PROMOTERS FOR SOAP FLOTATION OF PHOSPHATE MINERALS

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ABSTRACT

Detergents are being used in some phosphate ore beneficiation plants as promoters to enhance the efficiency of the soap (or soap-diesel oil) flotation process. In the present investigation attempts were made to study the effect of promoters on the recovery of phosphate values from phosphate ore of Eshidiya mines, Jordan. Alfa Olefin Sulfonate (AOS), Linear Alky Benzene Sulfonate (LABS) and Urea were studied as promoters in conjunction with soap-light diesel oil emulsion. While AOS and LABS are detergents, urea is a polar non-electrolyte reagent known to act as hydrotrope. It is observed that all the three promoters show enhanced flotation efficiency compared to flotation with soap-emulsion. Interestingly urea along with soap-emulsion showed better performance compared to AOS with soap-emulsion or LABS with soap-emulsion.

Keywords: hydrotropes, flotation collectors, detergents

INTRODUCTION

Most of the phosphate ores are being beneficiated by froth flotation technique. Phosphate ores containing siliceous gangue minerals are beneficiated (Glembotski et al, 1972; Gaudin, 1977; Sekhar et al, 1986; Srinivas et al, 1996; Sekhar and Chouhan, 1998) by direct flotation of phosphate minerals using fatty acids and their salts as collector and sodium silicate as depressant for silicate minerals. Light Diesel Oil (LDO) is sometimes used (Glembotski et al, 1972) as an extender of the hydrocarbon chain of the collector. The flotation process currently used for processing of phosphate ore of Eshidiya mine of M/s Jordan Phosphate Mines Company Ltd. is direct flotation. Ore fractions are fed to coarse and fine flotation circuits separately after desliming and sizing to coarse (~1 mm+500 microns) and fine (~500+53 microns) fractions. The ore is conditioned with emulsion of tall oil and light diesel oil at a pH of 9 - 9.5. Sodium silicate is added to depress silicate minerals. The phosphate mineral is floated from silica and the rougher concentrate is cleaned once in case of coarse and twice incase of fines flotation. The emulsion is prepared by mixing tall oil with light diesel oil at the ratio of 1:1.2 and the mix is soapanified by adding sodium hydroxide adjusting the pH of 6 per cent solution at 11.

In some plants detergents are used to enhance the efficiency of the process. For example Alfa Olefin Sulfonate (Sekhar and Jain, 2006) is used along with soap at Jhamarkotra (India) beneficiation plant. SPS, that is sodium petroleum sulfonate (Roux et al, 1989) is used along with distilled tall oil fatty acid (eg, Unitol DSR90) at Phalaborwa (South Africa) plant. Our earlier work (Sekhar et al, 2009) on Eshidiya phosphate ores suggests that addition of urea along with the soap-light diesel oil emulsion enhances the recovery of phosphate minerals. In the present study of phosphate ore of Eshidiya mines (Jordan), Alfa Olefin Sulfonate, Linear Alky Benzene Sulfonate (LABS) and Urea are studied as promoters along with soap-light diesel oil emulsion to determine the process performance of these reagents.

EXPERIMENTAL

Materials

Ore: Eshidiya mines, Jordan, siliceous phosphate ore is studied in batch flotation experiments. Carbonate apatite is the principal mineral present in the ore and the predominant gangue minerals

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are quartz and clay. The ore was wet sieved in order to remove coarse reject (+2 mm), intermediate product (-2mm+1mm) and slime material (-53 μm). The -1mm+53 μm fraction is further sized to coarse (-1mm+53 μm) and fine (-500+53 μm) fractions. The fine fraction is taken for the present studies. The d80 of the feed used for the flotation studies was 437 μm. The sized feed was dried and used in the flotation experiments. The feed and flotation products were analysed for tri calcium phosphate and acid insolubles by spectrophotometer and acid digestion methods respectively.

Reagents

All the reagents used in the tests are of commercial grade which are being used in the plant. The tall oil (95 per cent Fatty Acid, Iodine No. 131, Titer 8°C) is supplied by M/s Arizona Chemical company, USA. LDO by Jordan Oil Corporation. Sodium silicate is of 36 per cent concentration and sodium hydroxide (98 per cent NaOH, Na₂CO₃ 0.5 per cent max) are supplied by National Caustic and Chlorine Co, Saudi Arabia. Alfa Olefin Sulfonate (38 per cent active matter, 0.2 per cent free alkali, 2 per cent sodium sulfate, 2 per cent sodium chloride, 4 per cent free oil (100 per cent basis) and pH of 5 per cent A/M solution is 9 ± 1) is supplied by M/s Godrej Industries Ltd, Mumbai India. Linear alkyl benzene sulfonate (70 per cent active matter, 1.5 per cent unsulfonated organic matter, 3 per cent sodium sulfate, <0.01 per cent free alkali as NaOH, 0.1 per cent sodium chloride and pH of 5 per cent A/M solution is 9 ± 1.5) is supplied by Jordan sulfo chemicals company, Amman, Jordan. Agriculture grade urea analyzing 46 per cent nitrogen, 0.7 per cent max moisture, 1.2 per cent max biuret, 100 per cent free of harmful substances and non radioactive is used.

METHODS

Flotation experiments were conducted in a two litre Denver type sub-aeration flotation cell. The ore pulp was conditioned at 50 per cent solids in the same cell at 1100 rpm for 2 minutes with sodium silicate and 1 minute with emulsion. The tap water is used in all the experiments. After conditioning, the pulp was diluted to 25 per cent solids before flotation. The promoters were mixed in the emulsion wherever required and then used. In the flotation kinetic studies, five floats were collected at cumulative time intervals of 0.25 minute, 0.50 minute, 0.75 minute, 1 minute and 2 minutes. The products (concentrates and tailings) were then filtered, dried, weighed and analysed for tri calcium phosphate and acid insolubles by spectrophotometer and acid digestion methods respectively. Conventional open cycle flotation tests were also carried out using reagent doses as practiced in plant. The rougher concentrate was cleaned twice to get the final concentrate. One litre flotation cell was used for first and second stages cleaning.

Tests 1 to 4 are flotation kinetic experiments and 5 to 8 are conventional flotation tests. Reagent doses for Test 1 are as practiced in the plant ie, 0.97 kg/t tall oil, 1.13 kg/t diesel and 0.35 kg/t sodium silicate. The reagent regime and test conditions for tests 2, 3 and 4 are same as test 1 except for the addition of promoters ie, AOS (300 grams/ton), LABS (172 grams/ton) and Urea (2.3 kg/t) respectively. The procedure adopted for Test 5, 6, 7 and 8 are rougher flotation followed by two stages of cleaning as practiced in the plant but without recycling the middlings. The tests 6, 7 and 8 are repetition of test 5 with the addition of AOS (300 grams/ton), LABS (172 grams/ton) and Urea (2.3 kg/t) respectively. The ore feeds of tests 1, 2, 3 and 4 are from one batch and of tests 5 to 8 are from another batch collected at different times from the plant.

RESULTS AND DISCUSSIONS

Flotation Kinetic studies

The results of the experiments from 1 to 4 are given in Table 1 and are also depicted in Figure 1. From the figure it is clearly evident that the P₂O₅ recoveries were much higher when promoters are used. Out of the three promoters tested, urea was found more effective than AOS and LABS.

Conventional flotation tests

The open cycle flotation test results are given in Table 2 and are also shown in Figure 2. It is noted that the final P₂O₅ recoveries are of the order of 40 - 50 per cent when emulsion alone is used and the recoveries remarkably improved with the addition of promoters. The order of efficiency of the reagents tested in terms of P₂O₅ recovery (shown in brackets) at a 35 per cent P₂O₅ grade of concentrate is as follows:
Emulsion with Urea (75 per cent) > Emulsion with LABS (71 per cent) > Emulsion with AOS (66 per cent) > Emulsion only (—).

The results obtained with promoters show higher P$_2$O$_5$ recoveries at equal concentrate grades. The reason why urea improves the recovery of phosphate mineral during soap flotation may be due to its ability to act as hydrotrope (Roy and Moulik, 2003) or due to its ability to change the structure of water (Gershon and Pratt, 1982) near the phosphate mineral surface such that bubble particle attachment is enhanced or both these mechanism are operative.

### TABLE 1

Results of the kinetic experiments.

<table>
<thead>
<tr>
<th>Fraction</th>
<th>Test 1</th>
<th>Test 2</th>
<th>Test 3</th>
<th>Test 4</th>
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<tbody>
<tr>
<td></td>
<td>Wt%</td>
<td>Grade % P$_2$O$_5$</td>
<td>% Cum. P$_2$O$_5$ Rec</td>
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</tr>
<tr>
<td>F1</td>
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<td>33.46</td>
<td>19.57</td>
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<td>33.52</td>
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<td>10.40</td>
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</tr>
<tr>
<td>Calc. feed</td>
<td>100.00</td>
<td>19.57</td>
<td>100.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>

F1 = Float 1; F2 = Float 2; F3 = Float 3; F4 = Float 4; F5 = Float 5; and RT = rougher flotation tails.

![FIG 1 - Kinetic plot for cumulative P$_2$O$_5$ recovery of tests 1 to 4.](image-url)
CONCLUSIONS
Addition of promoters such as alfa olefin sulfonate or linear alkyl benzene sulfonate or urea enhance the effectiveness of soap–LDO emulsion collector.

Urea as promoter in soap emulsion flotation showed consistently higher recoveries without reducing the grade of the concentrate.

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REFERENCES


