CHAPTER 5 : CONCLUSION AND RECOMMENDATIONS

OVERVIEW

Chapter 5 constitutes of 2 main Sections which are Conclusion (Section 5.1) and Recommendations (Section 5.2). Section 5.1 presents a comprehensive discussion of the individual conclusions from both single and binary permeation experiments. Section 5.2 then presents recommendations that could better research in the current realm.

5.1 CONCLUSION

Despite the presence of several membrane gas separation studies currently, the literature review presented in the present study clearly unearthed the lack of intensive study on the separation of SO_2/O_2 using membrane technology. Studies involving gas permeation of SO_2 considered the single component permeation and or binary systems involving SO_2 and other gases besides O_2. The SO_2/O_2 binary system was neglected. In the binary systems considered, low to trace SO_2 compositions were employed and research based rather than commercially available membranes were used.

The latter background prompted focus on fully characterising commercially available gas separation and other potential gas separation membranes for binary SO_2/O_2 separation of mixtures containing both low SO_2 (25 wt% = 14.1 mol%) and high SO_2 (75 wt% = 60 mol %) compositions.

5.1.1 SINGLE PERMEATION

Of the six selected membranes (Hyflon M, Hyflon F, Teflon AF 2400, Nafion 117, Udel Polysulfone, and Halar) for the current study, pressure was found to affect SO_2 permeability remarkably in Nafion 117 and Udel polysulfone whilst a negligible effect of pressure on the permeability of other studied gases (O_2, N_2 and CO_2) was observed in the same membranes. The resultant SO_2/O_2 selectivity thus depended on pressure and therefore presented a vital attribute for the optimisation of SO_2/O_2 separation. O_2, N_2 and CO_2 permeabilities proved to depend sluggishly on pressure in all membranes. Gas fluxes in general increased with increasing pressure with all gases and in all membranes. Teflon AF 2400 presented the best overall flux for all gases at all studied pressures, however the poor SO_2/O_2 ideal selectivity ≈ 1 rendered the membrane unfit for further investigation. Halar presented the lowest gas flux and a SO_2/O_2 ideal selectivity ≈ 17, and could not be studied further due to the low flux. A compromise between flux and selectivity proved Nafion 117 and Udel Polysulfone suitable candidates for further investigation.

5.1.2 BINARY PERMEATION

Further characterisation of Nafion 117 and Udel Polysulfone at diverse temperatures, diverse SO_2/O_2 compositions and diverse partial SO_2 trans-membrane pressures was performed. The SO_2/O_2 separation potential of both membranes was astounding, Udel Polysulfone concentrated a SO_2:O_2 = 25:75 wt % feed gas mixture to SO_2:O_2 = 94:6 wt % at 15°C whilst Nafion 117 concentrated the same feed gas mixture to SO_2:O_2 = 87:13 wt % at 15° C. SO_2 permeate compositions in both Udel Polysulfone and Nafion 117 cases decreased with temperature and increased with pressure. The SO_2 and O_2 fluxes both increased with increased trans-membrane pressure since pressure is essentially the major driving force for permeation. Despite Nafion 117 possessing inferior separation capabilities than Udel Polysulfone, the SO_2 flux per micrometer thickness of membrane was generally about a magnitude greater than that of Udel Polysulfone. It is a pity though that thicknesses of Nafion based membranes as low as 1 µm are unknown of, however results from the current study could prompt research on the synthesis of ultra thin Nafion based gas separation membranes.

5.2 RECOMMENDATIONS

Some critical aspects could have been included in the current study that would allow better interpretation of results, further characterisation of membranes and ease of data acquisition from the experimental setup.

- Diffusion and sorption experiments done separately so as to fully ascertain if the permeability in question is diffusion or solubility controlled.
- Performance of stability tests of the membranes so as to investigate aging.
- Investigation of the effect of humidity on the binary system, as the gas mixture would be expected to be humid in the industrial application.
- Development of a model that would aid prediction of permeation behaviour.
- Use of more sensitive transducers so as to produce both the transient and steady state region of the pressure-time graphs.
- Use of an automated data logging technique so as to reduce human error.