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STUDY ON THE IMPROVEMENT OF TALC CONCENTRATE

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Abstract. The mechanism and feasibility of separation of talc from tremolite and dolomite by flotation was investigated. Experimental results showed that H_2SO_4 possesses good selective properties in soap flotation that qualify it as selective depressant for tremolite and dolomite. It seems that H_2SO_4 forms with calcium sites an insoluble hydrophilic compound of type $CaSO_4.2H_2O^-$.

Talc being nonpolar mineral possessing high natural floatability could adsorb the nonionized oleic acid molecules the p*K*a of which is 5.5 and be floated off.[1] Results of amine flotation showed that talc could be separated from dolomite but not from tremolite. H_2SO_4 was without beneficial effect in amine flotation due to the adsorption of dodecylaminium ions on silicon sites in the case of tremolite and the positive surface charge of dolomite.

Natural pure talc $Mg_3Si_4O_{10}(OH)_2$ is rare. It is usually associated with tremolite $Ca_2Mg_5Si_8O_{22}(OH)_2$, dolomite $Ca\,Mg(CO_3)_2$, chromite $FeCr_2O_4$, magnetite Fe_3O_4, magnesite $MgCO_3$, pyrite FeS_2, and others. Elimination of substantially associated minerals and gangue by gravity and magnetic separation is becoming standard practice. However, tremolite and dolomite, being diamagnetic and having specific gravity equal to that of talc, usually accompany the latter contaminating talc concentrate with calcium oxide. In this paper the amenability to selective flotation of talc, tremolite and dolomite was studied.

Experimental

The materials used in this investigation were of the highest possible purity. Chemical reagents were of the analytical grade. Reasonably pure crystals of talc, tremolite and dolomite from the southern parts of Eastern Desert of Egypt (Hamata district, Wadi Gulan El-atshan) were crushed in a porcelain mortar and screened to give a −100,+150 mesh fraction for flotation tests and −150,+200 mesh fraction for streaming potential studies. Microscopic examination of the obtained fractions showed that they were clean and free of locked particles and gangue. The equipment used for streaming potentials was that previously used by the author.[2,3] The description of the Hallimond tube is given in a previous paper.[2] The procedure for the determination of adsorbed oleic acid (OLH) and dodecylamine (DA) on mineral particles were similar to that described in the literature[4] and used by the author.[5]

Results and Discussion

The results of measurements of zeta potential of talc, tremolite and dolomite in absence and presence of constant amounts of OLH and DA are graphically illustrated in Fig. 1. It is noted that the minerals tested to be unisoelectric at any pH. Dolomite has a positive, whereas talc and tremolite have a negative surface charge in acid and alkaline media. Addition of 50 mg/l OLH increased the negative surface charge of talc and tremolite and reversed the sign of zeta potential of dolomite at a pH of approximately 8. On the other hand, addition of 70 mg/l DA did not affect zeta potential of dolomite and decreased noticeably the negative surface charge of talc and tremolite over the pH range 5–8. The probable surface configurations of tremolite and dolomite are:

In the case of tremolite

(1)..SiO^-(2)..MgO^-, (3)..CaO^-, (4)..MgOH, (5)..$MgOH_2^+$, (6)..CaOH, (7)..$CaOH_2^+$.

In the case of dolomite: sites Nos. 3,6,7, and (8) ..CO_3H, (9)..CO_3^-.

The symbol..represents the crystal lattice surface.

Since the isoelectric point of calcium site is high[2,5] and taking into consideration the data shown in Fig. 1,

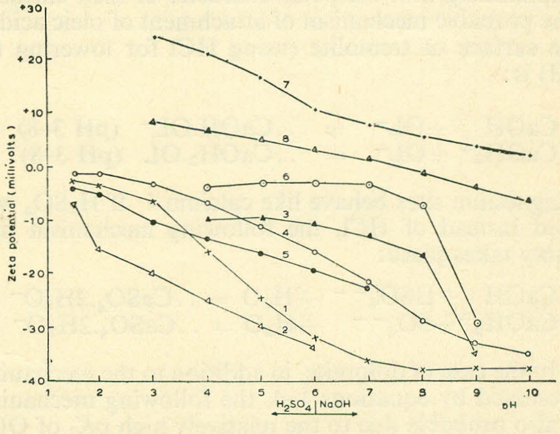

Fig. 1. Zeta potential of minerals as a function of pH:(1), talc, (2) talc in presence of 50 mg/l oleic acid, (3) talc in presence of 70 mg/l dodecylaminium chloride, (4) tremolite, (5) tremolite in presence of 50 mg/l oleic acid, (6) tremolite in presence of 70 mg/l dodecylaminium chloride, (7) dolomite, (8) dolomite in presence of 50 mg/l oleic acid.

it is probable that site No. 1 predominates in acid and alkaline media; site Nos. 2 and 3 predominate in high alkaline medium; Nos. 4–7 predominate in acid and slightly alkaline circuits; No. 8 predominates in acid and alkaline media; No. 9 could exist only at pH values above 10 owing to the fact that the pK_a of HCO_3^- is 10.36.

A study of the floatability of talc, tremolite, and dolomite in anionic and cationic collector systems, using oleic acid and dodecylamine as collectors, respectively, allowed some conclusions to be reached regarding the conditions which determine the transition between flotation and nonflotation of each mineral. The per cent flotation of talc is slightly affected by the pH variation and the kind of acid used for adjusting the pH (Fig. 2). Tremolite hardly responds to soap flotation and H_2SO_4 reduced markedly its floatactivity. On the other hand, dolomite responds well to soap flotation over the pH range 4–9. The pH could not be lowered below 4 because of the solubility of dolomite. When H_2SO_4 is used instead of HCl for adjusting the pH, the dissolution of dolomite was rather impeded and the consumption of the acid was greatly decreased. The pH of the pulp is, therefore, stabilized and could be lowered to approximately 3. Moreover, H_2SO_4 deactivates markedly the floatability of dolomite and tremolite probably due to the formation with calcium sites of an insoluble hydrophilic compound of the type $..CaSO_4.2\,H_2O^-$.

At the end of every flotation test the collector adsorbed on mineral grains was quantitatively determined. The results are plotted in Figs. 3 and 5. The adsorptive capacity of talc for oleic acid increased by decreasing the pH reaching relative maximum at about 3 (Fig. 3). This indicates the natural hydrophobic and nonpolar character of talc possessing high adsorptive capacity for the nonionized oleic acid molecules present. By contrast, the adsorptive capacity of tremolite and dolomite for the nonionized oleic acid molecules is much less than that for oleate ions emphasizing thus the polar character of their surfaces. The probable mechanism of attachment of oleic acid to the surface of tremolite (using HCl for lowering the pH) is:

$$..CaOH \;+ OL^- \;=\; ..CaOH.OL^- \quad (pH\ 3\text{–}8) \quad (1)$$
$$..CaOH_2^+ + OL^- \;=\; ..CaOH_2.OL \quad (pH\ 3\text{–}8) \quad (2)$$

Magnesium sites behave like calcium.[5] If H_2SO_4 was used instead of HCl, the following mechanism probably takes place:

$$..CaOH \;+ HSO_4^{--} \;+ H_2O = ..CaSO_4.2H_2O^- \quad (3)$$
$$..CaOH_2^+ + SO_4^{--} \;+ H_2O = ..CaSO_4.2H_2O^- \quad (4)$$

In the case of dolomite, in addition to the mechanism presented by equations 1–4, the following mechanism is also probable due to the relatively high pK_a of OLH and CO_3H^-:

$$..CO_3H \;+ OL^- \;=\; ..CO_3HOL^- \quad (pH > 3) \quad (5)$$

The response of the minerals investigated to amine flotation is shown in Fig. 4. It is seen that the floatactivity of talc is greatly increased by increasing the pH above 8. Since amine salts ionize readily below a pH of about 6, and the ionization slows down rapidly with the rise of pH above 6 and ceases at approximately 8.5[6] it is reasonable to assume that the nonpolar

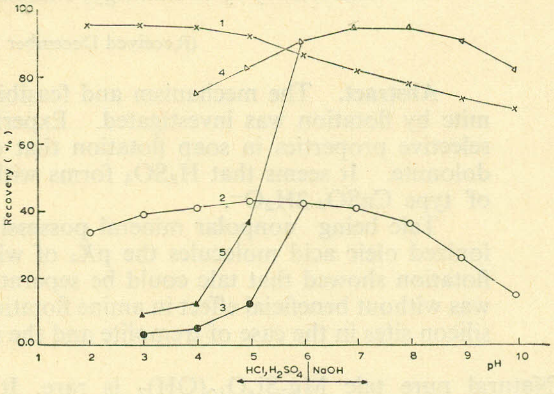

Fig. 2. Recovery of minerals using 50 mg/l oleic acid as collector, (1) talc, (2) tremolite using HCl for adjusting pH, (3) tremolite using H_2SO_4 for adjusting pH, (4) dolomite using HCl for adjusting pH (5) dolomite using H_2SO_4 for adjusting pH.

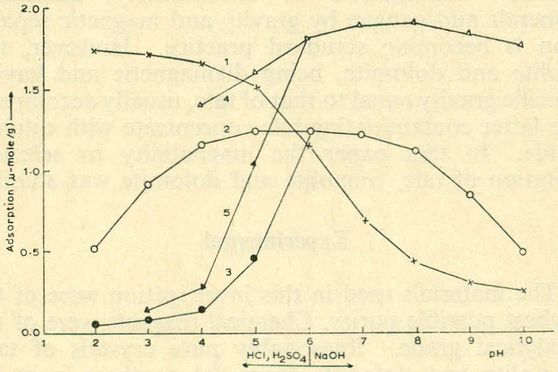

Fig. 3. Uptake of oleic acid (50 mg/l) by (1) talc (2) tremolite using HCl for adjusting pH, (3) tremolite using H_2SO_4 for adjusting pH, (4) dolomite using HCl for adjusting pH (5) dolomite using H_2SO_4 for adjusting pH.

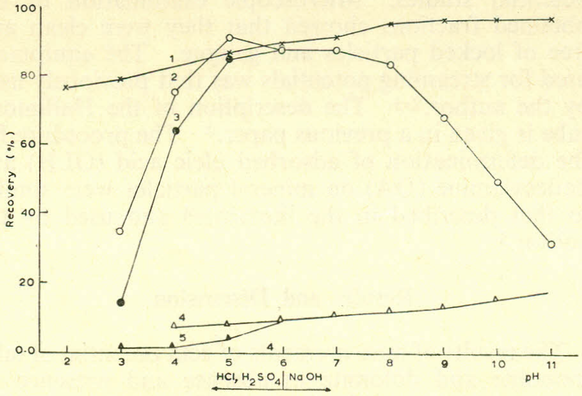

Fig. 4. Recovery of minerals using 70 mg/l dodecylaminium chloride as collector: (1) talc (2) tremolite using HCl for adjusting pH (3) tremolite using H_2SO_4 for adjusting pH (4) dolomite using HCl for adjusting pH, (5) dolomite using H_2SO_4 for adjusting pH.

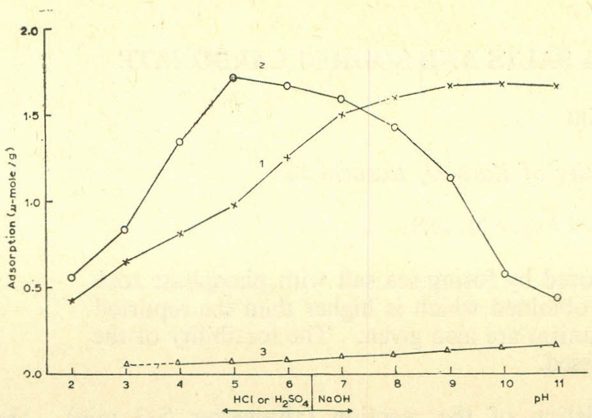

Fig. 5. Uptake of dodecylaminium chloride (70 mg/l) by (1) talc, (2) tremolite, (3) dolomite.

hydrophobic surface of talc adsorbs preferentially the nonionzed molecules of dodecylamine (RNH_2) which enhance its floatability. On the other hand, tremolite responds to amine flotation over the pH range 5–8. The decrease of the per cent floated at pH below 5 is, perhaps due to the increase of the positive surface charge. The drop of recovery at pH above 8 may be attributed to the decrease in the concentration of dodecylaminium ions. Curve No. 4 in Fig. 1 suggests that dolomite does not respond to amine flotation at all. This is very probable due to the high pH of isoelectric point of dolomite and hence its positive surface charge.

The data plotted in Fig. 5 show that the adsorptive capacity of talc for nonionized DA molecules is higher than that for ion species. The relative maximum adsorptive power of tremolite for DA was observed around neutrality. On the acid and alkaline side of the pH range 5–8 the attachment of dodecylaminium ions to the surface became less probable. The mechanism may be represented as follows:

$$..SiO^- + RNH_3^+ = ..SiO.H_3NR \quad (pH\ 4\text{–}8) \quad (6)$$

Dodecylaminium ions are attached to the negatively charged sites, namely silicon, and hence the formation of $..CaSO_4.2H_2O^-$ in H_2SO_4 medium does not affect the adsorption. It also seems that neither the positively charged dodecylaminium ions nor the nonionized molecules could be fixed on the positively charged dolomite surface. This may explain the beneficial action of H_2SO_4 in soap flotation and absence of its effect in amine flotation. This is also consistent with the low adsorptive capacity of dolomite for DA and its unamenability to amine flotation.

On the whole, Figs. 2–5 suggest that the effectiveness of a given collector species differs from one mineral to another according to the crystal structure of the latter. For nonpolar mineral, for example talc, the nonionized collector molecules are effective. For polar minerals, for example tremolite and dolomite, the collector ion species are effective.

Conclusion

It is quite possible, in principle, to separate talc from tremolite and dolomite by flotation in the pH interval of 3 using H_2SO_4 for adjusting the pH and in presence of 50 mg/l oleic acid. The probable mechanism is postulated.

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