Cationic guar gum as a depressor for gangue in froth flotation of pyritic-zinc ore from Rajpura Dariba Mines, Udaipur, India

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INTRODUCTION

Flotation is one of the important operations in ore beneficiation process. Chemical auxilliaries play an important role in the froth flotation process[1]. In order to obtain a successful flotation of slimy sulphide ores, two types of chemical auxilliaries are basically in use i. e. (i) a hydrocolloid acting as flocculant for gangue material, commonly referred as a depressor and (ii) a collector or a metal reagent, which conditions the mineral surface (by adsorption and making it more hydrophobic) so that it will rise to the surface when a frother is added. Besides these, certain other chemicals are also sometimes used to augment the action of either depressor or collector[2].

Quite frequently, the usefulness of a gangue depressor is overlooked in a mineral processing industry, because in many ores, the effective gangue separation takes place even without use of a depressor. In certain other cases, where gangue separation is not very effective, the contamination of the froth with silica gangue can cause serious interference in subsequent operations such as smelting, leaching and electrolysis. The use of a gangue depressor in the flotation process offers certain other advantages e.g. the flocculant also acts as an aid in the process of solid-liquid separation and dewatering of the slime[3], resulting in energy saving and better recycling of water and control of pollution. A large number of the chemical auxilliaries, which act as silica depressors, are being marketed by big, international companies like, Hankel of Dusseldorf, West Germany. These auxilliaries, which may be synthetic (petroleum based) water soluble resins or natural or modified natural hydrocolloids owe their flocculating action to their ability to get adsorbed on hydrated surface of silica and talc by hydrogen bonding. Adsorption of the depressor on the gangue mineral prevents the adsorption of collector on these particles, so that they will not rise with the forth. Liner polymers are particularly effective flocculants because they can bind several particles causing agglomeration and precipitation.

A plant polysaccharide guarn (guar gum, a galactomannan from the leguminosae plant cyamopsis tetragonalobus), in native form is known to be a good flocculant in certain aqueous systems[4] and its use has been recommended in certain mineral processing operations. In this communication we describe the successful use of a cationic derivative of guar gum as a gangue depressor in the flotation of zinc sulphide ore (sphalerite) from the Rajpura Dariba Mines of M/s Hindustan Zinc Ltd., Udaipur, India.

EXPERIMENTAL PROCEDURE :

Material and method :

Cationic derivative of gaur gum : The synthesis of cationic gaur gum was carried according to a reported method[5,6]. This derivative has the following characteristics :

i) Nature of cationic group : Strong base type quaternary $-N^{+}(CH_3)_3Cl^{-}$ —with degree of substitution (D.S.) Ca : 0.12.

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ii) Appearance : 150 mesh, free flowing, slightly grey, nonhygroscopic powder.

iii) Dispersibility in water and pH : Easy to disperse under moderate stirring, non-lumping and improved hydration rate compared to the parent gum pH of 1 % solution Ca : 6.5—7.5.

iv) Viscosity of fully hyrated solution 0.5% = 350 and 1% 1500 cps (Brook field viscometer, number three spindle at 20 r.p.m.) The aqueous solutions are stable for three days as indicated by viscosity measurements.

A 0.5% aqueous solution is easily used as a depressor by continuous feeding in the flotation liquor.

Zinc sulphide ore concentrate : The concentrate used in the flotation experiments was a sample from the normal, cleared and ground ore (150 mesh) being used in the commercial flotation plant of Rajpura Dariba Mines. The feed (zinc concentrate cleaned in the commercial plant of 3000 tons/day of ore) has the following composition (Table 1).

Flotation test : These were carried using a Dorr-Oliver laboratory flotation cell using an air blower. The agitator worked at 450 r.p.m.

The following parameters were fixed after many experiments :

i) Cell capacity 31.
ii) Ordinary water was used (1.01).
iii) Solid —liquid ratio was 1:4.
iv) Conditioning time 10 mts.
v) Flotation time 3 mts.
vi) MIBC (Methyl isobutyl carbinol) as frother.
vii) Sodium isopropyl xanthate as a collector.
viii) pH adjustment by lime using pH meter.

Table 2 shows the results of the flotation test under fixed parameter referred above for the feed of a definite composition (Table 1).

For comparision, the blank flotation tests were carried out without using depressor as well as using guar gum and its cationic derivative as the depressors.

It is seen that when no depressor was used, 245 gm of the froth was near quantitative (99%), but most of the silica also (6.19 gm) floated with the froth. The silica content of this froth is higher than the permissible limit for smelting.

On addition of underivatised guar gum as a depressor at concentration ranging from 200–800 mg/kg, silica depression amounted from 20–30% but at the same time there was a considerable lowering in the recovery of zinc.

When the cationic derivative of guar gum was used as silica depressor, under optimum conditions, silica depression was 42% and recovery of zinc was 96%. The froth contained about 1.5 % silica only.

Thus it is observed that the cationic derivative of guar gum is a very satisfactory gangue depressor for the froth flotation of sulphide ores.

Flotation test was also carried out on artificial zinc cocentrate as feed having 193.7 gm ZnS, 6.3 gm PbS, 31.2 gm FeS_2, 0.25 gm CuS, and 19.9 gm gangue, with 2% graphitic carbon and 6.25 gm silica. Although the depression of silica was good (65.5%) the recovery of zinc was poor (72%). In fact the artificial feed differs considerably from the natural ore in the physical form and comparison is difficult to make. In the natural feed some silica may be associated with the sphalerite particles and may float.

Analytical procedure :

Zinc in the froth was determined by EDTA complexometric titration using xylenol orange as indicator at pH 5.3[7]. Silica was determined gravimetrically[8].

For flotation the standard laboratory methods were used.

Adsorption studies of guar gum and cationic guar gum on silica :

For this purpose ground quartz (150 mesh) was used. Adsorption experiments were

Table —1 : The composition of the feed (Zinc concentrate, 250 gm.) zinc was in the form of zinc blende (ZnS), lead as galena (PbS), copper and iron as chalcopyrite ($CuFeS_2$).

Metal	%	Actual amount of metal in the feed: As free metal (gm)	Wt. of metals as Sulphides (gm)
Zinc	52.0	130.00	ZnS = 193.70
Lead	2.8	7.00	PbS = 8.08
Copper	0.1	0.25	CuS = 0.37
Iron	5.8	14.50	FeS_2 = 27.20

The remaining is presumed to be gangue (16.77 gm) containing 6.25 gm silica.

Table — 2 : Flotation tests for zinc sulphide ore.
(Fixed parameters given in the text)

Feed ore 250 gm (a), containing 130 gm Zn (b) and 6.25 gm silica (c)

	Test No. and depressor form (mg / kg)	Froth (gm) Total wt (d)	Froth Zn (e)	Froth Silica (f)	Tailings (gm) Tailings wt (a-d)	Tailings SiO_2 (c-f)	Recovery of Zn in froth $\left(\frac{e \times 100}{b}\right)\%$	SiO_2 depressed $\frac{(c-f)100}{c}\%$
1	Blank flotation (without any addition of depressor)	245.0	129.0	6.10	5.0	0.15	99.2	2.4
2	Guar gum as depressor 200 — 800	190.0	100.0	4.75	60.0	1.50	76.9	24.0
3	Cationic guar gum as a depressor							
	100	215.0	116.0	4.40	35.0	1.85	89.2	29.6
	200	220.0	118.0	4.18	30.0	2.07	90.7	33.3
	300	230.0	126.0	3.60	20.0	2.60	96.9	41.6
	400	230.0	120.0	4.50	20.0	1.75	96.9	28.4
	600	225.0	123.7	4.50	25.0	1.76	95.1	28.1

carried in a 500 ml flask containing 2 gm ground silica and 200 mg depressor in solution. After a desired interval of time the concentration of the reagent in the aqueous solution was determined and from the difference from the original amount of the depressor taken, the amount of reagent adsorbed on silica was found.

Since there is no reported method for determination of guar gum in a very dilute solution a new method was developed in our laboratory. This is based on the borax reaction of cis-hydroxyl groups in the polysaccharides which results in liberation of free acid and a linear relationship between the acid formed and the guar gum concentration was established.

At the recommended concentration of the depressor (400 mg/kg) the adsorption of the depressor on the silica surface reaches a saturation value so that large excess beyond this level should not be used. In fact the use of large excess of depressor results in lowering the yield of zinc sulphide in the froth (Table 2).

It is presumed that the adsorption of the depressor on the silica particles reduces its affinity for the collector (Xanthate) to such an extent that it will not float.

Conclusion :

The pyritic ores of zinc-lead and copper, which represents the major world resource of these metals, are difficult to beneficiate using selective flotation. For effective elimination of silica in the form of gangue very fine grinding of ore (300 mesh) is necessary because the gangue minerals are entrapped with the crystal planes of the metal sulphides. This requires lot of power and labour. At moderate grinding (150 mesh) and without use of a silica depressor most of the silica also floats with the froth. By using a cationic guar gum as silica depressor, the gangue particles are effectively flocculated without appreciable decrease in the recovery of zinc in the froth. Hence, cationic guar gum is considered to be a very suitable silica depressor. It is found it to be even more effective than certain commercial products being used in the flotation plant of Rajpura Dariba Mines.

Although this study has been confined to zinc sulphide ore only, it is expected that the same mechanism shall also operate in case of other sulphide ores. There is a plan to carry out such experiments. The conventional inorganic silica depressors such as sodium silicate have been used in the flotation of sulphide ores but the effectiveness of the organic hydrocolloids as depressors is far better particularly at low concentrations. The resulting tailings are also easy to dewater because of the formation of coarse aggregates. The depressor which is a modified natural product is completely biodegradable and does not create the problem of water pollution. The depressor is made from a dependable renewable natural source and it is economical to use.

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DISCUSSION

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Question 1 : What are your comments on the interlocking of the sphalerite and SiO_2 particles in R-D-ores flotation?

Author : Sphalerite and SiO_2 particles are always interlocked in the ore. The liberation of these shall depend upon the degree of grinding.

Question 2 : When they are not liberated, how could you separate them?

Author : When sphalerite and silica particles are not completely liberated, there will be some contamination of silica in the froth and sulphide mineral in the gangue.

Question 3 : As far as I know the problem of silica in Zn concentrate is due of unliberation only. comment ?

Author : Yes, the problem of silica in ZnS concentrate is due to incomplete liberation. However if a particle is more than 50% ZnS, the collector shall make it eonugh hydrophobic to float. Similarly if particle is more than 50% SiO_2, the depressor shall make it enough hydrophilic to sink. This justifies the use of a collector and a depressor. In presence of a depressor the separation of the mixed (unliberated) particles is improved. Effective separation of ZnS can be done in a 150 mesh size where as in absence of a depressor the complete liberation takes place at 250 mesh. Thus a lot of energy is saved.

Question 4 : What is the pH to be used when your reagent is used ?

Author : Strongly cationic guar derivative is effective over a wide pH range, pH 5—9.

Question 5 : Guar gum is used extensively in almost all uranium recovery plants as flocculant and how the use of this indigenous product could not be tried in that industry?

Author : Yes' the use of guar gum is particularly effective in processing uranium ore. A cationic derivative of guar gum is now produced in India (Ms Digchem Industries, I — Heavy Industrial Area, Jodhpur 342001) which is more effective in mineral processing than the native non-ionic guar gum.

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