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Recovery of galena and sphalerite concentrates by froth flotation using alkaline salts of vegetable oils

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Abstract
Groundnut, palmkernel, sheabutter and soyabean oils with their respective sodium and potassium salts were used as possible substitutes as frothers and Xanthate collectors for recovering galena and sphalerite concentrates from the complex sulphide ores. The highest recoveries for galena, using both potassium and sodium salts of the oils were; groundnut 81.11% and 81.56%; palmkernel 79.27% and 80.32%; sheabutter 64.08% and 62.02%; and soyabean 57.40% and 55.68%. The corresponding values for sphalerite were: groundnut 80.03% and 76.44%; palmkernel 61.88% and 55.45%; sheabutter 35.14%; 29.20%; soyabean 24.51% and 20.43%. The results show that the alkali salts of groundnut and palmkernel oils are potential substitutes for the synthetic collectors and frothers.

Introduction

Among the vast mineral deposits available in Nigeria are galena/ sphalerite ores, which occur mainly at Ishiagu in the eastern part of Nigeria with an estimated reserve of 15 million tonnes, [12]. Despite this, the country imports lead and zinc components at exorbitant prices. Therefore, the needs for lead and zinc concentrating and smelting plants are rather glaring. Nigerian lead/zinc ores are amenable to the two-stage froth floatation processes [3].

Froth flotation is a versatile mineral processing technique, which utilizes the difference between the physico-chemical surface properties of a mineral [4] and can be used to achieve specific separations from complex ores such as lead – zinc, copper –zinc [4, 5]. For effective and efficient froth flotation, Jowett [5] opined that the mineral particles must be small enough so that the bubble will be able to carry them to the surface of the water. If the mineral particle is too large, it will peel away from the bubble when the bubble starts to rise [6]. This is why flotation can only be used for separating fine particles. Onyemaobi [2] opined that galena with size range of -212μm + 75μm gave the optimum results when concentrated by froth flotation. Ajayi [3] observed that optimum recovery of both galena and sphalerite concentrates can be obtained in the particle size range of -106μm + 75μm.

Unfortunately, flotation reagents particularly collectors and frothers are so expensive and scarce in Nigeria. This work is aimed at exploring the possibility of using various salts of locally available fatty acids and their natural oils as collectors and frothers with a view to replacing xanthates as collectors and methyl Isobutyl carbinol (MIBC) as frother, used in the flotation of galena – sphalerite concentrates from lead – zinc complex ore.

Materials and Methods

Materials

Ore Preparation

2.75kg of galena – sphalerite ore was procured from Ishiagu. The ore was crushed in a jaw crusher and later pulverized in a ball mill of Mineral Processing Laboratory of the Federal University of Technology, Akure, Nigeria.

Methods

Collectors' Preparation:

75ml of 2.5M solutions NaOH and KOH were added separately to 50g of groundnut oil. The respective mixtures were then boiled and stirred in a water bath until homogenous mixture was obtained. The same procedure was repeated for sheabutter oil, soyabean oil and palmkernel oil. Their respective salts (soap) were obtained and used as collector.

Particle Size Analysis:

The particle size analysis of the comminuted ore sample was carried out at the Department of Metallurgical and Materials Engineering, Obafemi Awolowo University, Ile – Ife, Nigeria. The particle size ranges used were + 300μm, - 300 + 250μm, - 250 + 125μm, - 125 + 106μm, -106 +75μm and - 75μm.

Ishiagu Sulphide Ore Analysis by Atomic Absorption Spectrometer (AAS):

0.2g of galena – sphalerite ore was measured out of each of the size fractions obtained. Each sample was dry ashed at 850^{0}C for 3hrs. They were cooled in desiccators for about 30 minutes. 3ml of 0.1MHCl was added to each sample, stirred and filtered. Each filtrate were made up to 100ml with distilled water. The solutions were analysed for metallic ions using the Atomic Absorption Spectrophotometer (AAS) at the Department of Industrial Chemistry, Federal University of Technology, Akure (FUTA), Nigeria.

Recovery of galena and sphalerite concentrates by froth flotation using locally derived frothers and collectors.

50g of complex sulphide ore were weighed and put into the flotation cell and mixed with 1100ml of distilled water to form a pulp. The pH of the pulp was adjusted to 9 using Na_2CO_3 solution in order to depress sphalerite and pyrite in the ore. The pulp was then agitated by operating the flotation cell impeller pre–set at 1350rpm. After 2 minutes of agitation, $ZnSO_4$ was introduced into the cell to depress the zinc present in the ore. 5mg of sodium salt of palmkernel oil, as collector, was added into the pulp after 3minutes and the mixture was agitated for another 3 minutes. Then 5mg of palmkernel oil was introduced as frother.

After this, the flotation machine was aerated. 3minutes after the addition of frother, the froth was collected. This process was repeated for the various salts of sodium and potassium as collectors and the various oils were used as frothers. All the six size fractions were used for the froth flotation process. Each recovered galena and sphalerite concentrate was sun – dried and digested.

Results and Discussion

The result of the Guardin Schman particle size analysis is shown in Fig.I. (Ishiagu ore), Figures 2-9 summarize the experimental results of floatation of Ishiagu galena and sphalerite concentrates using locally derived collectors and frothers. Table I shows the result obtained for the pre-floatation chemical analysis of the ore by AAS.

Table I: Pre-flotation Chemical Analysis of Complex Sulphide Ore showing Elemental composition by AAS (values in ppm)

Particle Size Fraction (Micron)	Fe	Pb	Zn	Cd	Ca	Ni	Na	K	Cu
+300	8.03	10.04	3.20	6.99	0.48	0.08	1.89	2.56	5.49
-300 + 250	8.42	10.64	3.38	7.58	0.53	0.10	2.60	3.77	4.06
-250 + 125	10.22	10.08	3.58	8.62	0.53	0.10	2.63	3.84	4.20
-125 +106	8	11.12	3.41	8.56	0.53	0.01	2.72	3.91	3.78
-106 +75	9.82	10.73	3.14	8.51	0.89	0.21	2.91	3.98	6.77
-75	8.40	10.65	3.90	7.92	0.50	0.12	2.53	3.14	5.66

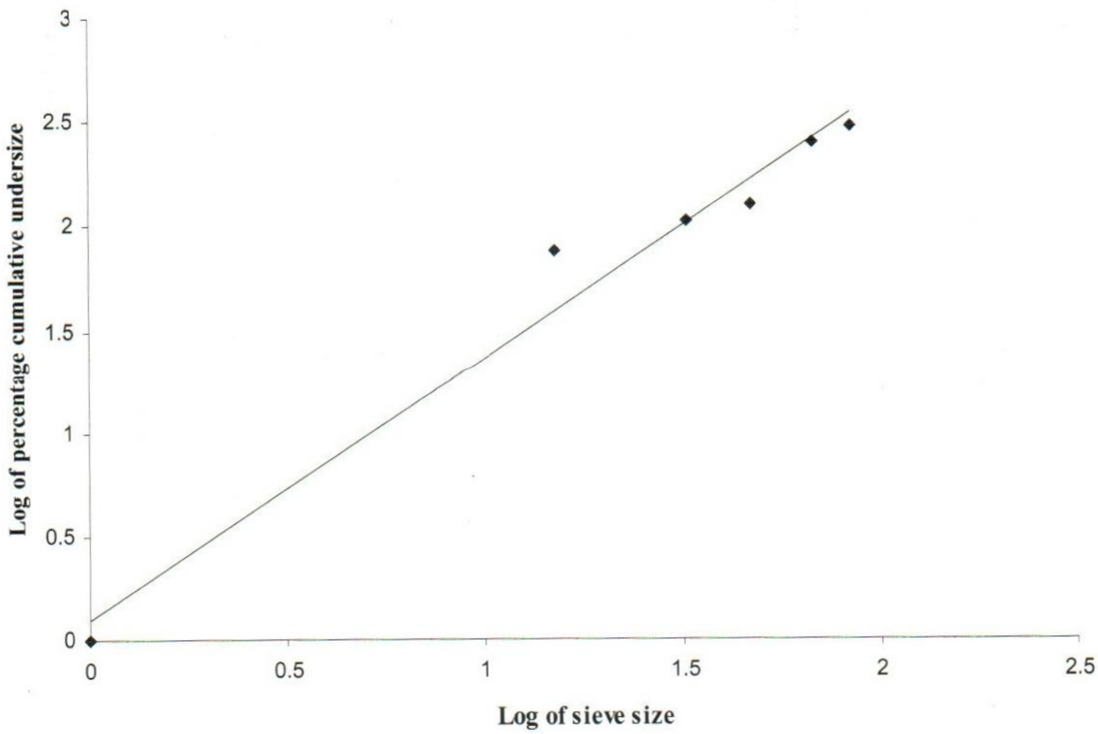

Figure 1: Guadin-Schman analysis of Ishiagu ore

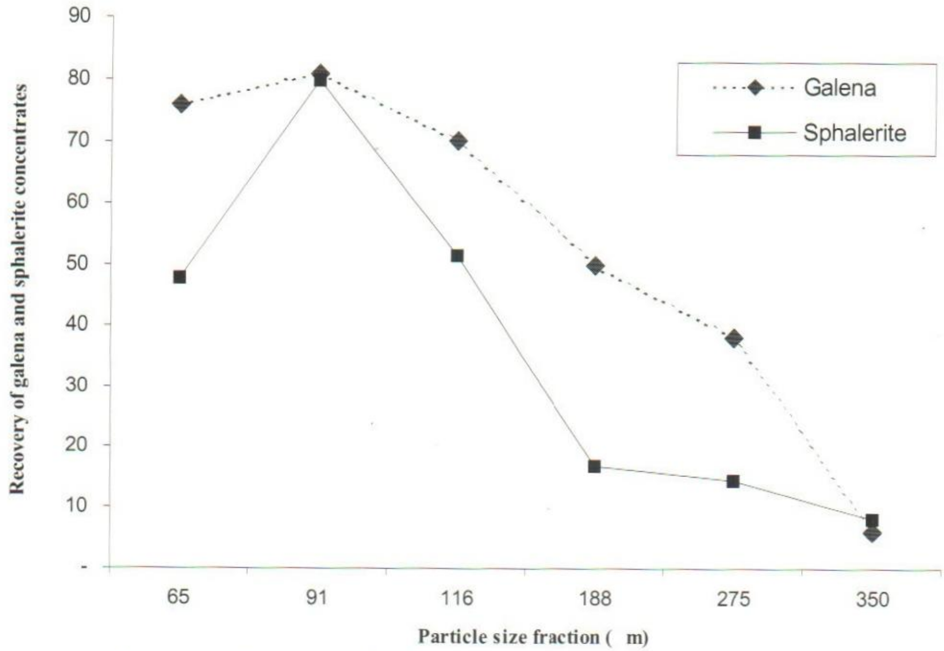

Figure 2: Recovery of galena and sphalerite concentrates versus particle size fraction using potassium salt of groundnut oil as collector

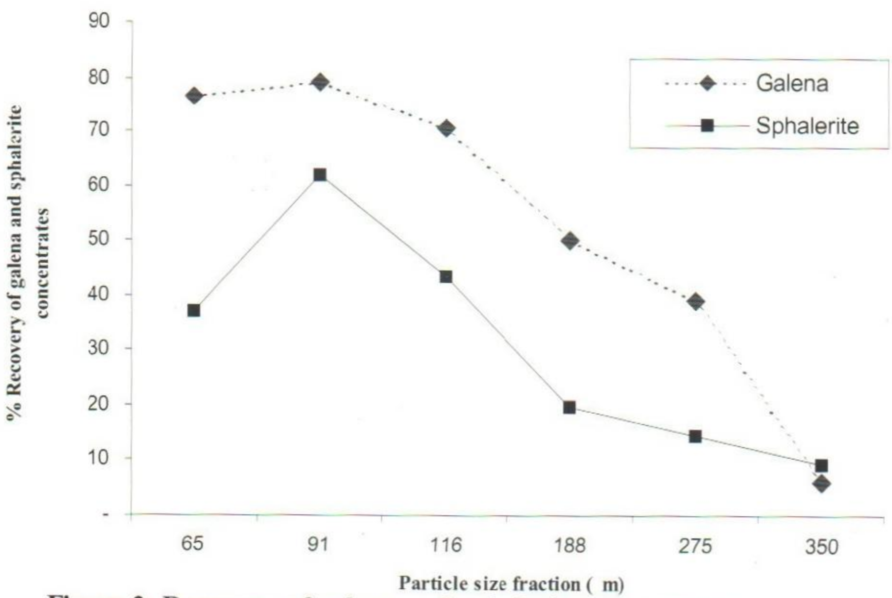

Figure 3: Recovery of galena and sphalerite concentrates versus particle size fraction using sodium salt of groundnut oil as collector

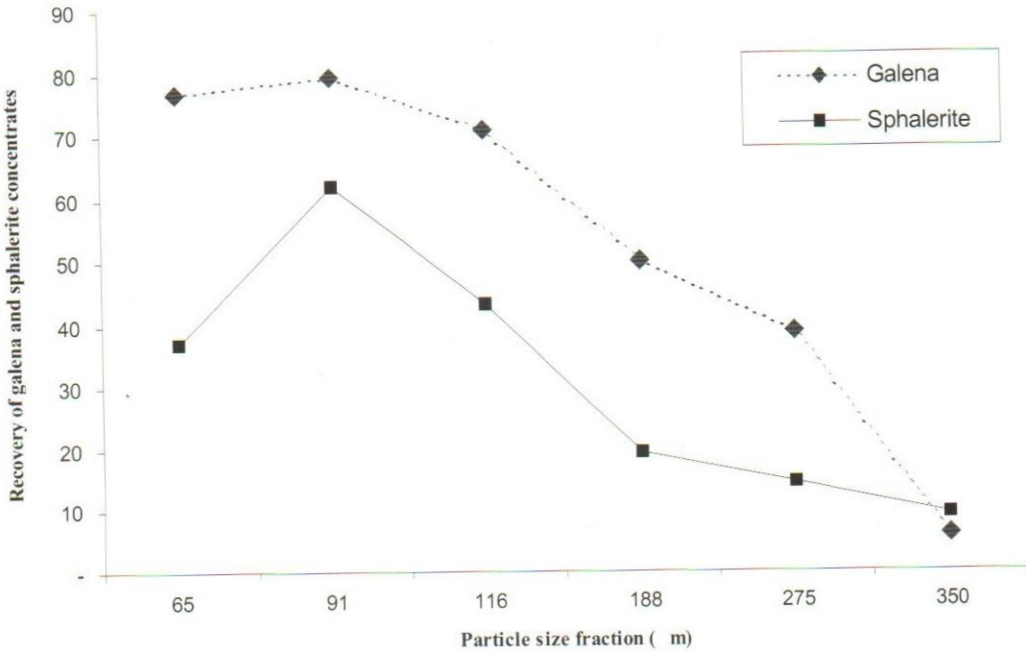

Figure 4: Recovery of galena and sphalerite concentrates versus particle size fraction using potassium salt of palmkernel oil as collector

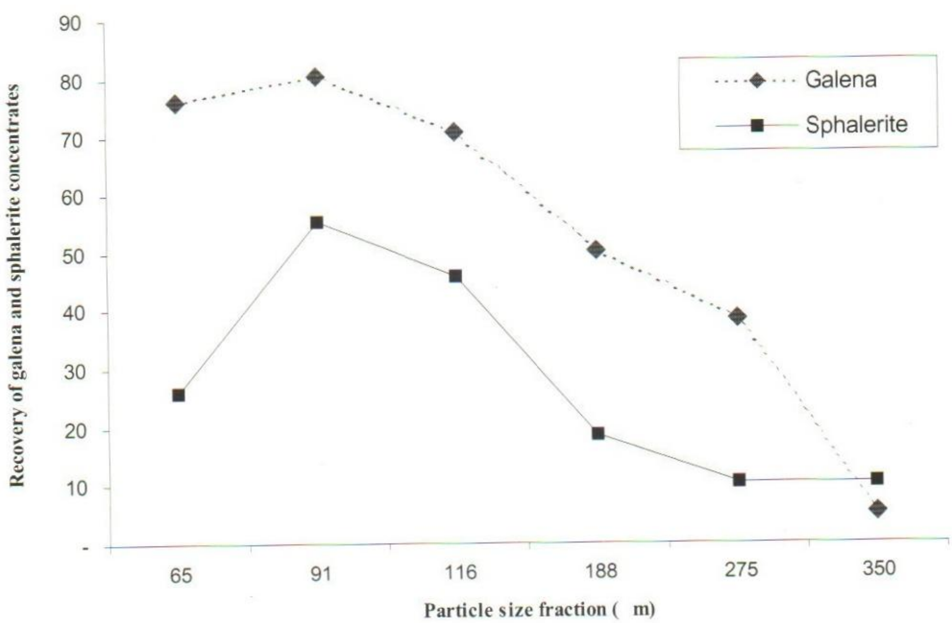

Figure 5: Recovery of galena and sphalerite concentrates versus particle size fraction using sodium salt of palmkernel oil as collector

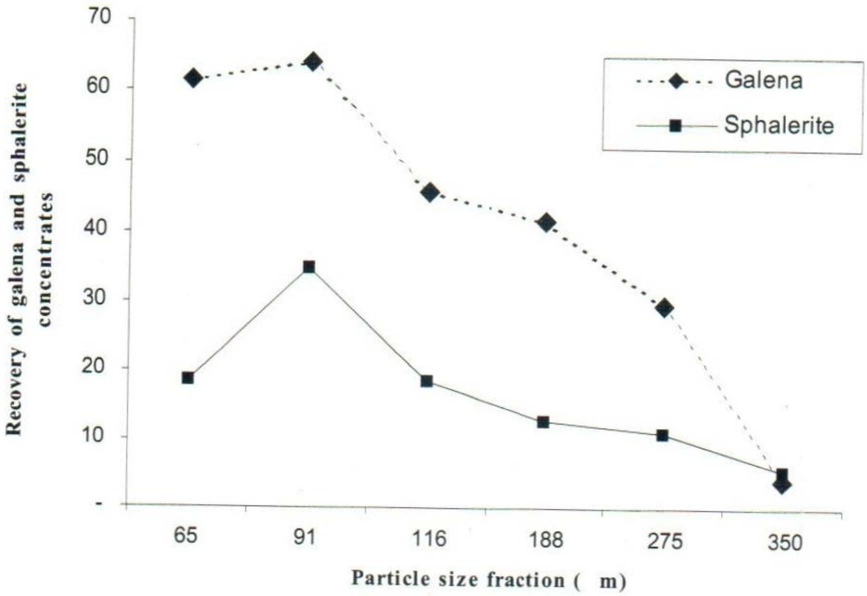

Figure 6: Recovery of galena and sphalerite concentrates versus particle size fraction using potassium salt of sheabutter oil as collector

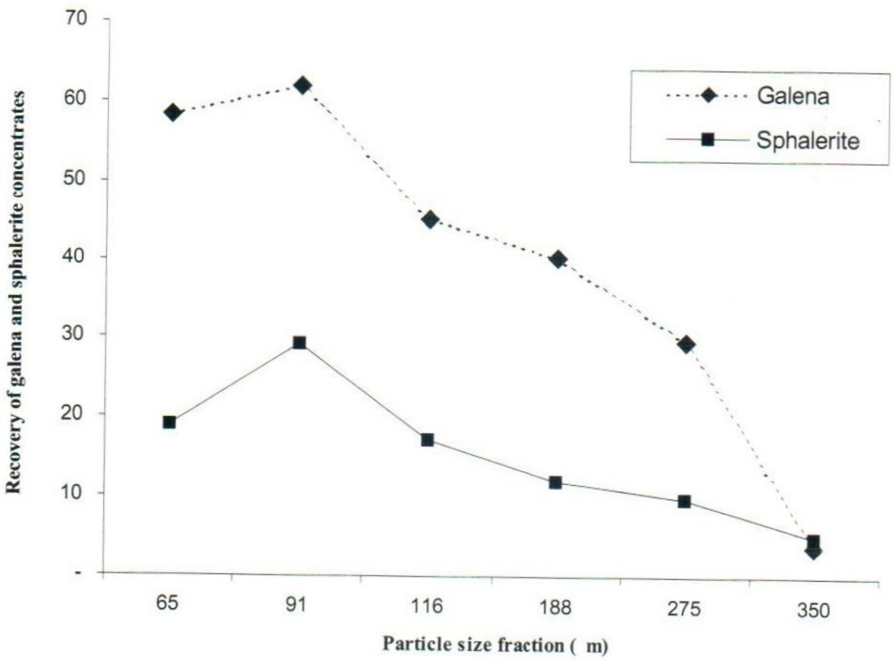

Figure 7: Recovery of galena and sphalerite concentrates versus particle size fraction using sodium salt of sheabutter oil as collector

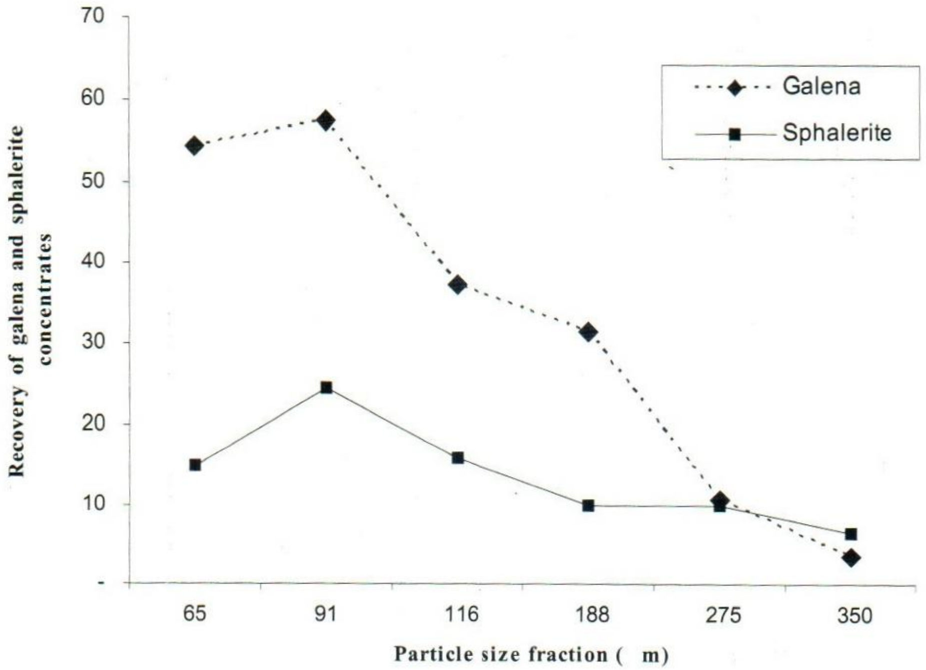

Figure 8: Recovery of galena and sphalerite concentrates versus particle size fraction using potassium salt of soyabean oil as collector

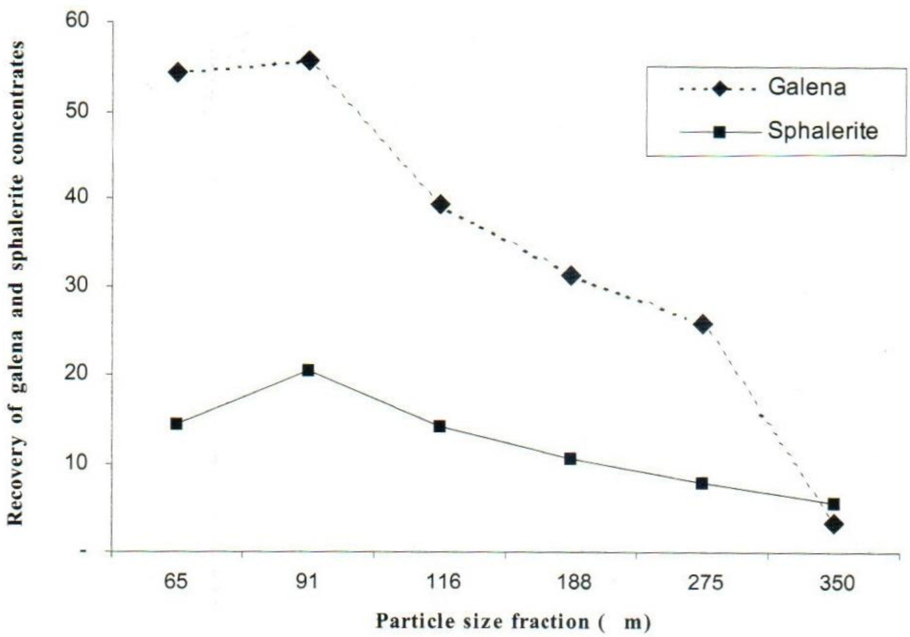

Figure 9: Recovery of galena and sphalerite concentrates versus particle size fraction using sodium salt of soyabean oil as collector

Figure 1 depicts the result of particle size analysis of Ishiagu sulphide ore. It is discernible that as the ore particle size decreases, the recovery increases up to the particle size fractions of - 106 + 75μm. Beyond this size fraction, the recovery begins to decrease. This may be attributable to incomplete liberation of both galena and sphalerite from their associated gangue minerals, which have the tendency of reducing surface area of the particles for collectors' absorption. Consequently, this imparts hydrophobic property on the mineral particle and drastically reduces the particles flotability. Besides, increase in the mineral particle size decreases the contact angle, thus reduces the air bubbles adhesion to the mineral particles thereby decreasing their floatability.

Figure 2 shows the recovery of galena and sphalerite concentrates versus particle size fraction using potassium salt of groundnut oil as collector and groundnut oil as frother. Here, the highest recovery of 81.56% and 80 .03% were obtained for galena and sphalerite concentrates respectively. Figure 3 gives the corresponding values of highest recoveries of galena and sphalerite concentrates using sodium salts of groundnut as 81.56% and 76.44% respectively. These values are obtained at the particle size fraction of 106 + 75μm. These results compare favourably with previous work for both galena (highest recovery of 90.96%) and sphalerite (highest recovery of 95.54%) con-centrates using sodium xanthate as collector and methyl isobutyl carbinol as frothers[3].

Figures 4 and 5 show the response of galena and sphalerite concentrates to potassium and sodium salts of palm kernel as collectors (palm kernel oil as frothers) respectively. For potassium salt collector, the highest recoveries of the galena and sphalerite concentrates are 79.27% and 61.88% respectively. The corresponding values for sodium salt collector are 80.32% and 55.45% respectively. This is lower than the values obtained using groundnut oil.

Figures 6 and 7 illustrate the effects of potassium and sodium salts of sheabutter collectors (sheabutter oil as frother) on the recovery of galena and sphalerite concentrates. For potassium salt collector, the highest recoveries are 35.4% and 64.08% for galena and sphalerite respectively. The equivalent values for sodium salt collector are 62.02% and 29.20%. The recoveries are less than the values obtained using palmkernel oil.

Figures 8 and 9 show the effects of potassium and sodium salt of soyabean as collectors (and soyabean oil as frother) on the recoveries of galena and sphalerite concentrates. The highest recoveries of 57.4% and 24.51% were obtained for galena and sphalerite concentrates using potassium salt of soyabean oil. The recovery values for sodium salt of soyabean oil (collector) are 54.31% and 20.43% for galena and sphalerite concentrates respectively.

It is seen that groundnut oil and palmkernel oil, and their respective sodium and potassium salts showed good promise as frothers and collectors respectively in recovering galena and sphalerite concentrates. The effectiveness of these oils could be due to the proportion of combined unsaturated fatty acids in the oils. It has been observed that oleic acid and its alkali salt, as frother and collector respectively, are more effective than any other fatty acids [6, 11, 12].

The presence of saponins in soya bean oil and shea butter may be responsible for the seemingly low recovery of the ore [8]. It is a well-known fact that the saponins are hydro-philic, thus reducing the surface chemistry of the ore at the interface of the media [12].

Conclusion

In the use of potassium and sodium salts of groundnut, palmkernel, sheabutter and soyabean oils as collectors (and their respective oils as frothers) in the selective froth floatation of Ishiagu sulphide ore, the highest galena and sphalerite concentrates recovered were at the particle size fraction of $-106+75\mu m$ at pH of 9.

The results also revealed that potassium and sodium salts of groundnut oil and palm kernel oil used as collectors and their natural oils as frother respectively show good performance in recovering both galena and sphalerite concentrates. Ishiagu ore can therefore be processed using these locally derived collectors and frothers and these can suitably substitute for the synthetic xanthates and MIBC collector and frother respectively.

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