Some Physico-chemical Characteristics of Chalcopyrite Ore

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Summary: Fresh ore samples from Shinkai copper ore site were collected, crushed and grinded. Different mesh sizes were analyzed for densities and the concentrations of copper. Point of zero charge (PZC) of the ore was determined as a function of temperature (293 – 323 K) and was observed to decrease with temperature for all the mesh sizes. The mineral assay of the solid showed that the concentration of SiO_2 decreases while the concentration of copper increases with decrease in the particle size of the ore.

Introduction

Copper is one of the most abundant elements in the earth crust. Due to its uses in electrical appliances, pipes, industrial machinery, coinage and alloys, its mining is increasing day by day. It generally occurs in nature as oxides or sulphides. The most common oxide ores are cuprite (Cu_2O), malachite $CuCO_3.Cu(OH)_2$ and azurite $2CuCO_3.Cu(OH)_2$ while sulphides ores include chalcocite (Cu_2S), chalcopyrite ($CuFeS_2$), bornite (Cu_5FeS_4) and tetrahedrite ($3Cu_2S.Sb_2S_3$). The copper ores usually contain a lot of other valuable elements like iron, zinc, lead, arsenic, cobalt, cadmium etc. which need to be removed to obtain the pure copper.

The present study is concerned about the physico chemical characteristics of the chalcopyrite ore collected from Shinkai in North Waziristan Agency, Pakistan. The ore is characterized by x-ray diffractometry, density measurement, point of zero charge, surface area etc. and subjected to wet analyses.

A crucial part of the ore flotation process is interaction of the mineral with the reagents used to float sulfide minerals. These interactions are controlled by the nature of charge present on the surface of adsorbent. The generation of surface charge on the mineral particles is considered to be either due to preferential dissolution or due to hydrolysis of surface species followed by pH-dependent dissociation of surface hydroxyl groups [1-3].

The present study therefore takes care of the effect of temperature, particle size and potassium ethyl xanthate presence in solution on the PZC of the chalcopyrite ore.

Results and Discussion

Characterization of Copper Ore

The characterization of copper ore by various methods is given below:

X- ray Diffractometry

The X- ray diffraction pattern for the ore sample recorded from 2- 65° angle can be seen from Fig. 1. The diffractogram when compared with standard charts, indicates that the sample is composed of mainly the chlorites and quartz. A peak, however, between 29°- 30° is identified as that of chalcopyrite. Similar X-ray diffraction pattern was observed in the literature [5] for the said sample.

Density

Densities of the different sieve fractions are listed in Table 1, which are found to lie between 2.68 to 2.85. The observed values are close to the values calculated theoretically, as reported in the literature [6]. The densities for quartz and chalcopyrite being 2.65 and 4.10 respectively, the observed value of 2.78 indicates that the sample consists of about 50 % of quartz and 10 % of the chalcopyrite.

Table-1: Sieve size effect on densities

SIEVE SIZE MESHASTM-11-70 (USA)	DENSITY
-35+60	2.78
-60+80	2.78
-80+100	2.78
-100+140	2.68
-140+200	2.85
-200(PAN)	2.78

Note: PAN is generally used for the last fraction of the sieve collected in a sieve less pot.

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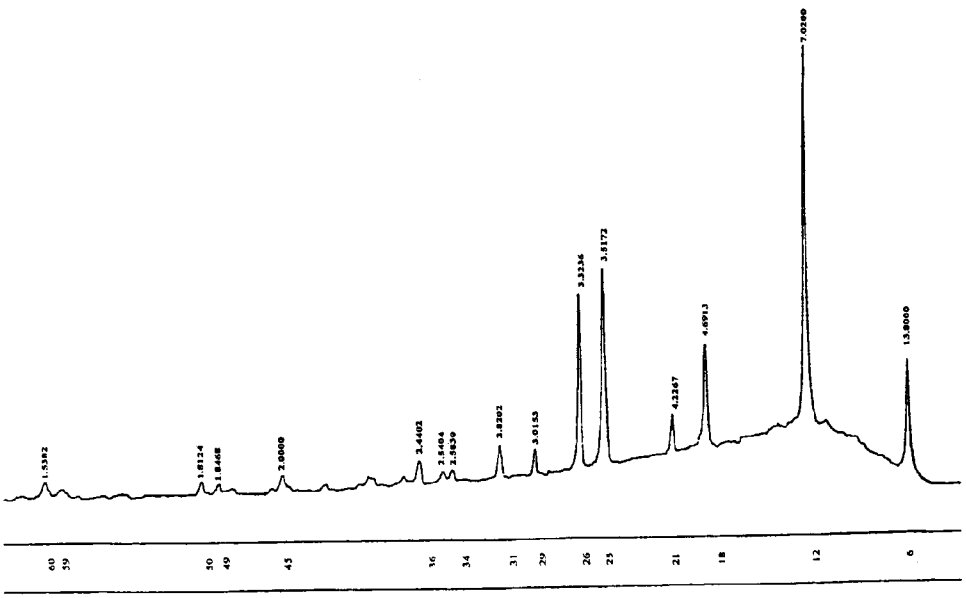

Fig. 1: X-ray diffractogram of copper ore sample.

Point of Zero Charge

The point of zero charge (PZC) for the ore was determined in the presence of 0.1M KNO_3 at 293K. As can be seen from Figs (2-4) the PZC value lie at pH 6.70, for sieve fraction –200, 6.40 for –140+ 200 and 6.00 for –60+80 at 293 K. The decrease in PZC with the increase in particle size may be correlated with the concentration of SiO_2 content present in the different mesh sizes of the sample. As can be seen from the Table 3, the concentration of SiO_2 increases in the sample with the increase in its particle size, which shift the PZC of the sample towards the lower pH values, the PZC value of SiO_2 has been reported in the literature [7, 8] to lie between the pH 2-4.

It can also be observed from the Figs (2-4) that the PZC values decrease with the increase in temperature. This trend in PZC with temperature indicates that the deprotonation of the solid increases with rise in temperature pointing towards the endothermic nature of the surface deprotonation Similar variation in PZC with temperature are well documented in the literature [9] for metal oxide/ hydroxides. The presence of potassium ethyl xanthate in the solution has no effect on the PZC of the sample, showing the absence of any role of sulphur in creating the charge on the surface of the solid.

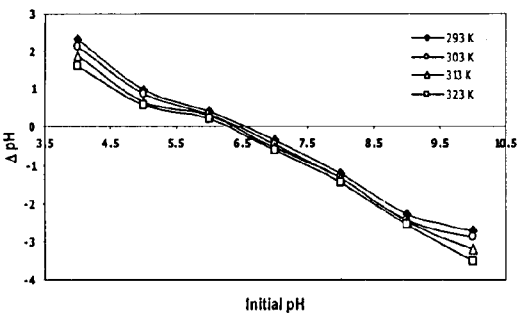

Fig. 2: Temperature effect on PZC of sample = -200 mesh.

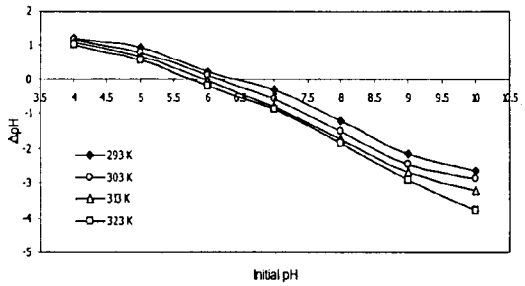

Fig. 3: Temperature effect on PZC of sample = -140 + 200 mesh

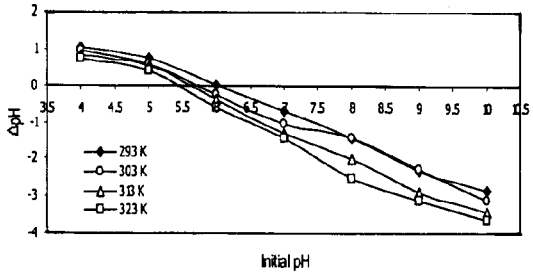

Fig. 4: Temperature effect on PZC of Sample = -60+80 mesh

Sieve Analysis

Sieve analysis of the ore is presented in Table (2). The results obtained show that the sample is of moderate hardness because nearly 75 percent of the ore with the grinding time of 5 minutes passes through 100 mesh sieve.

Table-2: Sieve analysis of ore after grinding by Ball Mill for 5 minutes.

Sieve Size MESH ASTM-11-70 (U.S.A)	% Weight Actual Retained	Cumulative Retained	Cumulative Passed
+35	13.12	13.12	86.88
-35+60	2.36	15.48	84.52
-60+80	3.92	19.40	80.60
-80+100	5.49	24.89	75.11
-100+140	10.11	35.00	65.00
-140+200	27.31	62.31	37.69
-200(PAN)	37.69	100.00	0.00

The mineral assay of all sieve sizes are listed in Tables (3,4). These tables show that the concentration of SiO_2 decreases while the concentration of R_2O_3 (Fe_2O_3 + Al_2O_3), CaO, MgO and Sulphur increases with decrease in particle size. Table 3 also indicates an increase in concentration of total copper with decrease in particle size. This behavior may be due to the degree of hardness of SiO_2. The degree of hardness of SiO_2 is about 7 while the other components have lower degree of hardness i.e. Chalcopyrite=3.5-4, S=1.5-2.5 etc. [6]. The SiO_2, therefore, remains less damaged during grinding, resulting in a very small effect upon its exposed surface area. This increase in the concentration of copper can be assigned to the increased attack of acid on the sample due to an increase in the exposed surface area of CuO on account of its lower degree of hardness as compared to SiO_2.

Experimental

Sample

Fresh ore sample from Shinkai, North Waziristan Agency, Pakistan were collected, crushed and grounded to different mesh sizes. Mesh size of (-200) was used during the experiments.

Preparations of Sample

Locally made jaw crusher was used for crushing purposes .The crushed sample was grinded into powder for 3-5 minutes in ball mill. The powder was sieved by using different sieve size of US standard, which were then stored in air tied polyethylene bottles for further investigations.

Characterization of Sample

X-ray Diffractometry

A dry powder of –200 mesh ore sample was subjected to the X-ray analysis using X-ray

Table-3: Metal concentrations of different sieve fractions of the ore

Mesh Size	%Loss on Ignition	$\%SiO_2$	$\%R_2O_3$	$\%Na_2O$	$\%K_2O$	%CaO	%MgO	% S	$\%TiO_2$
-35+60	6.14	50.90	31.95	Traces	0.29	0.44	11.70	2.68	0.33
-60+80	5.99	49.30	32.20	Traces	0.29	0.35	11.75	2.71	0.43
-80+100	5.87	53.94	29.65	Traces	0.24	0.42	11.55	2.69	0.28
-100+140	5.96	50.24	31.10	Traces	0.29	0.51	12.25	2.71	0.37
-140+200	6.13	43.88	31.30	Traces	1.24	0.54	12.35	2.88	0.47
-200	7.66	42.10	35.00	Traces	0.29	0.50	12.50	3.25	0.59

Table- 4: Mineral assay of different sieve fractions of the ore

Mesh Size	Total Cu (ppm)	Cu as Sulphide (ppm)	Cu as Oxide (ppm)	Ni (ppm)	Co (ppm)	Zn (ppm)	Ag (ppm)	Fe (ppm) x 10^4
-35+60	6520	6200	320	94	75	23	0.6	6.3
-60+80	6700	6430	270	94	73	23	0.6	5.4
-80+100	6830	6590	240	93	75	22	0.5	6.2
-100+140	7000	6760	240	94	73	23	0.7	5.1
-140+200	7600	7370	230	93	78	24	0.7	5.7
-200	8000	7800	200	106	82	28	0.9	8.7

diffractometer model JDX-73 with Mn-filtered Cu-Kα radiation. The diffractogram thus obtained was analyzed from the resulting peaks.

Densitity Measurement

50 mls empty and doubly distilled water filled volumetric flasks were weighed respectively. 20 grams of the different samples were taken in these flasks which were then filled with doubly distilled water and were weighed again. Densities were calculated from the difference between the weights.

Point of Zero Charge

The point of zero charge (PZC) for copper ore was determined by mixing 30mL of 0.1M KNO_3 to 0.5g of the solid sample in 100mL conical flasks. The pH of the suspensions in the flasks was adjusted from 4 to 10 with increment of 1pH unit, either by HNO_3/KOH. The mixtures were then kept shaking in an end-to-end shake bath for 24 hours at the desired temperature. After 24 hours of equilibration, the equilibrium pH of the suspensions were recorded by using pH meter.

Assay Determination

Ore analyses were performed by taking 0.5g of sample in 2 mls of aqua regia in a test tube and were digested in water bath for one hour. Afterwhich 8 mls of distilled water were added and allowed to stand till all the suspended materials settled down. The clear solutions were then withdrawn and diluted to the required concentration. The concentration of Cu, Fe, Pb, Ni, Zn, Co etc. in solution were determined by using atomic absorption spectrophotometer, Perken Elmer model 3100. Copper as oxide was determined by taking one gram of the sample in 30 mls of 10% H_2SO_4 solution in a beaker and shaken for one hour at room temperature. The clear solution was then decanted and was run through atomic absorption spectrophotometer for the determination of copper. The concentrations of sulphur, Al_2O_3, Fe_2O_3, SiO_2 etc. were determined by the methods reported by Furman [4] .

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