International Journal of Scientific Research in Chemical Sciences
Vol.7, Issue.6, pp.26-30, December (2020)
Research Paper
E-ISSN: 2455-3174

Flotation Behaviour and Adsorption Mechanism of Green Reagent (Potassium salt of groundnut oil) to Gold-bearing ore

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Available online at: www.isroset.org

Received: 04/Oct/2020, Accepted: 21/Nov/2020, Online: 31/Dec/2020

Abstract— The flotation behaviour and adsorption mechanism of green reagent (groundnut oil) to gold-bearing rock was investigated. Samples of the mineral were sourced from Iperindo deposit regions in Ilesha local government area, Osun State, Nigeria. The sourced samples were crushed, homogenized and sieved via 100% passing -63+45 μm. The flotation behavior and adsorption via froth flotation concentration technique using green reagent (potassium salt of groundnut oil and groundnut oil) as flotation reagents. Flotation parameter used were pH value of 8.0, 8.5, 9.0, 9.5 and 10.0, at a pulp density of 50, 100, 150, 200 and 250 g/cm^3, collector concentrations of 200, 300, 400, 500 and 600 mg/dm^3 and agitation speed of 1200, 1250, 1300, 1350 and 1400 rpm respectively. Chemical analysis of the concentrate samples before and after froth flotation, revealed that the crude assaying of 103 ppm at -63+45 μm has been successfully upgraded to 630 ppm Au at a recovery of 97.9% via a pulp density of 50 g/cm^3, concentration of 600 mg/dm^3, pH of 9 and agitation speed of 1350 rpm when potassium salts of groundnut oil was used as collector and groundnut oil as frother. Hence, this is the optimum froth flotation condition suitable for the recovery of gold ore. This show that potassium salt of groundnut oil is a potential flotation reagent for the flotation of minerals.

Keywords— green reagent, groundnut oil, gold, adsorption, flotation, mechanism

I. INTRODUCTION

In mineral processing Industry, froth flotation has proven to be one of the most effective methods used to concentrating minerals [1]. This process exploit the difference in the electrochemical properties of mineral surfaces, that is, between hydrophobic and hydrophilic surfaces in order to separating valuable minerals. This can occur naturally and most of the time, it is usually induced artificially with the aid of a chemical reagents [2]. Surface modification is widespread in engineering fields [3] however, despite surface modification; the floatability of valuable mineral always depend on particle size. As a result of this fine or coarse particles do require more surfactant to float for hydrodynamic reasons [4]. In mineral engineering, the hydrophobicity enhancement of mineral by collector adsorption to ensure hydrophobized mineral is selectively attached to air bubble in a pulp is one of the key requirements in mineral concentration [5]. It becomes imperative to developing a novel surfactant using a locally sourced which can serve as a possible substitue with good performances for the flotation of a given mineral because an efficient reagent adsorption concentration do control the overall surface hydrophobicity and improve the flotation of valuable mineral. Groundnut oil, being a locally-sourced material, is a good lubricant due to high lubricity, viscosity, biodegradability and low toxicity. In Nigeria, the major sources of edible oil are groundnut which is also called peanut and oil palm [6]. Groundnut is an important source of oil for millions of people in Nigeria due to the fact that the country do produce 1917 tonnes of peanuts on annual basis [7]. These nuts are among the oldest oil crops in cultivated in Nigeria and are mostly consumed as snack, after roasting [8]-[9], as cooking oil, production of soap, margarine, and cosmetics [10]. Without any doubt, groundnut oil is a useful source of energy and had made an important contribution to the diet in many countries, also serving as a good source of protein, lipid and fatty acids for human nutrition [11]-[13] Oil quality and its stability are therefore very important to consumers [14]. Systematically, due to its environmental benefits, the use of groundnut oil as an alternative locally-sourced reagent in mineral processing industry is quite desirable [15]. It major component fatty acids are oleic acid (46.8% as olein), linoleic acid (33.4% as linolein), and palmitic acid (10.0% as palmitin) [16]. In Nigeria, Iperindo lode gold ore is one of the few primary gold deposits known. The gold ore contained highly silicified fine-grained and the veins are mainly as discrete particles, up to 100 μm in size, at grain boundaries between quartz and carbonates and the most prominent and dominant sulphide in Iperindo lode gold deposit is pyrite [17]. Similarly, other associate mineral are dolomite, Annie and sylvite. The traces of K, Ba and Rb, in this compound shows the ore as a typical mesothermal gold deposit [18]. The lode gold deposit lies in Ilesha schist belt and some 4 km to the east of a major

crustal 'break' known locally as the Ifewara-Zungeru fault[19]. The mineral resources estimated grades using a block model spatially constrained by geological and statistical parameters was 4,580,863 tonnes at a grade of 3.8 [20].

II. RELATED WORK

This research focuses on the Iperindo lode deposit in Ilesha. Most of the previous works from different authors focuses on the process routes for Ilesha placer deposit, either by gravity concentration, amalgamation or cyanidation. However, [21] studied the recovery efficiency of Ilesha placer gold ore by flotation using locally sourced frother and collector. The results obtained shows that optimum recovery of 91.8 per cent when potassium salts of groundnut was used as collectors. Furthermore, the important of designing a products and processes that reduce the utilization and production of harmful substances becomes imperative [22]

III. METHODOLOGY

Ten kilograms (10 kg) ore was sourced from Iperindo, Osun State goldfield deposit site which is about 23 square kilometers having latitude 7°35'0'' E and longitude 4°30'0'' N. Samples collected were crushed using a sledge hammer to size range of 2 – 4 cm, followed by further reduction to 1 mm using a Denver Laboratory Jaw Crusher (Model – D12). The resulting crushed ore sample was properly homogenized and sieved via -63+45µm.

a. Preparation of collector

2.5M of potassium hydroxide solution was prepared by dissolving 140g of potassium hydroxide pellets in one liter of distilled water. 75 ml of 2.5 KOH solution was added to 50 g of groundnut oil in flask. The resulting mixtures were boiled and stirred in water until homogeneous mixtures was produced. The respective potassium salts which is the collector for the flotation of gold ore was obtained.

b. Froth flotation experiment for green reagent

The flotation experiment was carry out using a mineral particle size fractions of -63+45 while the flotation parameters used in studying the extent of recoveries of gold concentrates from the ore are pulp density, pulp pH, collector's concentration and the speed of the agitation of the flotation cell impeller. The pulp was prepared using 20 percentage weight solid particle size of -63+45 µm charged into the flotation cell and agitated for three minutes. The pH of the pulp was adjusted by adding drops of lime solution to a pH of 9. The pulp density was put at 50 g/cm^3, agitation speed of 1200 rpm and agitation time of three minutes. Thereafter, 400 mg/dm^3 of K^+ salt of groundnut oil (soap) as collector was added to the pulp and conditioned for three minutes. After this, 2 ml of groundnut oil was added as frother. The pulp was aerated for three minutes and floated gold concentrate was recovered, dried and weighed. The procedure was repeated for at various pH of 8.0, 8.5, 9.0, 9.5 and 10, pulp density of 50, 100, 150, 200 and 250 g/cm^3, collector concentration of 200, 300, 400, 500 and 600 mg/dm^3 and agitation speed of 1200, 1250, 1300, 1350 and 1400 rpm respectively. The froth from each test was removed, dried in an electric oven and weighed. The percentage gold concentrates recovered from the particle size fractions under various froth flotation operating parameters were then imputed.

IV. RESULTS AND DISCUSSION

a. Pulp density

The results of pulp density variation against gold concentrate recovery and grade show in figure 1, it was observed that as the pulp density increase, low recovery and high grade was achieved which in economically point of view is viable because the cost of extraction is reduced but the return of final product will be low. However, gold is a precious metal it will be a bonus. The highest gold concentrate recoveries of 92.60 % was obtained at a pulp density of 50 g/cm^3 when potassium salt of groundnut oil was used.

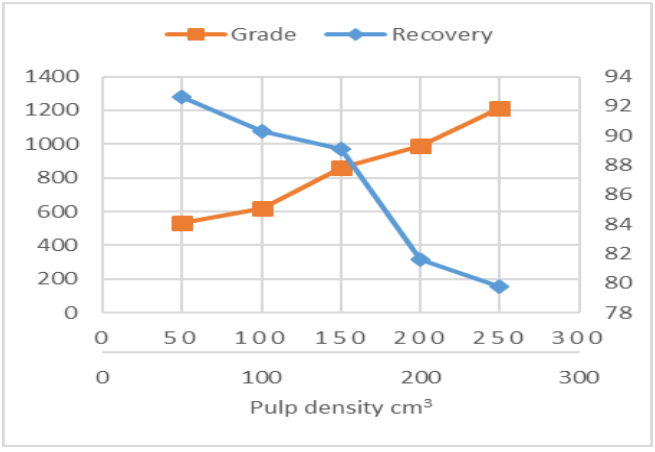

Figure 1: illustrates the effect of pulp density variation on gold concentrate recovery and grade

b. Collector concentration

Figure 2 show that gold concentrate recovery increases with increasing collector concentration. The plots reveal that potassium salt of groundnut oil, as collector, at a concentration of 0.60 g/dm^3, gives the highest recovery of 97.90%. It shows there is a strong relationship between the size of the clusters and the concentration of the collectors, and with the highest collector concentration providing the largest cluster which lead to the recovery of gold particles experienced. Furthermore, the effectiveness of green surfactant could be due to the proportion of the combined unsaturated fatty acid present in the oil (groundnut oil) used in preparing the collector. It is reported in the literature that oleic acid and its alkali salt, as frother and collector respectively, are more effective than any other fatty acids (Will, 1988). It appears that high percentage of oleic acid (46.8 % as olein*) and* linoleic acid (33.4 % as linolein*)* may be crucial to the recovery. The green collector, which has shown a good recovery, contains 46.8 % oleic acid and less percentage of other fatty acids *(USDA, 2018).*

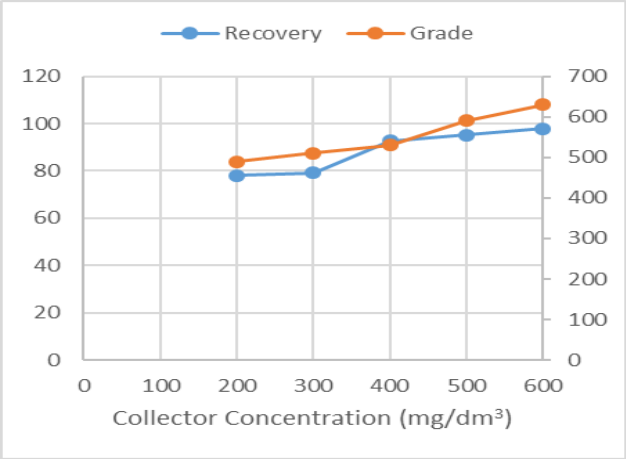

Figure 2: illustrates the effect of pulp density variation on gold concentrate recovery and grade

c. pH

The effect of pulp pH variation on gold concentrate recovery and grade is presented in Figure 3. It was observed that the recovery of gold concentrate increases with an increase in the pulp pH up to a pH value of 9 when gold recovery begins to decline with an increase in pulp pH. The highest gold concentrate recovered was 92.60% at a pH of 9 when potassium salt of groundnut oil was used as collector. This result confirms the assertion made by Bulatovic (1997) that the maximum recovery of gold could be obtained at the pH range of 7.5 – 9.0 and beyond pH of 9, gold recovery decreases. It was suggested that the highest recovery at pH of 9 may be due to complete ionization of the green reagent used which promotes the production of more polar (charged) ends for gold particle to attach itself and therefore, increases the hydrophobicity of gold particles in the pulp (Jowett, 1975). This consequently, increases its floatability and hence, enhances recovery.

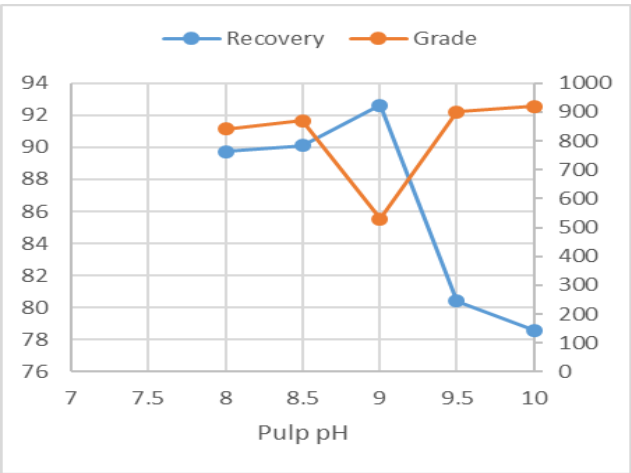

Figure 3: illustrates the effect of pulp density variation on gold concentrate recovery and grade

d. Impeller speed

The effect of agitation speed on gold concentrate recovery and grade as shown by Figure 4 depicts the influence of agitation speed on the fine particles size fraction used. This shows that the recovery of gold increases with increasing agitation speed until 1350 rpm was attained. Furthermore, there was a sudden decrease in recovery and a significant increase in the grade. It was observed that a minimum impeller speed is necessary for the efficient recovery of gold concentrate from its ore when green reagent was used at a recovery of 92.60%.

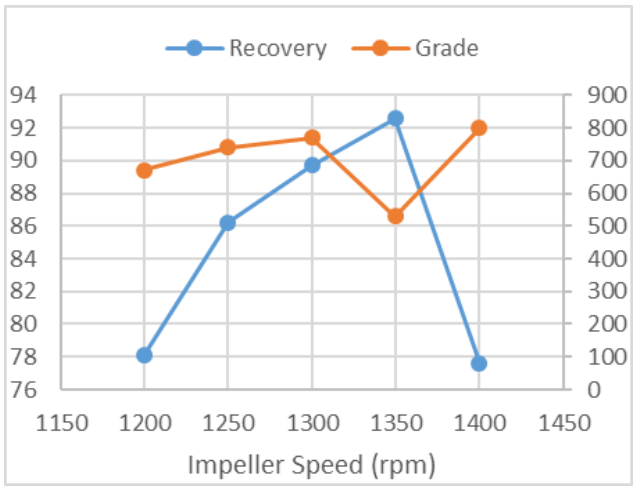

Figure 4: illustrates the effect of impeller speed variation on gold concentrate recovery and grade.

e. Optimum Recovery

Figure 5 shows optimum recovery plots of gold concentrate when green reagent was used for the flotation of gold ore. It was depicted that 97.90% optimum gold concentrate recovery was obtained using potassium salt of groundnut oil as collector. This optimum value was achieved at the following optimized flotation parameters: 50 g/cm^3 pulp density, pulp pH of 9, impeller velocity of 1350 rpm, collector concentration of 0.60 g/dm^3 and mineral particle size of 45 µm.

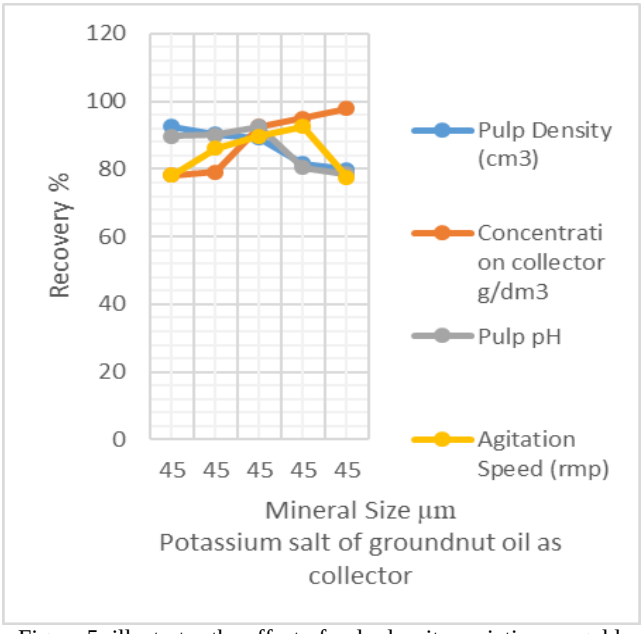

Figure 5: illustrates the effect of pulp density variation on gold concentrate recovery and grade

V. CONCLUSION AND FUTURE SCOPE

The flotation behavior and absorption mechanism of green reagent (potassium salt of groundnut oil) to gold ore was investigated by flotation tests. It is a proven fact that green reagent (potassium salt of groundnut oil) is a novel surfactant which shows good performances for flotation of gold ore. It can serve as possible subtitute to convectional reagents because efficient reagent adsorption concentration control the overall surface hydrophobicity which considerable improve the flotation of the valuable mineral. Based on the experimental observations, the following conclusions could be drawn. The optimum value was achieved at the following optimized flotation parameters: 50 g/cm^3 pulp density, pulp pH of 9, impeller velocity of 1350 rpm, collector concentration of 0.60 g/dm^3 and mineral particle size of 45 µm. However, chemical analysis of the concentrate samples before and after froth flotation, revealed that the crude assaying of 103 ppm at -63+45 µm has been successfully upgraded to 630 ppm Au at a recovery of 97.9 %. This results indicate, the process design of the Ilesha goldfield would ensure sustainable solid mineral development which entails exploration, exploitation, processing, extraction and utilization of the depletable resources under safe and environmentally friendly condition if adequate attention is pay towards the utilization of locally-sourced reagents. However, sustainable development of green reagents which can be sourced locally and develop to floating other valuable minerals is highly desirable.

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Engr. Yomi Adetula pursed Bachelor of Engineering in the department of metallurgical amd material Engineering from the Federal University of Techonology Akure, Ondo State, Nigeria in 2015 and Master of Engineering from the same department and institution in 2020. He is currently seeking for Ph.D Student position in reputable institution across the globe. His main oblective is to contribute immensely to the body of knowledge especially in the area of mineral processing, chemical and extractive metallurgy to uplift any institution he find himself to an enviable status among its global counterparts and also become a renowed scholar with uncommon scholarship, innovative research, proficient leadership in the mineral industry and qualitative consultancy services. He is a laureate global fellow and a member of NMS, NIM and

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