

EFFECT OF pH ON BENEFICIATION OF PHOSPHATE BY SELECTIVE FLOTATION

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ABSTRACT

Flotation of carbonate minerals from phosphate ores was investigated, using oleic acid as collector and aluminum sulphate and sodium hydroxide as pH modifiers. Separation of carbonate from phosphate minerals was anticipated under various pH conditions. The pH of the flotation pulp has a significant effect on separation. Flotation selectivity was found to be the highest under moderate alkaline conditions. However, the highest yield and recovery were obtained under slightly acidic conditions. The lowest efficiency was observed at pH range from 7 to 8.5. Explanation of the high flotation response was proposed in terms of the differences between the electrokinetic behaviors of carbonate minerals (calcite and dolomite) and phosphate minerals under various pH conditions.

Keywords: Phosphate Rock Beneficiation, Adjusting ph, Flotation, Carbonates Separation.

INTRODUCTION

It has been suggested that phosphate minerals can be depressed in a slightly acidic medium [1-7], however carbonate minerals can be activated in a moderate alkaline medium [8-11].

Anionic collectors have been employed industrially in beneficiation of both siliceous phosphate and carbonate rocks [12-18]. Hence calcareous phosphate ores can be upgraded by floating the carbonates (calcite and/or dolomite) in a slightly acidic medium by depressing the phosphate minerals or in a moderate alkaline medium by activating the carbonates using an anionic collector.

An Egyptian phosphate rock contains both silicates and carbonates gangue materials was successfully upgraded in a slightly acidic medium, also in moderate alkaline medium by floating the gangue materials using oleic acid as collector in tap water. The paper presents the results obtained from the flotation tests.

EXPERIMENTAL

Materials

Ore: The phosphate sample used to carry out the experiments was collected from ElQuseir in the eastern desert of Egypt. The whole sample was-350

microns in particle size and contains 66% by weight of-63 microns materials. The chemical composition of the sample was: 58.47% T.C.P, 26.78% P_2O_5 , 3.72% H_2O , 7.62% I.R, 6.98% SiO_2 , 3.08% SO_3 , 0.57% Al_2O_3 , 1.54% Fe_2O_3 , 46.2% CaO, 1.5% MgO, 12.8% LOI and 3% organic matter.

The full chemical analysis of the head sample as well as the P_2O_5 percent in the concentrates and in tailings products were made at the laboratory of Red Sea company for phosphate. However, the determination of the loss on ignition (LOI) of the products which is a fair indication of the amount of carbonates was conducted immediately after each experiment.

Reagents: Oleic acid was used as collector, while ethyl alcohol was used as frothing reagent. Adjusting the pH of the flotation pulp was made by the addition of aluminum sulphate [$Al_2(SO_4)_3 \cdot 14H_2O$] to create the acidic environment, however sodium hydroxide (NaOH) to produce the alkaline environment.

TEST PROCEDURES

The froth flotation tests were carried out in a Denver laboratory flotation machine with a capacity of 1 liter. Both phosphate material and the pH

adjusting reagent were introduced into the flotation cell and slurred with tap water at impeller speed of 1200 rpm and solids concentration 60% for five minutes after which oleic acid and ethyl alcohol were added and the pulp was diluted to contain only 30% of solids and agitated for further five minutes. Then the air inlet was opened, while the speed of the impeller was reduced to 900 rpm. The mineralized froth was collected until the froths become barren. Both products (float and sink) were filtered, dried, weighed and analyzed.

Regarding the amounts of different reagents, the dosages of oleic and ethyl alcohol were kept constant for all tests, these being respectively 175g/t and 50g/t of feed. However, the dosages of aluminum sulphate and sodium hydroxide were varied between 0.125 to 1.5 Kg/t to give different pH values.

RESULTS AND DISCUSSION

The results of flotation tests conducted as a function of pH using 0.175 kg/t oleic acid as collector (Figures (1-3)) predicated selectivity under the following conditions:

- 1- Separation of carbonates from phosphate minerals between pH 8 to 10.
- 2- Separation of carbonates from phosphate minerals in the pH range of 6 to 7.
- 3- Yield and phosphate recovery under alkaline conditions were lower than under acidic conditions, while the selectivity was vice versa.
- 4- Two peak points for both yield and recovery are obtained at pH values 6.7 and 9.2.
- 5- The selectivity increased by increasing the pH under alkaline conditions, whereas approximately remained constant by lowering the pH value under acidic conditions.

Figure (1) shows the grade of concentrate as a function of pH. Lowering the pH in acidic conditions is seen to increase P_2O_5 content of the concentrate, however, lowering the pH in alkaline conditions is seen to decrease the P_2O_5 content of the concentrate. Figure (2) illustrates the effect of pH on the yield and the recovery of phosphate minerals. It can be seen that the curve for the weight yields follows very distinct trend, it indicating the effect being more marked at pH 6.7 and 9.2 than at pH below 6.7 and above 9.2. Since maximum yield obtained at these pH range between these two values or at pH values the yield of either side of

these falling remarkable. It can be also seen that the curve of recovery follows the weight yield curve. Hence any discussion regarding the weight yield curve generally is applicable to the recovery curve.

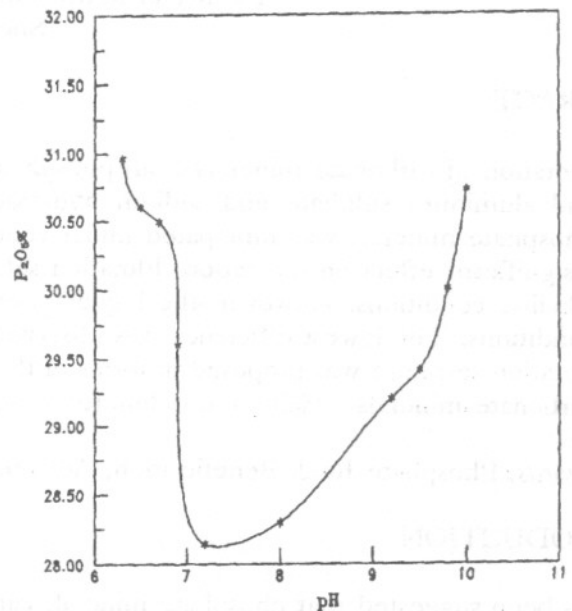


Figure 1. Effect of Variation of pH on the Grade of the Concentrate.

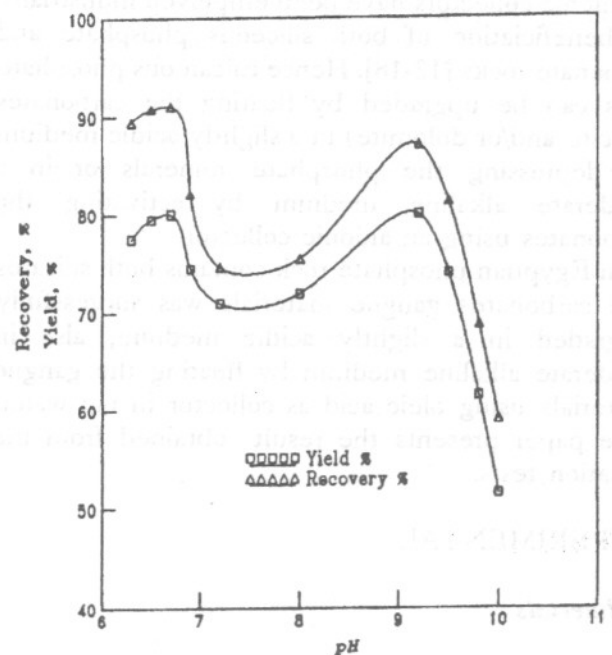


Figure 2. Effect of Variation of pH on both Yield and Phosphate Recovery.

The results of loss on ignition which is a good indication of the amount of carbonates in the products are presented in Figure (3). This figure shows the amount of carbonates in both tailings and concentrate. It can be seen that the carbonate content of the concentrate increases with rise of pH, but levels out between pH 7 and 8, then giving very marginal decrease from pH 8 to 9.2, then falls sharply by increasing the pH above 9.2.

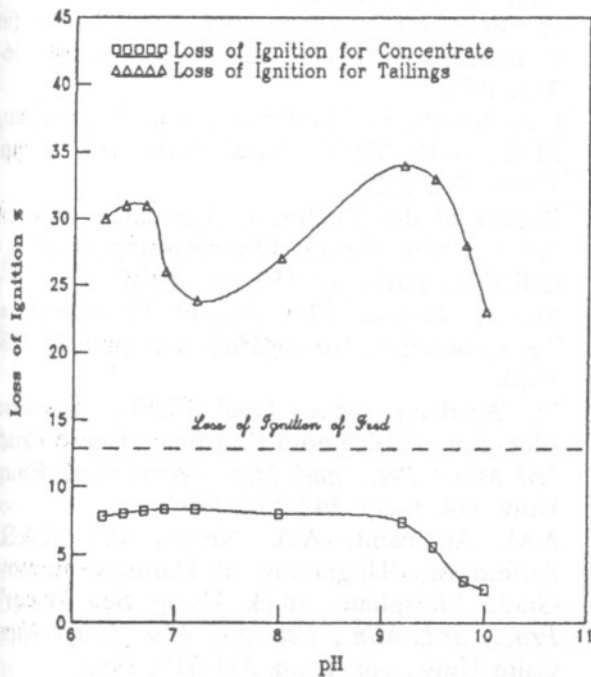


Figure 3. Effect of Variation of pH on the Loss of Ignition for Tailings and Concentrates.

The trend of the curve of carbonates content in tailings is completely similar to those of the yield and the recovery. Hence the above explanation regarding the yield and the recovery curves to a great extent is applicable to this curve. It appears from the above that the separation of carbonates from phosphate minerals using oleic acid to be pH dependent, Slightly acidic conditions (pH 6-6.8) and moderate alkaline conditions (pH 8.5-10) are required to obtain maximum separation efficiency. Here some consideration should be given to the surface charges of the various solids within the system in order to explain the above results. The electrokinetic studies on calcite and apatite [4,8,9,11] have indicated that the surfaces of calcite particles

exhibit a positive charge even in alkaline conditions, when NaOH was used to raise pH of calcite slurry, however, reversal of the sign of calcite occurring at pH 11.8, producing a low negative zeta potential at higher pH values. Apatite, however, shows negative surface potentials, except at low pH where charge reversal occurs at about pH 3.

Assuming these conditions, in the case of using oleic acid as anionic collector in the flotation of phosphate minerals associated with carbonate gangue, then from a very simplified model of the electrostatic forces, oleic acid, will not be adsorbed onto the negatively charged phosphate minerals, however, will be preferentially attached to the positively charged surfaces of calcite, subsequently the calcite will report with floats. On the other hand, it has been proved that the three calcium/phosphate complexes ($\text{Ca}(\text{H}_2\text{PO}_4)_2$, CaHPO_4 , and CaH_2PO_4) can exist in the acidic conditions in apatite/water systems. These complexes are suggested to cause apatite depression in the acidic conditions [1,4]. Therefore, it can be anticipated that the anionic collector is not adsorbed on the surface of carbonate minerals, hence flotation of carbonates can be carried out.

While some explanation of the flotation of carbonate minerals under both slightly acidic and alkali conditions has been proposed, the high selectivity obtained with the slightly alkaline medium has not been discussed. It is very apparent that concentrates of low carbonate content are generally produced with the slightly alkaline conditions. Here, it is suggested that when NaOH was added to raise the pH of the phosphate slurry the free sodium ions with the oleic acid can produce the sodium oleate which will be present with the remained portion of oleic acid or the oleic acid would be completely changed into oleate salts particularly at the higher concentrations of sodium ions, i.e, we will have a system having the sodium oleate salt as anionic collector which is more selective reagent than the acid [19-21]. Hence, the selectivity of sodium oleate system which is much greater than that of the only oleic acid system, is the cause of the improved results.

CONCLUSIONS

From the results and discussion reported in this paper, it can be concluded that:

- 1- Separation of the carbonate gangue from phosphate rocks can be achieved using oleic acid in a small dosage (starvation level) under a slightly acidic condition or under moderate alkaline condition.
- 2- The alkaline system has greater selectivity than the acidic system, whereas, the acidic system produces higher yield and recovery.
- 3- All effects are considered in terms of:
 - a- The differences in the electrokinetic behaviour of carbonate and phosphate minerals in acidic or alkaline medium in solids/water system.
 - b- The phosphate minerals being depressed in the acidic medium, while the carbonates will be activated in the alkaline medium.
 - c- The collector is suggested to be chemically absorbed on carbonate surfaces.

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