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Determination of Trace Element in Bauxite Ore using Voltammetric Techniques

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Abstract—*The elemental analysis of different ores, industrial samples have been performed using voltammetry. The preliminary separation of major constituent reducing at less negative potential then the element bring determined is necessary in most cases including chalcopyrite, Ag based alloy, Al and As in Zn based alloys, Au in calcium based alloys. Bauxite is usually strip mined because it is almost always found near the surface of the terrain, with little or no overburden. Approximately 70% to 80% of the world's dry bauxite production is processed first into alumina, and then into aluminium by electrolysis as of 2010. Bauxite rocks are typically classified according to their intended commercial application: metallurgical, abrasive, cement, chemical, and refractory. In this work we propose a technique which will Trace elemental analysis of ores natural origin samples and Industrial wastes in biometrics, have been performed using oscillographic polarography and to explore the Differential Pulse Polarography (DPP) method of instrumental for determination of trace elements in ore.*

1. INTRODUCTION

Bauxiteis analuminium ore, is the world's main source of aluminum. It consists mostly of the minerals gibbsite $Al(OH)_3$, boehmite AlO(OH) and diaspore AlO (OH), mixed with the two iron oxides goethite and hematite, the clay mineral kaolinite and small amounts of TiO_2. Lateritic bauxites (silicate bauxites) are distinguished from karst bauxite ores. The carbonate bauxites occur predominantly in Europe and America above carbonate rocks (limestone and dolomite), where they were formed by lateritic weathering and residual accumulation of intercalated clay layers – dispersed clays which were concentrated as the enclosing limestone gradually dissolved during chemical weathering, highest aluminums content are frequently located below a ferruginous surface layer. The aluminum hydroxide in the lateritic bauxite deposits is almost exclusively found.

In 2009, Australia was the top producer of bauxite with almost one-third of the world's production, followed by China, Brazil, India, and Guinea. Although aluminum demand is rapidly increasing, known reserves of its bauxite ore are sufficient to meet the worldwide demands for aluminum for many centuries. Increased aluminum recycling, which has the advantage of lowering the cost in electric power in producing aluminum, will considerably extend the world's bauxite reserves.

Bauxite is usually strip mined because it is almost always found near the surface of the terrain, with little or no overburden. Approximately 70% to 80% of the world's dry bauxite production is processed first into alumina, and then into aluminum by electrolysis. Bauxite rocks are typically classified according to their intended commercial application like metallurgical, abrasive, cement, chemicals, and refractory.

2. EXPERIMENTAL – INSTRUMENTATION

Chemical and Reagents

All the chemicals used, to prepare the experimental sets, were of Anala R/BDH grade. Stock solutions of Ag, Au, Cu, Pb, Ni, Fe, Ca, Mg, Al, Sn and Sb were prepared by dissolving a requisite amount of their soluble salts in deionised water. Gelatin solution was prepared in hot distilled water.

The solutions were standardized by known methods (1) and diluted as required.

Preparation of the Sample

The Samples was procured from the Geology department of Dr. Hari Singh Gour Central University Sagar (M.P) Mineral samples were collected from Bodal – Bhandaritola village, Rajnandgaon, Chhatarpur district (M.P.). BAUXITE ORE SAMPLE**:** 1gm finely pulverized mineral sample was dissolved in 10 ml of hydrofluoric acid (26.5N) and final volume made to 100 ml of distilled water.

Preparation of analyte and recording of voltagram/ polarography

The procedure for preparation of analyte, and the pasture of trace analysis, should be simple, convenient, should not leave any contaminating element in the analyte and should not destroy the ions of interest at any level.

The procedure for preparation of analyte from the sample solution is described as follows -

Ore Sample (Bauxite minerals)

The sample solution (10 ml) was mixed with 10 ml of 1 M ammonium tartrate solution as supporting electrolyte and 0.01% gelatin as maximum suppresser was taken in a polarographic cell and, the final volume was made up to 100 ml with distilled water The pH of the test solution was adjusted to 9.0 ± 0.1, with ammonia solution. Pure nitrogen gas was bubbled through the test solution for 15 min and the pH of the test solution was checked before recording the polarogram and voltammograms.

3. RESULT AND DISCUSSION

Ore Sample of Bauxite

1. ***In potassium chloride***- The DC and DP Polarograms and DPAS Voltammogram of the sample solution shows four well defined polarographic and Voltammetric waves / peaks with $E_{1/2}$ / E_p= -0.06/-0.08, -0.86/-0.84, -1.20/-1.16 and -1.54/-1.62, V vs SCE, indicating the presence of Cu(II), Fe(II), Fe(III) and Mn(II), (Figure. 4.2 a,f & k) (20). The results indicated that the percentage recovery is over 98% for all the metal ions, with high accuracy and precision of the determination.

2.

3. ***In hydrochloric acid***- The DC and DP Polarograms and DPAS Voltammogram of the sample solution shows a wave / peak with $E_{1/2}$ / $E_p$values= -o.78/-0.82, V vs SCE, indicating the presence of Ti (IV). Besides, Cu and Fe which were also detect in KCI supporting electrolyte. (Fig. 4.2 b, g &l).

To confirm the presence of said metal ions in the sample a definite quantity of the standard solution of each metal was added to the analyte and polarogram were recorded under the identical experimental conditions. An increase in the wave / peak height of each metal ion signal was observed without any change in $E_{½}$ / $E_p$values.

Some synthetic samples of varying ion concentrations were prepared and their polarograms/ Voltammograms were recorded under identical experimental conditions. The results (Fig 4.2 p) indicated no change in $E_{½}$/ Ep values of the above mentioned metal ions. The linear relationship between the concentration of each metal ion and the corresponding wave/ peak height was also unchanged confirming the possibility of an accurate simultaneous qualitative and quantitative determination of the metal ions in the sample.

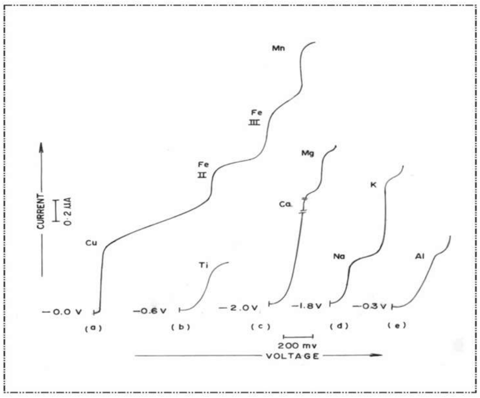

Figure-4.2

(a) Direct Current Polarogram of Bauxite Sample (100mg /100 ml) in 1M KCl + 0.001% gelatin at pH 4.5 ± 0.1.
(b) 1M HCl at pH 0.0 ± 0.1.
(c) and (d) 0.1 M TBAC at pH 2.0 ± 0.1 and 8.0 ± 0.1 respectively.
(e) 1M Sodium Acetate at pH 7.0 ± 0.1.

TABLE 4.21 ANALYSIS OF SYNTHETIC SAMPLE OF BAUXITE SAMPLE

Cu (II)	**Fe(III)**	**Mn(II)**	**Ti(II)**	**Ca(II)**	**Mg(II)**	**Na(I)**	**K(I)**	**Al(III)**
1.27	0.03	10.73	0.68	0.51	0.55	0.56	0.71	1.07
(1.26)	(0.03)	(10.72)	(0.67)	(0.50)	(0.54)	(0.56)	(0.72)	(1.08)
2.52	0.07	21.42	1.13	1.00	1.12	1.12	1.10	0.88
(2.52)	(0.07)	(21.4)	(1.04)	(1.00)	(1.12)	(1.12)	(1.11)	(0.89)
5.04	0.14	40.84	3.01	2.00	2.23	2.24	2.25	4.44
(5.02)	(0.14)	(40.8)	(2.91)	(2.00)	(2.23)	(2.24)	(2.25)	(4.43)
0.63	0.21	3.07	9.67	0.51	0.63	0.63	0.65	0.77
(0.63)	(0.2)	(3.05)	(9.98)	(0.55)	(0.62)	(0.63)	(0.65)	(0.77)
0.68	0.41	2.96	1.10	0.63	0.70	0.71	1.33	1.41
(0.67)	(0.39)	(2.95)	(1.09)	(0.77)	(0.71)	(0.72)	(1.34)	(1.42)
4.67	0.44	1.12	2.05	2.01	0.72	0.72	0.98	0.65
(4.67)	(0.43)	(1.12)	(2.05)	(2.03)	(0.72)	(0.72)	(0.99)	(0.66)

( ) Compositions of synthetic samples (mg/ 100 ml)

Amount Found * Using DPP

Table-4.22 Voltammetric & Polarographic Analysis Results On Bauxite Ore Sample (Mg/100mg)*

Metal Ion	Parameter	By DCP			By DPP			By DPASV		
		Added		Found	Added		Found	Added		Found
Cu(II)	**Amount**	-		0.105	0.127		0.105	0.127		0.105
		0.127		0.231			0.231			0.231
	% Rec.		99.5			100			100	
	S.D. **		0.02		-	0.01		-	0.01	
Fe(II)	**Amount**	-		0.335	0.336		0.335	0.336		0.335
		0.336		0.668			0.668			0.668
	% Rec.		99.5			99.2			99.2	
	S.D. **		0.07		-	0.06		-	0.06	
Mn(II)	**Amount**	-		0.031	0.027		0.031	0.027		0.031
		0.027		0.058			0.058			0.058
	% Rec.		99.3			99.4			99.4	
	S.D. **		0.06		-	0.02		-	0.02	
Ti(IV)	**Amount**	-		0.089	0.089		0.089	0.089		0.089
		0.089		0.177			0.177			0.177
	% Rec.		99			99.6			99.6	
	S.D. **		0.01		-	0.05		-	0.05	
Ca(II)	**Amount**	-		10.09	14.07		10.09	14.07		10.09
		14.07		24.14			24.14			24.14
	% Rec.		99.2			99.8			99.8	
	S.D. **		0.02		-	0.02		-	0.02	
Mg(II)	**Amount**	-		0.05	5.00		0.05	5.00		0.05
		5.00		0.12			0.12			0.12
	% Rec.		99.1			99.6			99.6	
	S.D. **		0.05		-	0.03		-	0.03	
Na(I)	**Amount**	-		0.03	0.08		0.03	0.08		0.03
		0.08		0.11			0.11			0.11
	% Rec.		99.5			100			100	
	S.D. **		0.04		-	0.05		-	0.05	
K(I)	**Amount**	-		0.485	0.595		0.485	0.595		0.485
		0.595		1.07			1.07			1.07
	% Rec.		99.6			99.8			99.8	
	S.D. **		0.02		-	0.06		-	0.06	
Al(III)	**Amount**	-		40.24	58.61		40.24	58.61		40.24
		58.61		98.85			98.85			98.85
	% Rec.		99.4			99.68		0.127	99.68	
	S.D. **		0.03			0.04			0.04	

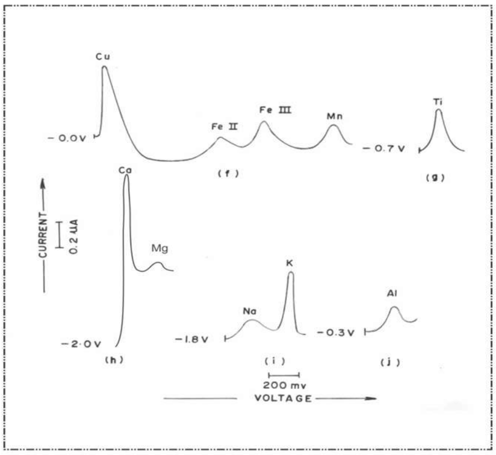

Figure-4.2

(f) Differential Pulse Polarogram of Bauxite Sample (100mg /100 ml) in 1M KCl + 0.001% gelatin at pH 4.5 ± 0.1.
(g) DPP of Bauxite Sample (100mg /100 ml) in 1M HCl at pH 0.0 ±0.1.
(h) and (i) DPP of Bauxite Sample (100mg /100 ml) in 0.1M TBAC at pH 2.0 ± 0.1 and 8.0 ± 0.1 respectively.
(j) DPP of Bauxite Sample (100mg /100 ml) in 1M Sodium Acetate at pH 7.0 ± 0.1.

Table 4.23 Final Analysis Results on Bauxite ORE Sample and Their Comparison with AAS

Metal ion	**Polarographic**	**AAS**
	(mg g^{-1} of the sample)	
Cu(II)	1.29	1.28
Fe(III)	3.93	3.94
Mn(II)	415	415.09
Ti(IV)	5.9	5.88
Ca(II)	0.5	0.51
Mg(II)	415	415.09
Na(I)	4.85	4.86
K(I)	5.85	5.86
Al(III)	40.24	55.02

Quantitative analysis of the sample using DCP, **DPP and** DPASV**:** Table 4.23 shows the final analysis results of bauxite ore sample for its metal content.

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