CHAPTER 4 BATCH FLOTATION OF SELECTED TTC's

4.1 Introduction

Batch flotation tests were conducted at the Billiton Process Research (BPR) laboratories and at the University of Cape Town (UCT). The first section will deal with research at BPR. The second (chapter 5) will be on work done at UCT, and this was primarily to elucidate mineral interactions with collectors during flotation. The dosing methods and frother (cresylic acid) used for these experiments were chosen from results of the previous chapter.

4.2 Biliton Process Research - Collector screening

The main objective of these flotation tests was to screen a pre-selected suite of collectors on Merensky ore for the 60l continuous tests, which are to follow in chapter 7.

Pressed powder tablets and suspensions were selected as alternate methods of dosing. The concentration of iC_3-TTC/C_{12}-mercaptan in the emulsion was 20%(m/m). Various concentrations of long chain TTC in iC_3-TTC were compared to pure iC_3-TTC. The covalent collector, iC_3/iC_4-ester, on its own and in combination with long chain mercaptans was tested in nitrogen and air mediums. The covalent collector dosed in combination was usually 10% of the total molar dosage. These pulp were flushed with nitrogen or air before milling and then floated with air.

Multiple stage dosing was used. The first fraction of collector was dosed as usual and then after 7.5 minutes of floating the batch was again spiked with another dosage of collector.

4.2.1 Materials and methods

A number of single component and mixtures of collectors were evaluated for flotation activity. Powders as pure iC_3-TTC and Kaolin-bonded and other mixtures were used.

- C_{12}-mercaptan
- Kaolin / TTC pellet
- C_{12}-TTC at different molar concentrations that varied from 0.2 to 0.5 C_{12}-TTC
- iC_3/iC_4 covalent TTC (9:1molar)
- iC_3/iC_4 covalent TTC/C_{12}-mercaptan (9:1molar) in nitrogen
- iC_3/iC_4 covalent TTC/C_{12}-mercaptan (9:1molar) in air

A Merensky ore sample was collected from section 10 at Impala Platinum. This sample was dried and then crushed in two stages with gyratory crushers. The ore was rod-milled before each batch flotation test to 80% -75µm and the milled ore washed into a 3l Denver cell. The same experimental procedures described in section 3.4.1 were used.

The detailed descriptions of the ore preparation and the flotation procedure are given in Appendix A.

4.3 Results and discussion

4.3.1 Powders

The iC_3-TTC/C_{12}-mercaptan was dosed as an emulsion. The long chain mercaptans were introduced to improve solids recovery. Table 4.3 shows the results of the batch flotation tests on these chemicals.

Table 4.1 Metals recovered without suspensions

Test		PGM		Cu		Ni	
Collector	**Mass Conc**	**Grade**	**Recovery**	**Grade**	**Recovery**	**Grade**	**Recovery**
	(g)	**(ppm)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**
Standard	131.71	37.33	86.45	0.56	94.12	1.04	65.72
Tablet powder	113.05	30.90	72.98	0.66	89.33	1.20	70.00
iC_3-TTC powder	118.29	39.63	90.59	0.58	90.69	1.07	69.51
iC_3-TTC/C_{12}-merc	116.05	43.93	93.11	0.62	91.75	1.11	61.81

Dosing with Kaolin-bonded iC_3-TTC if anything had a negative effect on PGM recovery (Table 4.1). The iC_3-TTC performed well compared to the standard collector suite. The addition of the long chain mercaptan to the iC_3-TTC also showed good enhancement in PGM recovery. The SIBX/DTP mixture recovered the most copper and also had the highest mass and water recovery.

4.3.2 Suspensions

4.3.2.1 Long and short chain TTC's

Previous work by Janse van Rensburg (1988) on long chain C_{10} and C_{12}-TTC's gave improvements on PGM and copper recovery. Four combinations of iC_3-TTC and C_{12}-TTC were tested. The mole fraction of 0.2, 0.3, 0.4 and 0.5 of C_{12}-TTC were studied. In table 4.2 the effect of C_{12}-TTC is given.

Table 4.2 Combinations of iC_3-TTC and C_{12}-TTC - Various concentrations

Test		PGM		Cu		Ni	
Collector	**Mass Conc**	**Grade**	**Recovery**	**Grade**	**Recovery**	**Grade**	**Recovery**
	(g)	**(ppm)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**
Standard	131.71	37.33	86.45	0.56	94.12	1.04	65.72
iC_3-TTC/C_{12}-TTC (0.2)	117.30	42.50	88.74	0.62	91.12	1.12	67.87
iC_3-TTC/C_{12}-TTC (0.3)	123.21	40.35	91.16	0.62	92.10	1.18	74.00
iC_3-TTC/C_{12}-TTC (0.4)	125.78	43.30	92.29	0.61	90.04	1.13	71.96
iC_3-TTC/C_{12}-TTC (0.5)	122.14	40.47	92.95	0.54	90.72	1.03	69.53

The highest mass-pull was obtained at a mole fraction of 0.4. The mass pulls increased with increasing mole fraction until 0.4 and then dropped.

The optimum concentration of long chain C_{12}-TTC is 40%. The introduction of long chain collectors also improved the final PGM grades and recoveries. No variations on the copper were observed. A slight improvement of nickel recovery was observed with concentrations of 30 and 40 percent C_{12}-TTC. Janse van Rensburg (1988) also observed improved PGM's and nickel selectivity with long chain TTC's.

4.3.3 iC_3/iC_4 covalent TTC's

According to Coetzer (1987) covalent collectors are good bulk collectors. Various combinations of the short chain ionic TTC's, long chain mercaptans and covalent iC_3-iC_4-TTC were evaluated.

4.3.3.1 Materials and methods

The covalent ester, iC_3/iC_4-TTC was tested as a single component and in combination with iC_3-TTC. The same method was used as described in 3.4.1.

Combinations of the covalent ester and the long chain mercaptan were tested in nitrogen and air. The collector was dosed in the mill before milling and flushed with nitrogen/air. The flotation gas varied between nitrogen and air.

4.3.3.2 Results and discussion

Table 4.3 shows the results of the covalent collector tests conducted in nitrogen and air.

Table 4.3 Covalent collectors tested in nitrogen and air

Test		PGM		Cu		Ni	
Collector	**Mass Conc**	**Grade**	**Recovery**	**Grade**	**Recovery**	**Grade**	**Recovery**
	(g)	**(ppm)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**
Standard	131.71	37.33	86.45	0.56	94.12	1.04	65.72
iC_3/iC_4 -TTC	122.13	25.83	59.07	0.61	88.45	1.09	68.79
iC_3- TTC/ iC_3/iC_4-TTC	109.30	52.63	93.63	0.69	91.69	1.27	72.27
iC_3/iC_4-TTC /C_{12}-merc(N_2)	122.47	41.90	91.38	0.59	92.08	1.12	71.21
iC_3/iC_4 -TTC/C_{12}-merc(O_2)	117.21	30.73	67.22	0.63	89.97	1.11	70.08

The covalent iC_3/iC_4 - ester improved the mass pull of the ionic TTC. The combination of the ionic and covalent collector increased the PGM grade and again also the final recovery. Improvement on copper and nickel recovery also occurred with this combination.

Covalent collectors can be dosed in the milling stage because they are oily and adsorb slowly. The experiments done with the nitrogen had better mass pull than those done with air had. Nitrogen conditioning also resulted in better PGM grades. Tests conducted in air showed a very low PGM grade and final recovery. The standard collector again had the best copper results, and there is a slight improvement on nickel recovery.

4.3.4 Multiple collector addition

The main objective of these tests was to determine whether sequential addition or spiking of TTC could improve the final recovery of the standard collector suite

(SIBX/DTP). Various combinations of the standard collector and long and short chain TTC were tested and the results are given in Tables 4.4-4.6.

4.3.4.1 Materials and methods

The same method as 3.4.1 was used to prepare the ore.

SIBX/DTP (Standard collector suite) was initially added at 20, 40 or 60g/ton ore. After 5 minutes of conditioning time collection of the concentrate was started. This continued for 7.5 minutes at which point a concentrate was collected. The total collector dosage was 80 g/ton and the ore was then spiked with the difference and floated for a further 12.5 minutes. The second collector dosages varied between standard, iC_3-TTC and C_{12}-TTC. The two concentrates were then analysed for PGM, Cu, Ni and Cr_2O_3.

4.3.4.2 Results and discussion

Table 4.4 shows the results for 20g/ton initial dosage. The detailed result tables are reported in Appendix B.

Table 4.4 Recovery after 20 minutes for 20g/ton (25%) initial collector dosage.

		PGM		Cu		Ni	
Collector	**Mass Conc(1+2)**	**Grade**	**Recovery**	**Grade**	**Recovery**	**Grade**	**Recovery**
	(g)	**(ppm)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**
STD	123.49	47.19	93.78	0.40	93.10	0.81	72.53
iC_3-TTC	114.87	40.34	86.07	0.38	88.77	0.83	70.34
C_{12}-TTC	124.02	57.54	93.91	0.36	91.60	0.83	75.04

The low collector dosage in the beginning of the test resulted in a watery froth. The additional dosage of collector after 7.5 minutes improved the froth and increased the mass recovery of the test as reported in Appendix B. The long chain of the C_{12}-TTC resulted in the best mass-pull and the highest PGM and nickel recovery. Increase in PGM recovery with the standard collector suggest that 60g/ton is not a sufficient collector dosage if compared to single stage dosing (Table 4.3).

Table 4.5 Recovery after 20 minutes of 40g/ton (50%) initial collector dosage

		PGM		Cu		Ni	
Collector	**Mass Conc(1+2)**	**Grade**	**Recovery**	**Grade**	**Recovery**	**Grade**	**Recovery**
	(g)	**(ppm)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**
STD	119.80	36.97	93.08	0.39	92.16	0.80	70.69
iC_3-TTC	116.34	50.16	92.10	0.38	91.54	0.85	71.56
C_{12}-TTC	126.45	32.27	92.11	0.34	89.78	0.80	71.21

It seems that the TTC collectors were effective only at higher initial dosages. The highest PGM and nickel grades were obtained with the iC_3-TTC. The short chain TTC is the most sensitive to the collector dosage stages. The higher initial dosage reduced the recoveries of the long chain TTC and the standard collector suite. The short chain TTC showed great improvement with more initial collector.

Table 4.6 Recovery after 20 minutes of 60g/ton (75%) initial collector dosage

		PGM		Cu		Ni	
Collector	**Mass Conc(1+2)**	**Grade**	**Recovery**	**Grade**	**Recovery**	**Grade**	**Recovery**
	(g)	**(ppm)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**
STD	126.75	29.22	92.18	0.33	92.49	0.70	73.20
iC_3-TTC	120.49	33.55	89.42	0.35	91.83	0.78	70.50
C_{12}-TTC	133.05	30.72	93.07	0.31	89.72	0.74	73.00

The 60:20 (75%) combination with the iC_3-TTC formed large bubbles for the first few minutes, but with the second addition the froth was better and had improved in depth.

The iC_3-TTC showed slightly lower recoveries and it seemed that the optimum collector dosage for the iC_3-TTC was 40 g/ton (50%) initial dosage. C_{12}-TTC and the standard collector had the best recovery results with 25% initial dosage and the long chain TTC's improved over the standard for the 25 and 75% initial collector dosage.

From these results one can conclude that not sufficient standard collector is dosed and that the optimum collector dosage should be inspected. The PGM recovery of the standard collector is better than previous batch tests with 60g/ton collector dosage. Multiple stage dosing can also be evaluated on plant conditions to improve recoveries.