt) _{o₂}	Membrane thickness	SO ₂ Molar Flux	O ₂ Molar Flux	Π _{so₂}	Π _{o₂}
Molar %		Bar ± 0.1		°C		mB.s ⁻¹	mB.s ⁻¹	mB.s ⁻¹	Molar				μm				
SO ₂	O ₂	SO ₂	O ₂		Run				SO ₂	O ₂				mol.s ⁻¹ .m ⁻²	mol.s ⁻¹ .m ⁻²	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹	mol.m.s ⁻¹ .m ⁻² .pa ⁻¹
14.10	85.90	0.30	1.83	25± 1	1	0.000185	0.00330	0.0031	69.63	30.37	0.0022	0.0009	75.00	7.58E-07	3.31E-07	1.89E-15	1.36E-16
14.10	85.90	0.30	1.83		2	0.000185	0.00340	0.0032	69.63	30.37	0.0022	0.0010	75.00	7.82E-07	3.41E-07	1.96E-15	1.40E-16
14.10	85.90	0.30	1.83		3	0.000185	0.00340	0.0032	69.63	30.37	0.0022	0.0010	75.00	7.82E-07	3.41E-07	1.96E-15	1.40E-16

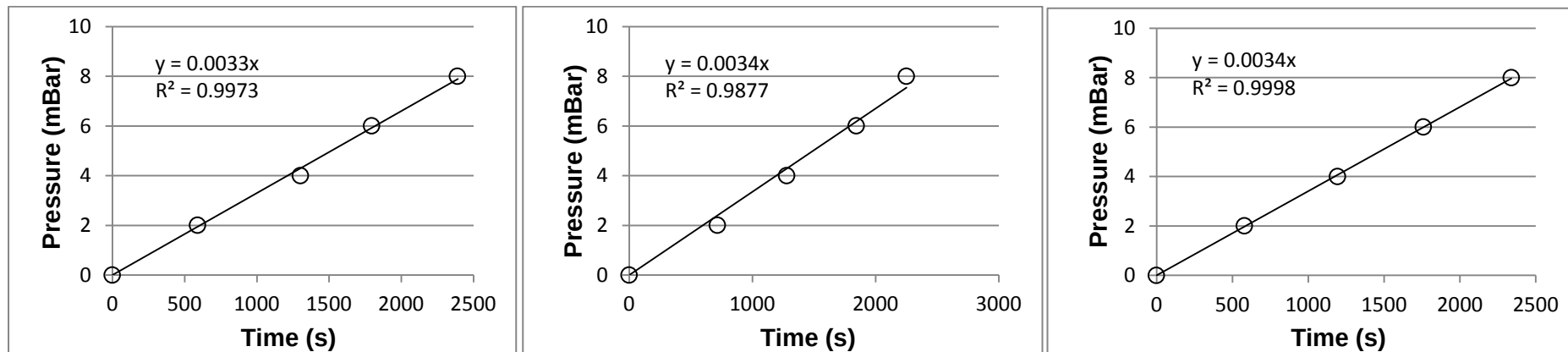


Figure D.104 Permeate pressure-time graphs for 25:75 wt (SO₂:O₂) in Udel Polysulfone @ 25°C & 0.3 bar Δp_{so₂}, 1st, 2nd & 3rd trials

APPENDIX E : EFFECT OF HUMIDITY ON GAS TRANSPORT IN A NAFION BASED MEMBRANE

OVERVIEW

Appendix E presents graphical information of the effect of humidity on gas transport in Nafion based membranes.

Figure E.1. affirms the importance of stating the experimental relative humidity when permeating gases through Nafion 117. The laboratory relative humidity in the present study was calculated to be 35%. It is a pity though that no device was available to measure the inner membrane cell relative humidity after evacuation. A safe assumption that the cell humidity was slightly less than the laboratory ambient relative humidity was used.

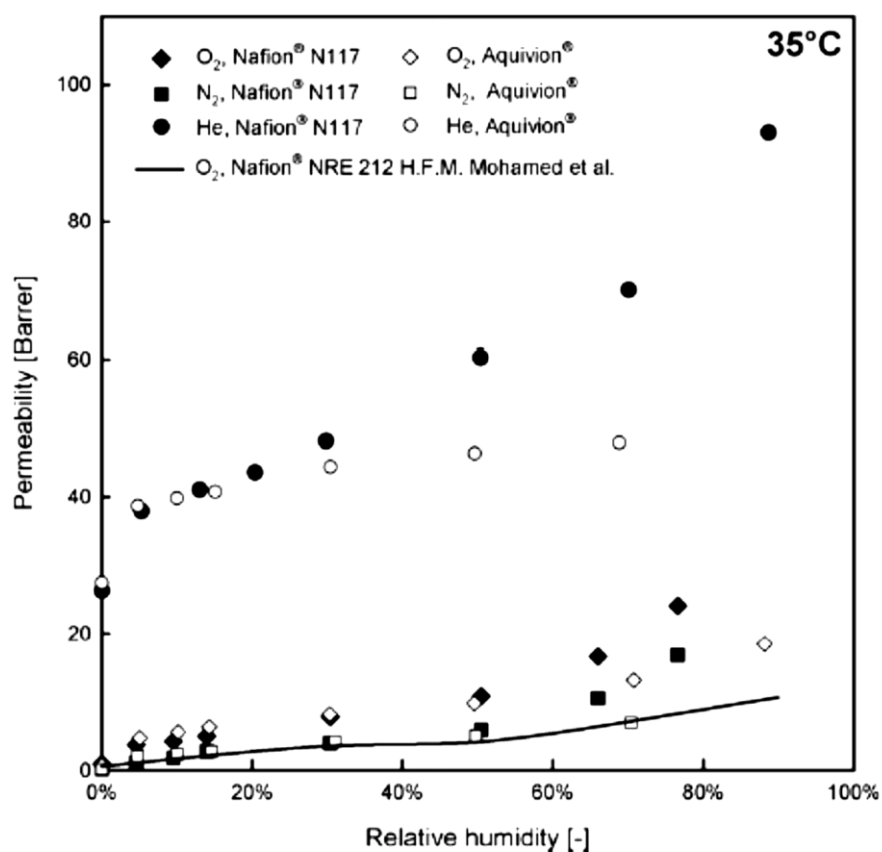


Figure E.1 Effect of humidity on gas transport through the Nafion 117 membrane (Adapted from Catalano, *et al.* (2012:6313))

REFERENCES

- [1] CATALANO, J., MYEZWA, T., DE ANGELIS, M.G., BASCHETTI, M.G. & SARTI G.C. 2012. The Effect of Relative Humidity on the Gas Permeability and Swelling in PFSI membranes. *International Journal of Hydrogen Energy*: 6308-6316

APPENDIX F : ERROR AND REPEATABILITY OF RESULTS

OVERVIEW

Appendix F presents the calculation procedure for error analysis of the permeation and composition experiments

EXPERIMENTAL ERROR AND REPEATABILITY FOR PERMEATION EXPERIMENTS

Table F.1 O₂ permeability in Hyflon M raw data for calculation of experimental error (Source: Table D11 & Table D12)

Feed Absolute Pressure	Temperature		Permeate Δt per $\Delta p=2\text{mBar}$						
mB.s^{-1}	$^{\circ}\text{C}$		s						
		Run	t_0	t_1	t_2	t_3	t_4	t_5	t_6
2000	25 ± 1	1	0.00	211.75	505.26	686.46	897.84	1090.11	1318.35
		2	0.00	249.86	434.59	676.05	933.04	1083.17	1419.46
		3	0.00	234.09	394.65	559.93	881.06	1035.96	1401.39

Table F.2 O₂ Permeability in Hyflon M calculated data for calculation of experimental error (Source: Table D11 & Table D12)

Feed Absolute Pressure	Temperature		$\Delta p/\Delta t_{\text{leak-Average}}$	$\Delta p/\Delta t_{\text{Total}}$	$(\Delta p/\Delta t)_{\text{ss}}$	Permeability	Permeability	Volumetric Flux
mB.s^{-1}	$^{\circ}\text{C}$		mB.s^{-1}	mB.s^{-1}	mB.s^{-1}	$\frac{\text{cm}^3 \cdot \text{mm} \cdot \text{day}}{1 \cdot \text{m}^2 \cdot \text{atm}^{-1}}$	Barrer	$\text{cm}^3 \cdot \text{s}^{-1} \cdot \text{cm}^{-2}$
		Run						
2000	25 ± 1	1	0.000123	0.00899	0.0089	270.9352	4.1261	7.03E-06
		2	0.000123	0.00873	0.0086	262.9904	4.0051	6.83E-06
		3	0.000123	0.00900	0.0089	271.2408	4.1307	7.04E-06

The resultant error from the permeation of O₂ in Hyflon M at a trans-membrane pressure of 2 Bar was calculated thus:

An average of the 3 permeability values gotten from the 3 different runs and was calculated first through equation F.1.

$$\bar{X} = \frac{\sum_{i=1}^n x_i}{n} \quad (F1)$$

Where:

$\bar{x}$ is the average permeability value.

x_i represents an individual experimental run.

n is the number of experimental runs.

$$\bar{X} = \frac{[270.94 + 262.99 + 271.24]}{3} = 268.39 \text{ cm}^3.\text{mm.day}^{-1}.\text{m}^2.\text{atm}^{-1}$$

The standard deviation of these values was calculated using equation (F2)

$$\sigma = \sqrt{\sum \frac{(x - \bar{X})^2}{(n-1)}} \quad (F2)$$

Where:

$\bar{x}$ is the average permeability value.

x represents an individual experimental run.

n is the number of experimental runs.

$$\sigma = \sqrt{\frac{[(270.94 - 268.39)^2 + (262.99 - 268.39)^2 + (271.24 - 268.39)^2]}{(3-1)}} = 4.68$$

The experimental error is then calculated at a 95% confidence interval with 3 degrees of freedom.

$$\text{Error} = \frac{Z\sigma}{\bar{X}} \times 100 \quad (\text{F3})$$

Where:

- $Z = \text{TINV}(1-0.95, 3) = 3.182$ in Microsoft Excel

The resultant calculated error value is 5.55% which proves the repeatability of the results.

EXPERIMENTAL ERROR AND REPEATABILITY FOR COMPOSITION EXPERIMENTS

Considering composition results presented in Table D.45 and D.46. SO₂ weight permeate compositions for the 1st, 2nd and 3rd trials were 86.74 wt %, 86.73 wt % and 86.73 wt % respectively. The resultant error was calculated thus:

$$\bar{X} = \frac{(86.74 + 86.73 + 86.73)}{3} = 86.7333$$

$$\sigma = \sqrt{\frac{(86.74 - 86.7333)^2 + (86.73 - 86.7333)^2 + (86.73 - 86.7333)^2}{3-1}} = 0.005774$$

Through Equation F3, the error was calculated to be

$$\text{Error} = \frac{3.182446 \times 0.005774}{86.7333} \times 100 = 0.0212 \%$$

The latter result proves the composition experiments to be repeatable.

APPENDIX G :CALIBRATION CURVE

OVERVIEW

Appendix G presents raw data that was used to plot the Gas Chromatograph calibration curve and the sample calculation that illustrates how the calibration curve was used to get the actual gas compositions

Table G.1 Gas chromatograph raw and calculated data for 25 wt% SO₂: 75 wt% O₂

Certified Gas Composition in Cylinder			Composition Ratio	G.C. Peak Area (UVs) x 10 ⁻⁴			Area Ratio			
Gas	Mol %	Mass %	wt/wt				A _{SO2} /A _{O2}			
				1 st trial	2 nd trial	3 rd trial	1 st trial	2 nd trial	3 rd trial	Average
SO ₂	14.1	24.72	0.3283	1.4973	1.4776	1.4728	0.3467	0.3456	0.3453	0.3459
O ₂	85.9	75.28		4.3183	4.2758	4.2651				

Table G.2 Gas chromatograph peak areas for 25 wt% SO₂: 75 wt% O₂

Area Percent Report										Area Percent Report										Area Percent Report									
Sorted By : Signal										Sorted By : Signal										Sorted By : Signal									
Multiplier : 1.0000										Multiplier : 1.0000										Multiplier : 1.0000									
Dilution : 1.0000										Dilution : 1.0000										Dilution : 1.0000									
Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs										Use Multiplier & Dilution Factor with ISTDs									
Signal 1: TCD1 B,										Signal 1: TCD1 B,										Signal 1: TCD1 B,									
Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %				Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %			
1	0.864	BB S	0.0401	4.31832e4	1.30716e4	74.25343				1	0.864	BB S	0.0385	4.27581e4	1.41405e4	74.31808				1	0.864	BB S	0.0412	4.26511e4	1.30797e4	74.33262			
2	8.823	BB	0.4819	1.49733e4	388.95679	25.74657				2	8.819	BB	0.4996	1.47758e4	385.13065	25.68192				2	8.817	BB	0.4786	1.47276e4	384.01572	25.66738			
Totals :				5.81565e4	1.34606e4					Totals :				5.75340e4	1.45256e4					Totals :				5.73787e4	1.34637e4				
Summed Peaks Report										Summed Peaks Report										Summed Peaks Report									

Table G.3 Gas chromatograph raw and calculated data for 50 wt% SO₂: 50 wt% O₂

Certified Gas Composition in Cylinder			Composition Ratio	G.C. Peak Area (Uvs) x 10 ⁻⁴			Area Ratio			
Gas	Mol %	Mass %	wt/wt				A _{SO2} /A _{O2}			
				1 st trial	2 nd trial	3 rd trial	1 st trial	2 nd trial	3 rd trial	Average
SO ₂	33.3	49.96	0.9985	3.0542	3.0443	2.6017	0.8368	0.8438	0.8258	0.8355
O ₂	66.7	50.04		3.6500	3.6079	3.1504				

Table G.4 Gas chromatograph peak areas for 50 wt% SO₂: 50 wt% O₂

Area Percent Report						
Sorted By : Signal						
Multiplier : 1.0000						
Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %
1	0.875	BB S	0.0397	3.64997e4	1.19430e4	54.44369
2	8.534	BB	0.5400	3.05415e4	689.45386	45.55631
Totals :				6.70412e4	1.26324e4	
Summed Peaks Report						

Area Percent Report						
Sorted By : Signal						
Multiplier : 1.0000						
Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %
1	0.872	BB S	0.0377	3.60790e4	1.16743e4	54.23633
2	8.534	BB	0.5840	3.04428e4	688.28784	45.76367
Totals :				6.65218e4	1.23626e4	
Summed Peaks Report						

Area Percent Report						
Sorted By : Signal						
Multiplier : 1.0000						
Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %
1	0.880	BB S	0.0372	3.15038e4	1.10748e4	54.76995
2	8.618	BB	0.5713	2.60165e4	607.86578	45.23005
Totals :				5.75203e4	1.16827e4	
Summed Peaks Report						

Table G.5 Gas chromatograph raw and calculated data for 75 wt% SO₂: 25 wt% O₂

Certified Gas Composition in Cylinder			Composition Ratio	G.C. Peak Area (Uvs) x 10 ⁻⁴			Area Ratio			
Gas	Mol %	Mass %	wt/wt							
				1 st trial	2 nd trial	3 rd trial	1 st trial	2 nd trial	3 rd trial	Average
SO ₂	60	75.00	3.0000	6.0339	5.9739	5.9330	2.56	2.57	2.58	2.57
O ₂	40	25.00		2.3587	2.3230	2.2984				

Table G.6 Gas chromatograph peak areas for 75 wt% SO₂: 25 wt% O₂

Area Percent Report						
Sorted By : Signal						
Multiplier : 1.0000						
Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %
1	0.889	BB S	0.0317	2.35865e4	9666.00000	28.10399
2	8.120	BB	0.6668	6.03393e4	1145.07080	71.89601
Totals :				8.39258e4	1.08111e4	
Summed Peaks Report						

Area Percent Report						
Sorted By : Signal						
Multiplier : 1.0000						
Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %
1	0.888	BB S	0.0294	2.32297e4	1.03415e4	27.99817
2	8.119	BB	0.6737	5.97390e4	1137.07312	72.00183
Totals :				8.29687e4	1.14786e4	
Summed Peaks Report						

Area Percent Report						
Sorted By : Signal						
Multiplier : 1.0000						
Dilution : 1.0000						
Use Multiplier & Dilution Factor with ISTDs						
Signal 1: TCD1 B,						
Peak #	RetTime [min]	Type	width [min]	Area [25 uV*s]	Height [25 uV]	Area %
1	0.882	BB S	0.0293	2.29843e4	9955.17090	27.92250
2	8.106	BB	0.6668	5.93304e4	1133.22754	72.07750
Totals :				8.23148e4	1.10884e4	
Summed Peaks Report						

GAS CHROMATOGRAPH CALIBRATION CURVE

Based on Tables G1 through G6, the graph in Figure G1 was plotted.

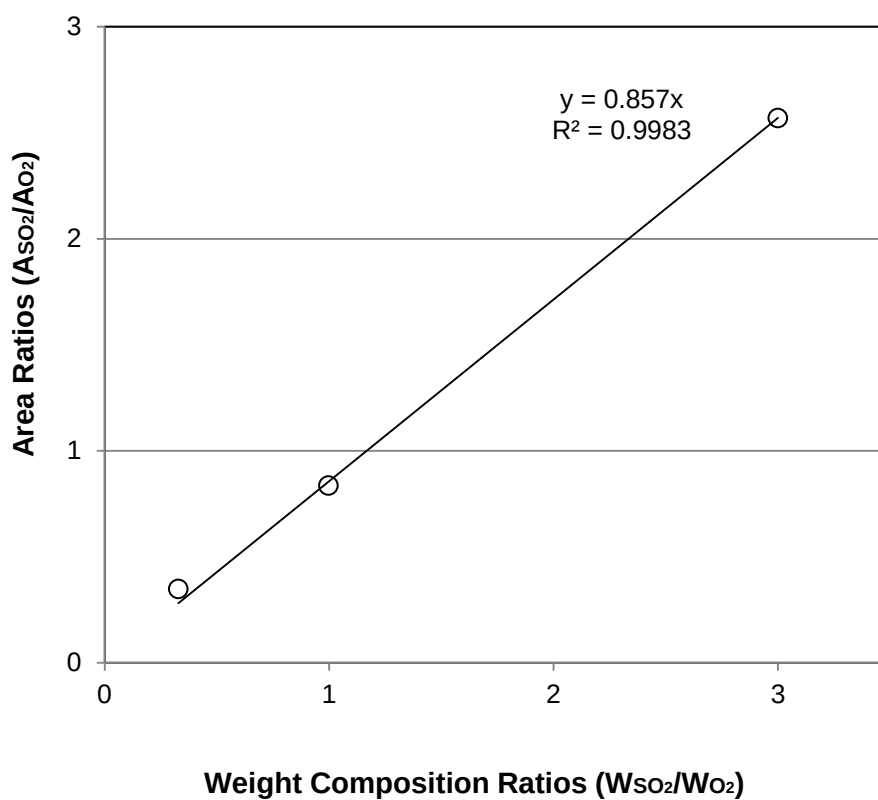


Figure G.1 Gas Chromatograph calibration curve

The Equation G1 relates area ratios (A_{SO_2}/A_{O_2}) to the weight ratios (W_{SO_2}/W_{O_2}).

$$\frac{A_{SO_2}}{A_{O_2}} = 0.857 \frac{W_{SO_2}}{W_{O_2}} \quad (G1)$$

Where:

A_{SO_2} is the SO_2 peak area

A_{O_2} is the O_2 peak area

W_{SO_2} is the SO_2 weight percentage composition

W_{O_2} is the O_2 weight percentage composition

Considering Tables D.45 to D47, a sample calculation made on the 1st trial to show how Equation G1 was used to calculate gas compositions from G.C. peak areas.

$$A_{SO_2} = 5.3803 \text{ UVs}$$

$$A_{O_2} = 0.9596 \text{ UVs}$$

$$A_{SO_2}/A_{O_2} = 5.6068 \text{ UVs}$$

Plugging the latter values into Equation G1:

$$5.6068 = 0.857 \frac{W_{SO_2}}{W_{O_2}} \quad (G2)$$

$$\text{But} \quad W_{SO_2} + W_{O_2} = 100 \quad (G3)$$

Making W_{O_2} subject of the formula in Equation G3, substituting in Equation G2 and simplifying Equation G1:

$$6.5424(100 - W_{SO_2}) = W_{SO_2}$$

$W_{SO_2} = 86.74\%$, and from Equation G3, $W_{O_2} = 13.26\%$

APPENDIX H :VAPOR LIQUID EQUILIBRIUM DATA

OVERVIEW

Appendix H presents the Aspen Plus predicted Vapour Liquid Equilibrium data for the industrial process streams in need of SO₂/O₂ separation in the Hybrid Sulphur process. The simulation files are in the CD labeled Appendix H

VAPOR LIQUID PROPERTIES OF PROCESS STREAMS

Based on the flow sheet proposed by Gorenssek & Summers, (2009:4106), of the streams converging at the absorber (44, 45, 46 47, 66, 68, 75, 82 and 94), streams (68, 75 and 82) constitute of negligible O₂ as is presented in Table 3.6, as such may be sent directly to the anolyte tank. The remaining six streams (44, 45, 46 47, 66 and 94) contain significant O₂ and SO₂ and thus ought to undergo SO₂/O₂ separation. Stream 47 is at a temperature of 233.42 °C, and elimination of part of the water in the stream could be performed through temperature reduction so as to reduce the water in the vapour phase and thus reduce the complexity of the stream from ternary (H₂O, SO₂ and O₂) to binary (SO₂ and O₂). It is envisaged that the temperature of stream 47 is reduced to 93°C whilst maintaining the 21 bar pressure to yield hypothetical stream 47A. Further reduction of stream 47 temperature below 93°C would result in O₂ in the stream condensing to the liquid phase, which is very undesirable as it is intended to recover O₂ out of the process. Mixing streams (44, 45, 46 47A, 66 and 94) and consequent flashing to separate the vapour and liquid phases then yields the vapour stream to be sent to the membrane gas separator. Tables H.1 and H.2 give the Aspen Plus predicted vapour liquid properties of the process streams in question.

Table H.1 Vapor liquid properties of the streams

Stream	Component	Vapour phase	Liquid phase	Temperature	Pressure
		Mole Fraction	Mole Fraction	°C	bar
44	H ₂ O	0.00014223	0.137166	15.5	21
	H ₂ SO ₄	0	0		
	SO ₂	0.1206969	0.7454446		
	O ₂	0.8791608	0.1173894		
45	H ₂ O	0.00047971	0.1055921	40.99	21
	H ₂ SO ₄	0	0		
	SO ₂	0.3025669	0.8388724		
	O ₂	0.6969534	0.0555354		
46	H ₂ O	0.00052849	0.1116414	41.78	21
	H ₂ SO ₄	0	0		
	SO ₂	0.3074325	0.8340342		
	O ₂	0.692039	0.0543244		
47	H ₂ O	0.5844521	-	233.42	21
	H ₂ SO ₄	2.74E-06	-		
	SO ₂	0.3979221	-		
	O ₂	0.017623	-		

Table H.2 Vapor liquid properties of the streams

Stream	Component	Vapour phase	Liquid phase	Temperature	Pressure
		Mole Fraction	Mole Fraction	°C	bar
47A	H ₂ O	0.025281	0.584549	93	21
	H ₂ SO ₄	4.36E-12	2.74E-06		
	SO ₂	0.4411756	0.397146		
	O ₂	0.5335434	0.0175335		
66	H ₂ O	3.02E-05	0.0069539	40	21
	H ₂ SO ₄	0	0		
	SO ₂	0.3313642	0.9386052		
	O ₂	0.6686057	0.0544408		
68	H ₂ O	-	0.986075	40.31	21
	H ₂ SO ₄	-	6.73E-07		
	SO ₂	-	0.0139243		
	O ₂	-	6.22E-08		
75	H ₂ O	-	0.9963529	41.14	21
	H ₂ SO ₄	-	3.44E-07		
	SO ₂	-	0.00364675		
	O ₂	-	9.63E-11		
82	H ₂ O	-	0.999579	40.21	21
	H ₂ SO ₄	-	0		
	SO ₂	-	0.0004209		
	O ₂	-	1.12E-13		
94	H ₂ O	0.0105858	0.3269469	84.71	21
	H ₂ SO ₄	1.90E-17	1.86E-11		
	SO ₂	0.6447541	0.6598976		
	O ₂	0.34466	0.0131555		
MIXTURE	H ₂ O	0.00600855	0.6106347	57.38	21
	H ₂ SO ₄	2.70E-13	2.90E-06		
	SO ₂	0.181643	0.3420161		
	O ₂	0.8123485	0.0473464		

DETERMINATION OF THE OPTIMUM FLASH TEMPERATURE RANGE

Determination of the optimum temperature range at which flashing of the mixture stream into the vapour phase (to be sent to the membrane gas separator) and liquid phase (to be sent to the anolyte tank) was based on minimising O₂ that would report to the liquid stream and minimising SO₂ that would report to the vapour phase.

Minimising the O₂ in the liquid stream would increase O₂ available for recovery in the vapour phase and ultimately in the membrane gas separator, whilst minimising SO₂ in the vapour phase would increase the SO₂ reporting to the liquid phase and ultimately to the anolyte tank. The latter is desired as the ultimate aim is to have SO₂ sent to the anolyte tank. Tables H.3 and H.4 present the vapour liquid properties of the product streams from the mixture stream flashed at 15°C, 25°C, 35°C, 45°C, 55°C and 57.38°C, all at a pressure of 21 bar.

Table H.3 Vapor liquid properties of the vapor phase stream

Stream	Component	Vapour phase	Liquid phase	Temperature	Pressure
		Mole Fraction	Mole Fraction	°C	bar
VAP	H ₂ O	0.00047057	-	15	21
	H ₂ SO ₄	2.97E-15	-		
	SO ₂	0.0624505	-		
	O ₂	0.9370789	-		
VAP	H ₂ O	0.0009162	-	25	21
	H ₂ SO ₄	9.64E-15	-		
	SO ₂	0.0865867	-		
	O ₂	0.912497	-		
VAP	H ₂ O	0.00170701	-	35	21
	H ₂ SO ₄	2.90E-14	-		
	SO ₂	0.1144938	-		
	O ₂	0.8837992	-		
VAP	H ₂ O	0.00306075	-	45	21
	H ₂ SO ₄	8.17E-14	-		
	SO ₂	0.1446021	-		
	O ₂	0.8523372	-		
VAP	H ₂ O	0.00529845	-	55	21
	H ₂ SO ₄	2.16E-13	-		
	SO ₂	0.17472	-		
	O ₂	0.8199815	-		
VAP	H ₂ O	0.00600745	-	57.38	21
	H ₂ SO ₄	2.7035E-13	-		
	SO ₂	0.1816336	-		
	O ₂	0.812359	-		

Table H.4 Vapor liquid properties of the liquid phase stream

Stream	Component	Vapour phase	Liquid phase	Temperature	Pressure
		Mole Fraction	Mole Fraction	°C	bar
LIQ	H ₂ O	-	0.4754236	15	21
	H ₂ SO ₄	-	2.23E-06		
	SO ₂	-	0.3982655		
	O ₂	-	0.1263087		
LIQ	H ₂ O	-	0.5036546	25	21
	H ₂ SO ₄	-	2.36E-06		
	SO ₂	-	0.397028		
	O ₂	-	0.099315		
LIQ	H ₂ O	-	0.5335798	35	21
	H ₂ SO ₄	-	2.51E-06		
	SO ₂	-	0.3879407		
	O ₂	-	0.078477		
LIQ	H ₂ O	-	0.5662657	45	21
	H ₂ SO ₄	-	2.67E-06		
	SO ₂	-	0.3713798		
	O ₂	-	0.0623517		
LIQ	H ₂ O	-	0.6018225	55	21
	H ₂ SO ₄	-	2.85E-06		
	SO ₂	-	0.348299		
	O ₂	-	0.0498755		
LIQ	H ₂ O	-	0.6106226	57.38	21
	H ₂ SO ₄	-	2.90E-06		
	SO ₂	-	0.3420248		
	O ₂	-	0.0473497		

Figure H.1 gives a plot of the O₂ mole fraction in the liquid phase and SO₂ mole fraction in the vapour phase against temperature based on data from Tables H.3 and H.4. The plot gives the optimum flash temperature and the subsequent optimum flash temperature range is determined thereafter.

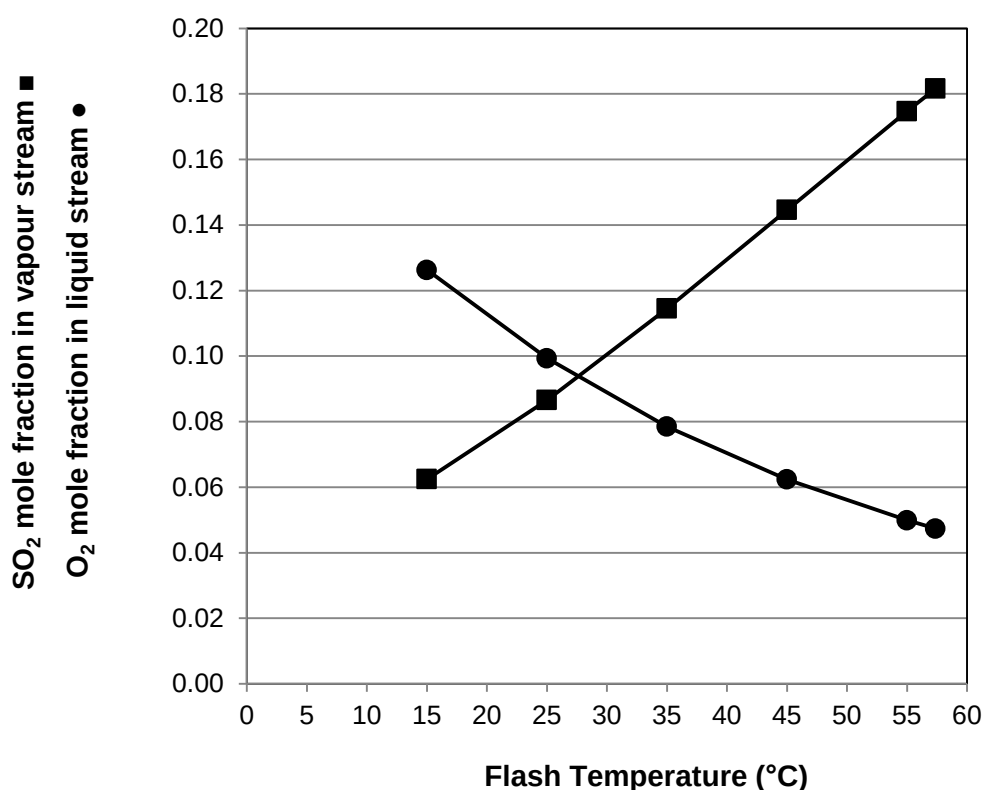


Figure H.1 Optimum flash temperature

Just as was mentioned earlier, it is important to note that it is desired to flash the mixture in such a way as to minimise O₂ in the liquid product stream (LIQ) and also minimise SO₂ in the vapour product stream (VAP). Figure H.1, shows that O₂ may be minimised in the liquid stream through flashing at increased temperatures. On the contrary, SO₂ may be minimised in the vapour stream through flashing at decreased temperatures. An optimum flash temperature point would attempt to address both contrasting behaviours and is represented by the intersection point of the two plots. The temperature of the intersection point is 27.6°C. The mixture temperature prior to flashing was predicted to be 57.8°C. Cooling the mixture stream temperature to 27.6°C from 57.8°C may add to the energy requirements of the process. It may thus be deemed optimum to flash the mixture stream at a temperature between 27.6°C and 57.8°C without introduction of cooling energy. The corresponding SO₂ and O₂ vapour stream mole percentage compositions resulting from flashing at 27.6°C and 57.38°C are (SO₂:O₂ = 9.35:90.54) and (SO₂:O₂ = 18.16:81.24) respectively. The latter define the composition range of the stream to be fed to the membrane separator. Table H.5 presents the vapor liquid properties of the vapor stream resulting from flashing the mixture at 27.6°C

Table H.5 Vapor liquid properties of the vapor phase stream after flashing at 27.6°C

Stream	Component	Vapour phase	Liquid phase	Temperature	Pressure
		Mole Fraction	Mole Fraction	°C	Bar
VAP	H ₂ O	0.00108137	-	27.6	21
	H ₂ SO ₄	1.2925E-14	-		
	SO ₂	0.093529	-		
	O ₂	0.9053896	-		

Figure H.2 presents a scheme of the proposed industrial setup discussed in Appendix H.

N.B. The Aspen plus simulation files with the vapor liquid data for the streams are given in the CD labelled Appendix H. The file titled “Condition of streams converging at absorber (proposed by Gorenssek & Summers, (2009:4107))” constitutes of streams connected to a dummy mixer. The main purpose of the file is to ascertain the vapor liquid properties of the streams proposed by Gorenssek & Summers, (2009:4107) as such conditions in the dummy mixer and the dummy output stream should be ignored.

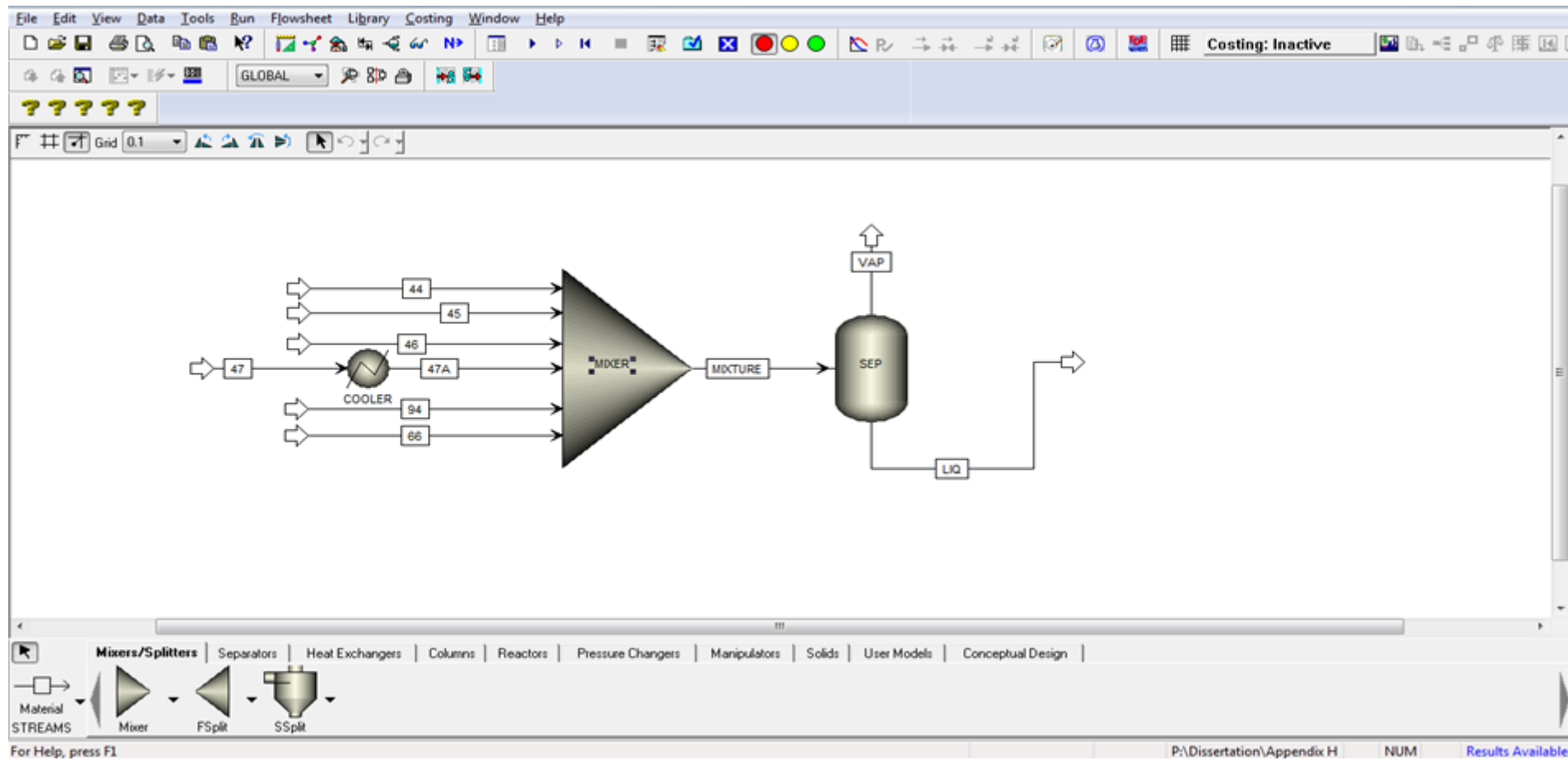


Figure H.2 Scheme of Aspen Plus proposed industrial setup

REFERENCES

- [1] GORENSEK, M.B. & SUMMERS, W.A. 2009. Hybrid sulphur flowsheets using PEM electrolysis and a bayonet decomposition reactor. *International Journal of Hydrogen Energy*, 34:4097-4114, 9 Aug.