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ZETA POTENTIAL AND FLOCCULATION BEHAVIOUR ON IRON ORE FINES USING MAGNAFLOC POLYMERS

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The flocculation behaviour of iron ore fines using magnafloc polymers as flocculants is studied along with zeta potential measurements by micro-electrophoresis method. Correlation between zeta-potential data and flocculation is examined. The effect of flocculant concentration, pH of the suspension on zeta potential and the role of calcium chloride on flocculation are discussed. The mechanism of flocculant adsorption on mineral surface is suggested using zeta potential measurements.

Key words: Flocculation, zeta potential, iron ore fines, magnafloc polymers

INTRODUCTION

The adsorption and flocculation properties of oxide minerals are influenced to a large extent by the electrochemical nature of the mineral-solution interface. In recent years, considerable attention has been devoted to the charge characterization of the mineral-solution interface by the use of electrokinetic technique. Zeta potential measurements have been used for a number of years to understand and monitor the electro kinetic phenomena at the mineral-flocculant interface [1]. In the current investigation, zeta potential studies have been conducted to understand the flocculation behaviour of Kudremukh iron ore fines using commercially available magnafloc polymers as flocculants.

EXPERIMENTAL

Materials

Iron ore fines used in the present investigation was obtained from the mines of Kudremukh, Karnataka and the chemical analysis of the same is shown in Table IA. The mineral sample was wet ground and subjected to sieving to obtain fractions finer than 32 microns. The particle size distribution is shown in Table II.

The details of the flocculants used in the present study are given in Table IB. Sodium hydroxide and hydrochloric acid were used to adjust the pH of the solution. All the chemicals used for the experiments were of analytical grade.

TABLE-IA: Chemical analysis of iron ore

Radical	% wt/wt
Total Fe	66.50
SiO_2	2.75
Al_2O_3	1.36
CaO	0.35
MgO	0.40
LOI	0.04

Methods

Zeta potential measurements were conducted using a simple micro-electrophoresis cell as shown in Fig. 1. The electrophoresis cell consists of a horizontal glass tube of a circular cross section with an internal diameter of 2.0 mm and a wall thickness of 0.5 mm. The length of the tube is 80 mm. Two thin foils of platinised platinum of rectangular shape were used as electrodes. Mineral suspension conditioned with modifiers and flocculants was transferred into the cell and a potential of 100 volts D C was applied through electrodes. Time taken by a particle to travel a fixed distance of 60 m was measured under a microscope. The polarity of the electrodes was

TABLE-IB: Details of the polymers

Sl.No.	Name of the flocculant	Chemical composition	Nature of charge	Physical form
1.	Magnafloc– 155	Poly acrylamide based polymer	Anionic	White granular powder
2.	Magnafloc– 1011	- do -	- do -	- do -

TABLE-II: Particle size distribution of iron ore fines

Size (microns)	% under	Size band (microns)	%
118.4	100.0		
54.9	100.0	118.4 – 54.9	0.0
33.7	100.0	54.9 – 33.7	0.0
23.7	100.0	33.7 – 23.7	0.0
17.7	99.8	23.7 – 17.7	0.2
13.6	96.2	17.7 – 13.6	3.6
10.5	88.9	13.6 – 10.5	7.3
8.2	79.5	10.5 – 8.2	9.4
6.4	68.0	8.2 – 6.4	11.5
5.0	56.2	6.4 – 5.0	11.8
3.9	44.5	5.0 – 3.9	11.7
3.0	32.0	3.9 – 3.0	12.5
2.4	20.1	3.0 – 2.4	11.9
1.9	12.8	2.4 – 1.9	7.3
1.5	9.8	1.9 – 1.5	3.0
1.2	8.8	1.5 – 1.2	1.0

Iron ore (−32 microns) in water was used in Malvern Instruments, Master particle size M 5.4

Specific surface area of the iron ore fines 2.1816 $m^2 \cdot cm^{-3}$

reversed and the rate of particle motion was determined in the reverse direction also. From the electrophoretic mobility values zeta potential was calculated using Smolunchowski equation [2].

$$\zeta = 4\,\pi\,\eta^{m}/\epsilon$$

where ζ = zeta potential (mV), m = mobility/voltage gradient $m^2V^{-1}sec^{-1}$, η = viscosity of the medium, ϵ = permitivity of the medium.

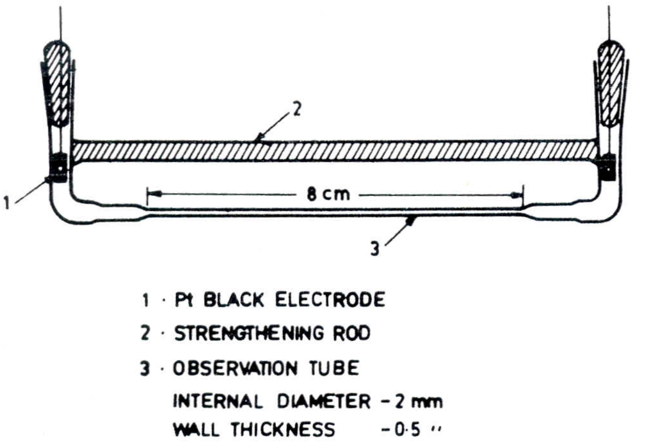

Fig. 1: The micro electrophoresis cell

The upper and lower stationary levels were determined by a separate experiment. A suspension of iron ore dispersed in 10^{-3}M KNO_3 was charged into micro-electrophoresis cell and the rate of particle motion was measured as described above, at different cell depths.

Flocculation experiments were done at a slurry consistency of 1% solids in graduated cylinders. Total volume of the suspension including the flocculant and other modifiers like calcium chloride was made up to the mark by diluting with water. The contents of the cylinder were inverted twenty times before allowed to settle and the settling rate was calculated. The flocculation response of the mineral was expressed as the percentage of suspended material settled in a fixed settling time.

RESULTS AND DISCUSSION

The observed velocities vs cell depth are plotted as shown in Fig. 2. The lower and upper stationary levels were located respectively at .15 mm and 0.45 mm from the velocity distribution curve. Zeta potential of iron ore fines as a function of pH was measured to find out the isoelectric point (i.e.p.). From Fig. 3, the i.e.p. of iron ore fines is found to be at pH 4.5, which almost corresponds to the i.e.p. of natural haematite ore reported by earlier investigators [3, 4].

Tests were carried out to find the influence of zeta potential of the particles on their flocculation by Magnafloc polymers at natural and (10^{-3} M KNO_3) ionic strength. Figure 4 shows the effect of zeta potential as a function of flocculant concentration. The results indicate that adsorption of anionic flocculant on positively charged iron ore fines reduces the zeta potential and even makes the surface negatively charged. This type of phenomenon suggests the specific adsorption of polymer molecules due to forces that are nonelectrical in nature and similar observations on haematite surface in the presence of an anionic polymer have been reported by the earlier workers [5, 6]. Tests could not be conducted beyond the polymer concentration of 0.025 kgt^{-1} of Magnafloc-155 and 0.03 kgt^{-1} of Magnafloc-1011, as there was excessive flocculation making the measurements difficult. Excellent flocculation has been observed even after the charge reversal. From the results, it is clear that for flocculation to be effective, zeta potential of the particles need not be zero [5, 6]. Figure 5 shows the effect of flocculation as a function of flocculant concentration.

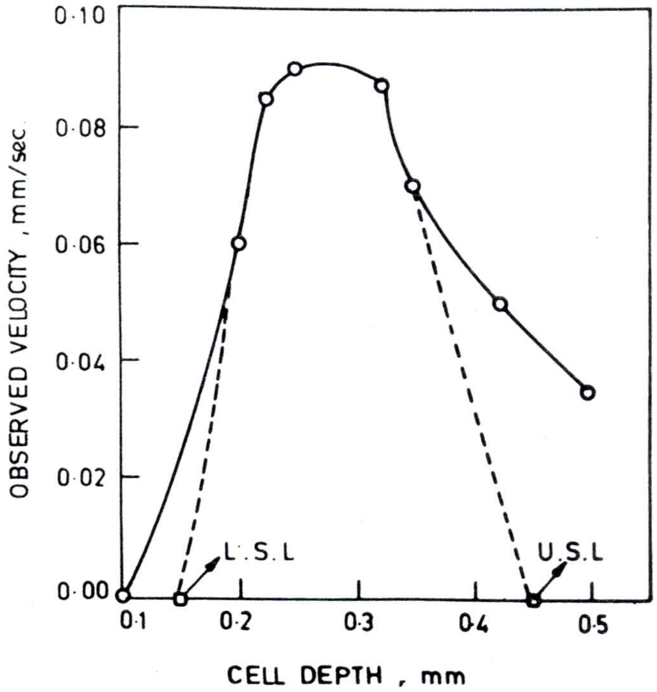

Fig. 2: Determination of stationary levels

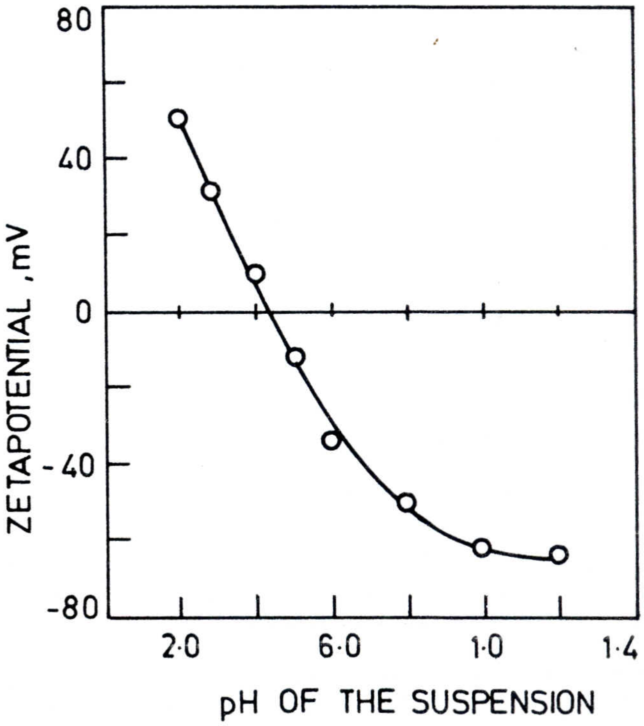

Fig. 3: Determination of isoelectric point

It has been observed that, as the pH of the suspension increases to pH 8.0 and above, the flocculation is found to be poor or nil. The addition of calcium chloride has been found to have significant role on flocculation. Figure 6 shows the effect of calcium chloride on flocculation at pH 11.0. Around 5 kgt^{-1} of calcium chloride is required to achieve good flocculation. Since mineral particles

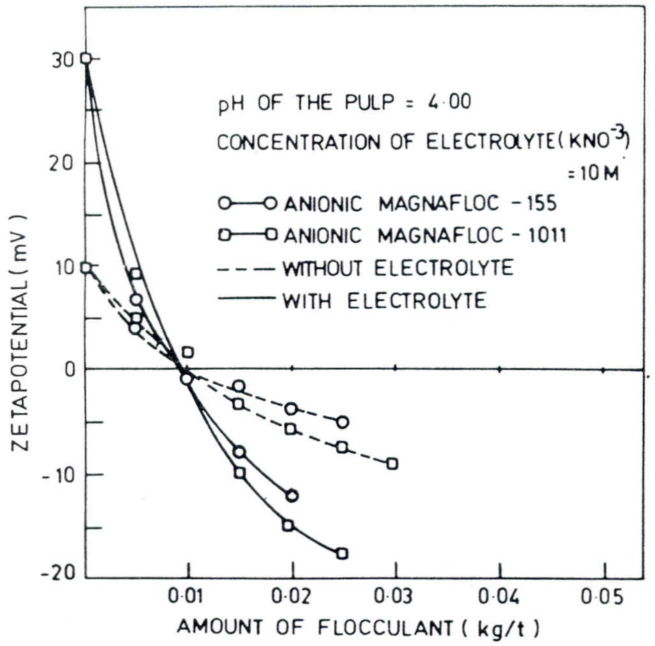

Fig. 4: Zeta potential as a function of flocculant dosage with and without electrolyte

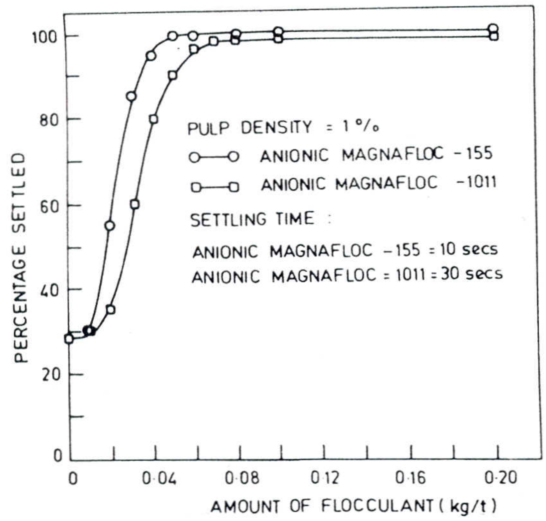

Fig. 5: Percentage iron ore fines settled vs flocculant concentration at pH 4

acquire negative charge in alkaline medium, a strong electrical double layer repulsion between the particles and also between the particle and anionic flocculant is found to exist. The addition of calcium chloride maintains positive charge on the particle, thus facilitating the adsorption of negatively charged flocculant. The addition of calcium chloride also reduces the electrical double layer repulsion between the particles. When an anionic flocculant is added to the pulp at this stage, flocculation is noticed which can be due to the interparticle bridging as reported by the earlier workers for anionic polymer flocculants [6].

Figure 7 shows the effect of calcium chloride on zeta potential in the presence and absence of flocculant at pH 11.0. There is no reversal of sign in zeta potential although values close to zero are attained facilitating flocculation. The presence of flocculant helps in further lowering of the zeta potential to less electronegative values. The adsorption of calcium ions on the surface of the negatively charged particles cause the compression of electrical double layer and facilitate the adsorption of anionic flocculant. The above zeta potential data are thus complementary to adsorption and flocculation behaviour of iron ore fines in the presence of calcium chloride.

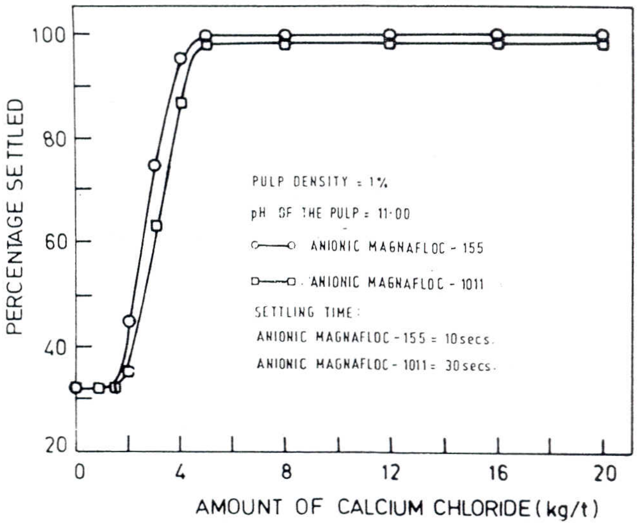

Fig. 6: Effect of calcium chloride on flocculation of iron ore fines

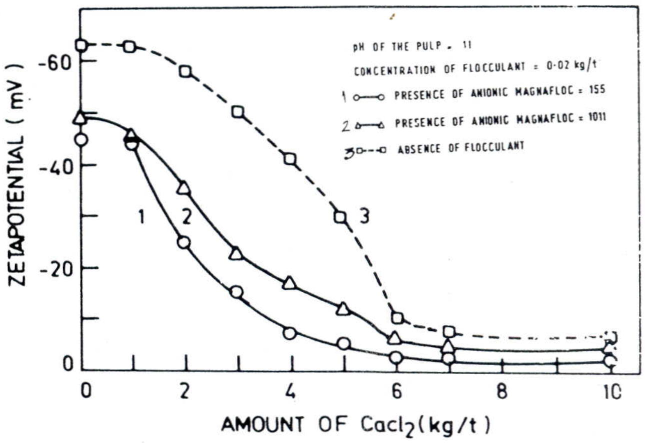

Fig. 7: Effect of calcium chloride addition on zeta potential in the presen and absence of flocculant

CONCLUSION

The two anionic magnafloc polymers are found to be good flocculants for iron ore fines at pH 4.00. Zeta potential data suggests the specific adsorption of flocculant on the mineral surface governed by the forces that are nonelectrical in nature.

The significant role of calcium chloride is evident from the flocculation results in the basic region. The adsorption of calcium ions on the surface of the particles helps in compressing the electrical double layer and facilitates the adsorption of anionic flocculants resulting in enhanced flocculation.

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