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FLOTABILITY STUDIES OF THE MINERALS APATITE, CALCITE AND DOLOMITE, USING FATTY ACID IN THE PRESENCE OF DIFFERENT DEPRESSANTS

R.M.F. Lima[1], G. R. Luvizzotto[2]
1 – Dr^a^., Prof^a^. do PPGEM / EM / UFOP
Departamento de Engenharia de Minas - Morro do Cruzeiro S/N°. – Campus Universitário
CEP.: 35.400-000 – Ouro Preto - Minas Gerais
E-mail: rosa@demin.ufop.br

2 – Mining Engineer – AngloGold Ashanti Brasil Mineração Ltda -Rodovia MGT 262 Km 26
CEP 34750-000 -Sabará- MG
E-mail: GRLuvizotto@AngloGoldAshanti.com.br

ABSTRACT

In this paper are presented the microflotation comparative result studies of the slightly soluble minerals, apatite, calcite and dolomite, which occur in Brazilian phosphate rocks, using as collector a commercial mixture of fatty acids (soy bean oil) in the presence of corn starch, sodium silicate, sodium and potassium tartarate and sodium phosphate depressants. In these studies, it was observed that the maximum floatability of the apatite, calcite and dolomite minerals at pH 10.5 was reached with dosages of 25, 50 and 75 mg/L and that the most efficient depressant for the selective separation among the studied minerals was the corn starch, followed by the sodium silicate, sodium and potassium tartarate and sodium phosphate. The sodium silicate was not an efficient dolomite mineral depressant.

KEY WORDS: Salt-types minerals, depressants, microflotation.

1 – INTRODUCTION

The fatty acid soaps are extensively used as an apatite collector in phosphate rock flotation. In the mineral industries of phosphate rock, a commercial mixture of fatty acids, such as soy bean oil, is used. The chemical composition of a typical commercial soy bean oil is presented at Table I below.

Table I – Soy bean oil chemical composition (Caire, 1992; Leja, 1983).

Fatty Acid	Chemical Formulae	Solubility (M) at 20°C	Composition (%)
Miristic	$CH_3(CH_2)_{12}COOH$	$1,0 \times 10^{-6}$	0,1 - 0,4
Palmitic	$CH_3(CH_2)_{14}OH$	$6,0 \times 10^{-6}$	7 – 11
Estearic	$CH_3(CH_2)_{16}COOH$	-	2,4 – 6
Palmitoleic	$C_{16}H_{30}O_2$	-	0,1 – 1
Oleic	$CH_3(CH_2)_7CH = CH(CH_2)_7COOH$	-	22 – 34
Linoleic	$CH_3(CH_2)_4CH = CHCH_2 = CH(CH_2)_7COOH$	-	50 – 60
Linolenic	$CH_3CH_2CH = CHCH_2CH = CHCH_2CH = CH(CH_2)_7COOH$	-	2 – 10

Brandão (1988) affirmed that the oxidation of the double connection in the oleic acid by the oxygen present in an aqueous environment leads to the partial polymerization of the hydrocarbon chains, turning the chemically absorbed film on the magnesite surface extremely stable, due to the strong covalent connections C - O - C among the neighboring chains and the van der Walls connections already existent.

Oliveira (2005) used conventional chemical analyses, gas chromatography and infrared spectrometry, performed the chemical characterization of two commercial samples of soy bean oil (Hidrocol), one partially hydrogenated and other without hydrogenation, both manufactured by Hidrovex. The results showed that both samples had approximately the same fatty acid composition. So the hydrogenation process of the soy bean oil partially hydrogenated was not effective. The infrared spectra of both samples were quite similar, but for the sample without hydrogenation, the index of acidity was superior to that of the hydrogenated sample 152.48 and 134.67 mg KOH / g of sample, respectively. With this information it is possible to affirm that there were a larger amount of free fatty acids in the soy bean oil without hydrogenation compared with the hydrogenated sample. Later, microflotation tests were performed with apatite from Monteiro-PB at pH 10.4 value. In these tests were used fatty acids with different neutralization degrees. With these studies it was concluded that at 70% fatty acid neutralization degree resulted in greater mineral floatability.

Through calculation of the solubility products of the inorganic dispersant chemical solutions Na_2SiO_2 and Na_3PO_4, Yuehua et al. (2003) concluded that the calcium silicate or phosphate precipitation on the surfaces of calcite ($CaCO_3$), apatite ($[Ca_{10}(PO_4)_6(OH)_2]$ and fluorite (CaF_2) is the main depression mechanism for those minerals. With these calculations, and later confirmed by zeta potential measures and floatability tests on these minerals, it was verified that the selective separation between apatite and calcite is possible for pH values understood between 9.2 and 11.5 when using sodium silicate depressant. In the case of sodium phosphate in fluorite suspension, it was evidenced that this reagent is a stronger depressant than the sodium silicate in pH values between 4 and 6.

In this work was made a comparative floatability study of the slightly soluble minerals apatite, calcite and dolomite by using the corn starch, sodium silicate, sodium phosphate and sodium and potassium tartarate as depressants in the presence of the collector soy bean oil (hydrogenated Hidocol) in order to obtain a selective separation condition for these minerals that are present in carbonated Brazilian phosphate rocks and are concentrated by froth flotation.

2 – MATERIALS AND METHODS

In this work mineral samples of apatite, calcite and dolomite were used in the size range from 147 to 44μm. Their chemical compositions are presented in Table II. The minerals apatite and calcite were obtained through purification by manual sorting and physical methods of concentration of samples from areas of the Tapira/MG mine with a high quantity of these minerals. The dolomite sample used was from the Ouro Preto/MG's region.

The chemical reagents were:

- Collector: hydrogenated soy bean oil, commercial name Hidrocol, manufactured by Hidrovex
- Depressants:

  Commercial corn starch, manufactured by Cargil

  Sodium silicate (PA)

Sodium phosphate (PA)

Sodium and potassium tartarate (PA)

- pH modifiers:

Sodium hydroxide (PA) – 5% w/v solution

Cloridric acid (PA) – 5% v/v solution

Table II – Chemical composition of apatite, calcite and dolomite samples (Lima et al., 2004).

Sample	P_2O_5 (%)	Fe_2O_3 (%)	MgO (%)	CaO (%)	Al_2O_3 (%)	SiO_2 (%)	TiO_2 (%)
Apatite	37,34	0,30	0,22	51,70	0,07	4,28	>0,1
Calcite	0,46	0,73	1,03	54,89	0,03	1,72	>0,1
Dolomite	0,26	1,57	22,36	30,41	0,07	1,50	>0,1

The microflotation tests were made in a modified Hallimond's cell. In a first phase, mineral sample (1g) floatability curves were obtained in function of the pH and soy bean oil collector concentration. Afterwards, in order to determine the best floatability conditions for each mineral (pH and collector dosage), were obtained the floatability curves of those minerals that were put in previous contact with the depressant solution under these best conditions of floatability in function of the pH and collector dosage. The contact time was 5 minutes for all minerals, apatite, calcite and dolomite, in a corn starch solution. In the case of sodium silicate, the contact time of apatite and calcite was 4 minutes and 2 minutes for dolomite. For sodium phosphate, it was 4 minutes for the calcite and 2 minutes for the apatite and dolomite, respectively. In the case of sodium and potassium tartarate depressants, the contact time was set for 6 minutes for all three minerals. After the mineral samples were conditioned with the depressant solutions, they were conditioned by a period of 3 minutes with a Hidrocol collector. Afterwards, they were floated for 1 minute at a flow of 60 mL/min. of nitrogen gas. Finally, the floated and sunken products were collected, filtered and dried in order to perform the mineral floatability calculations.

3 – RESULTS AND DISCUTION

Figures 1, 2 and 3 present the apatite, calcite and dolomite floatability curves in function of the pH and soy bean oil collector dosage. As it can be observed by the floatability curves for the three studied minerals, 100% floatability was not obtained under any of the tested conditions, and the use of the soy bean oil collector didn't result in selective mineral separation. In general, it was observed that the floatability of the three minerals with the dosage at 12.5 mg/L is less. In the cases with apatite and calcite, this behavior was clear for the pH values 4, 7 and above 11 (sees curves in the Figures 1 and 2). As it can be seen by Figure 2, calcite floatability was between 75 and 92% for all of the soy bean oil dosages and pH values tested. In addition, there was a small decline in floatability near the neutral value of pH (6 to 8), especially for the dosages of 25 and 50 mg/L. At those dosages, the mineral floatability was larger for the acid pH (3 to 6) range, too. In the dolomite case, it is clearly observed that floatability increases when collector dosage increases (Figure 3).

The apatite, calcite and dolomite microflotation test results, when using the soy bean oil collector at pH 10.5 in the presence of corn starch, sodium silicate, sodium and potassium tartarate and sodium phosphate depressants, are presented in Figure 4.

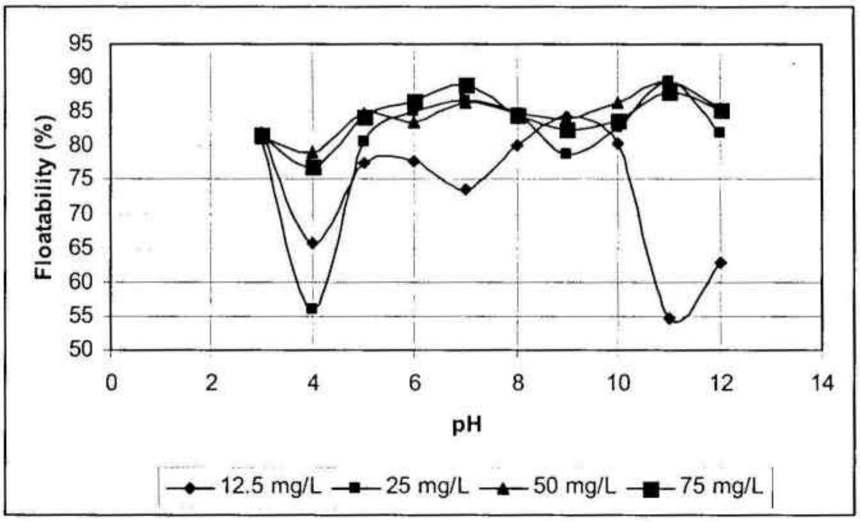

Figure 1 – Apatite floatability in function of the pH and soy bean oil dosage (conditioning time: 3 minutes).

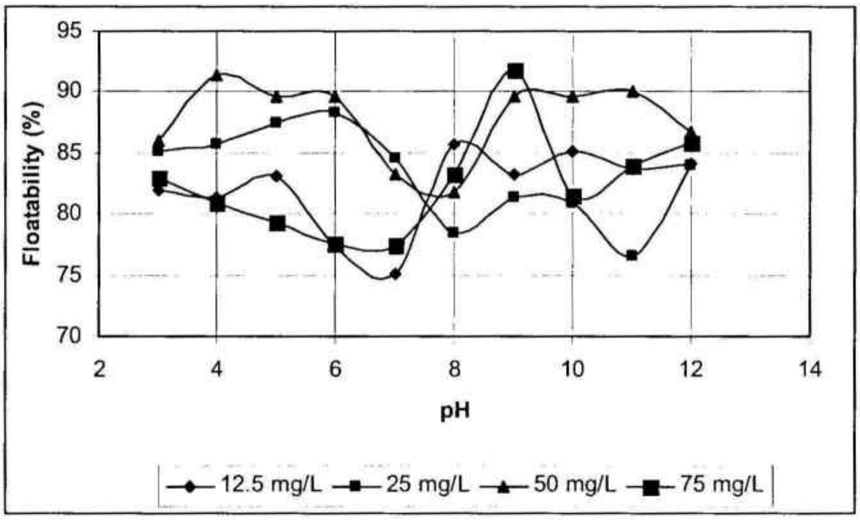

Figure 2 – Calcite floatability in function of the pH and soy bean oil dosage (conditioning time: 3 minutes).

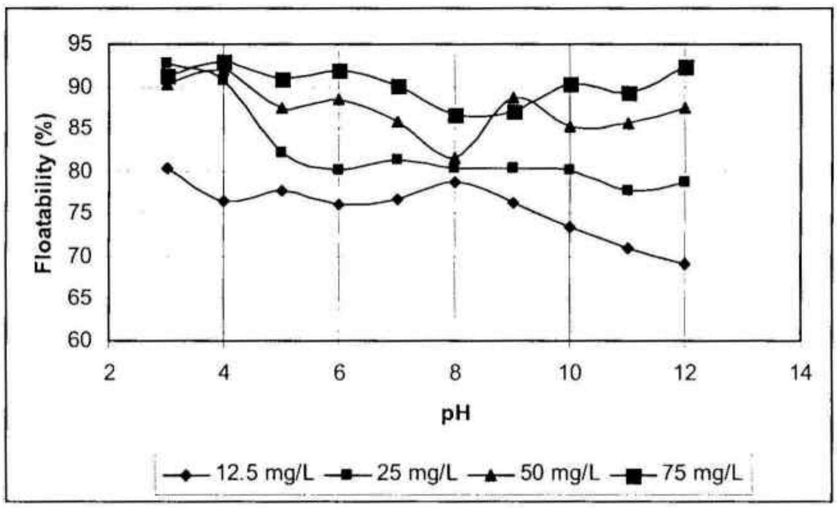

Figure 3 – Dolomite floatability in function of the pH and soy bean oil dosage (conditioning time: 3 minutes).

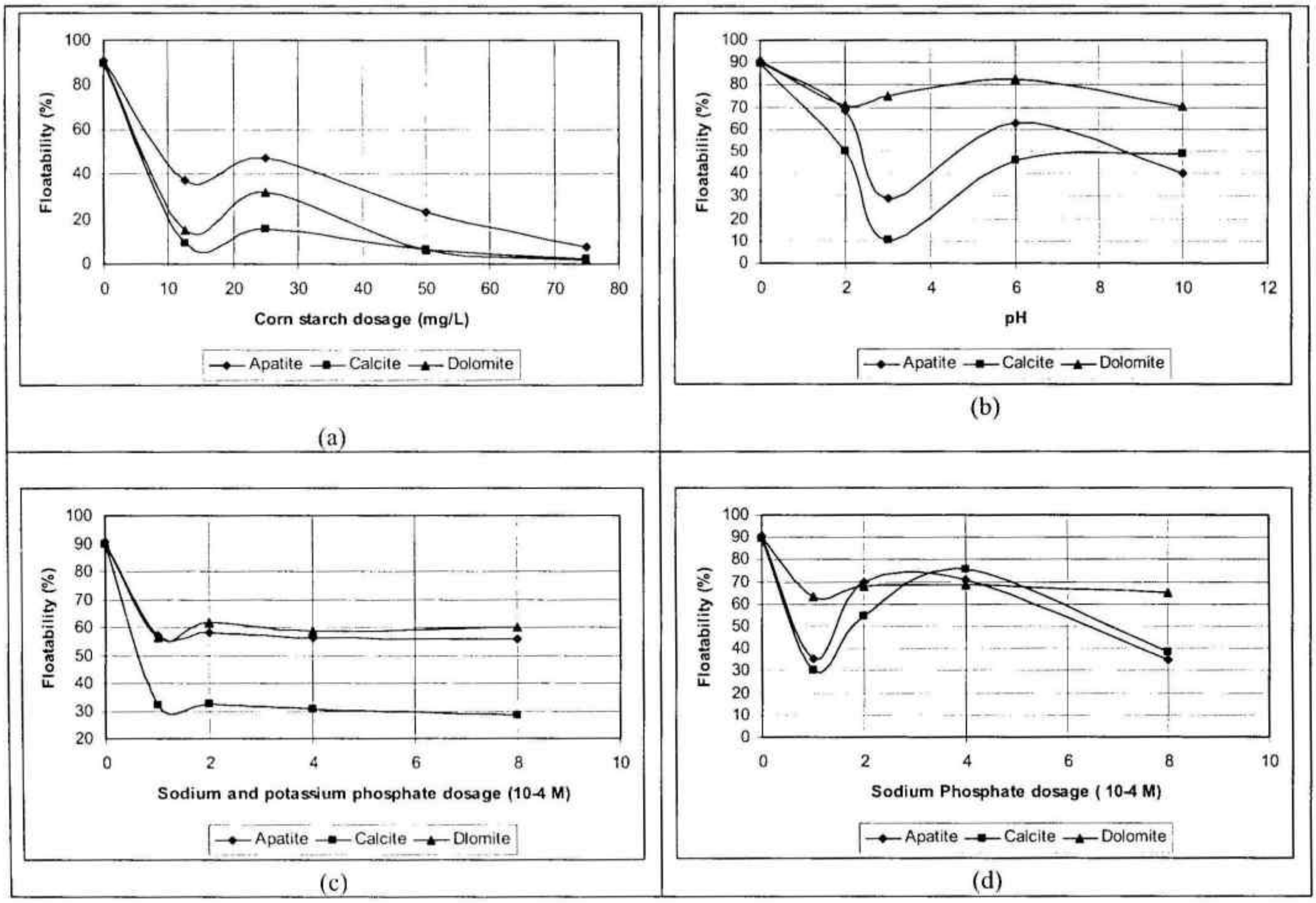

Figure 4 – Floatability curves for the apatite, calcite and dolomite minerals at pH 10.5 and a soy bean oil dosage of 25 mg/L for the apatite, 50 mg/L for the calcite and 75 mg/L for the dolomite in function of the depressant dosage:
(a) Corn starch
(b) Sodium silicate
(c) Sodium and potassium tartarate and
(d) Sodium phosphate.

Though Figure 4 (a), it can be seen that the corn starch was more powerful in depressing the calcite, followed by dolomite, and finally by apatite. At 75 mg / L, the floatability of the three minerals was close to 2%. In the case of the sodium silicate 4 (b), the depression efficiency order was the following: calcite, apatite and dolomite. However, the smallest floatability was about 10% for the calcite at a 2 x 10^{-4} M dosage. The same mineral depression efficiency order was observed for the reagents of sodium and potassium tartarate and for sodium phosphate, whose minimum floatability when using sodium and potassium tartarate was around 30% for the calcite and 60% for the apatite and dolomite, respectively. In the case of the sodium phosphate, were obtained minimum floatability of 30 and 35% for the calcite and apatite at a 1 x 10^{-4} M dosage, respectively and the floatability increased again when the dosage increased.

In general, it can be affirmed that there is the possibility of selective separation between apatite and carbonate minerals (calcite and dolomite) by using corn starch. It was verified that sodium silicate was more efficient in the depression of calcite, followed by apatite and that it was not very effective for dolomite depression at pH 10.5. The same tendency was verified for the sodium phosphate. In the case of the sodium and potassium tartarate, practically the same calcite floatability value (30%) was obtained with a 1 x 10^{-4}M of sodium phosphate depressant dosage. For all the inorganic depressants tested, it was verified that the apatite depression was greater or equal to the dolomite depression when using sodium and potassium tartarate. However, remember that different collector dosages were used for the three studied minerals (25, 50 and 75 mg/L for the apatite, the calcite and the dolomite, respectively).

4 – CONCLUSIONS

- The best floatabilities conditions for the apatite, calcite and dolomite minerals occurred at same pH value of 10.5 and dosages of Hidrocol at 25, 50 and 75 mg/L, respectively.

- The efficiency order for the selective separation between the apatite and calcite was: corn starch> sodium silicate > sodium and potassium phosphate or sodium phosphate, the latter two having the same efficiency.
- It was verified that there was greater apatite depression in relation to that of dolomite for all inorganic depressants that were tested, except for the sodium and potassium tartarate that produced similar results for the two minerals.

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