

STUDY OF THE DISSOLUTION OF BAUXITES IN MINERAL ACIDIC SOLUTIONS

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(Reçu le 14/08/2000 – Accepté le 05/06/2001)

Résumé : L'influence de différents facteurs sur les procédés de dissolution des composants simples et des mélanges d'oxydes de fer et d'hydroxydes d'aluminium a été étudiée. L'influence de la préparation thermique et des paramètres optimaux de dissolution des bauxites a été expliquée.

Des opportunités techniques et socio-économiques de l'utilisation de la méthode de dissolution par l'acide sulfurique dans la préparation des bauxites dans les toutes premières phases de leur transformation ont été données. Une attention particulière a été accordée aux aspects écologique et technologique des procédés de transformation de bauxites utilisant l'acide sulfurique ; ce qui a abouti à l'obtention de coagulants et à une diminution de la teneur en fer jusqu'à 5 % (mass.).

Mots clés : dissolution de bauxites, hématite, gibbsite, coagulants.

I - INTRODUCTION

An analysis of the development of the alumina's chemistry and technology shows that this field of science is not well studied. The needs are aimed more in the obtention of the aluminium metal than in obtaining aluminium salts. There are many ways of transformation of aluminium resources. The choice of one of them depends on the resources composition, the future use of the products and the opportunity of complex transformation.

The bauxite upon which we have investigated contains up to 23% (mass.) of iron. This makes difficult their transformation by the Bayer's scheme ; because of the red slurry [1].

The method we propose enters into the complex transformation of bauxite of high iron ratio and consists on the elimination of Fe_2O_3 at the very first steps of the process by dissolving them in mineral acids and on the use of the obtained solutions as coagulants.

II - EXPERIMENTAL

Dissolution investigations of iron and aluminium hydroxides, their mixtures and bauxites relatively to different factors have been done in a laboratory pilot, composed by a reactor with a stirrer (700 rds/mn) and an immersible thermometer with a temperature range from 30 to 90 °C. All the apparatus and substances of experimentation are of soviet origine. The bauxites samples have been obtained from Greece.

Heat preparation of bauxite has been proceeded in a temperature range of 450-600 °C during 10, 30 and 60 minutes under atmospheric pressure, in a furnace ; the samples have been put cold in it up to the needed temperature before putting on the time counter.

Dissolution process of the bauxite samples has been done with a stirring speed of 100 rds/mn, in a 28 ml of 4M H_2SO_4 during four hours under 100 °C, with a solide/liquide relative number S : L = 1 : 2.8. But kinetic investigations have been performed in 2M H_2SO_4 in order to increase the utilisation degree of the acid.

To determine the concentration of Al_2O_3 and Fe_2O_3 we have used direct and reverse titration [2] in a pH = 1-2 using trillion B for single compounds and ZnCl_2 for mixed compounds and bauxite, in a pH = 5.5. The analysis have been done using xilen orange indicator in the presence of an acetate buffer.

III - RESULTS AND DISCUSSIONS

The results of the volumetric determination of iron and aluminium and their statistical analysis are illustrated in tables 1 and 2. The experiment has been driven after one hour of heating under 550 °C.

The results show that iron oxide can be extracted up to 80 %, while at the same time near 4 % only of Al₂O₃ is extracted.

TABLE 1 : Statistical interpretation of the results of Fe₂O₃ volume determination, after one hour of heating under 550 °C.

N°	Extraction degree of Fe ₂ O ₃ α %	α - αm	(α - αm) ²	Calculations
1	81.93	2.60	6.76	
2	75.75	-3.58	12.8164	
3	79.73	0.40	0.16	S ² = 8.3822
4	77.01	-2.32	5.3824	S = 2.8952
5	82.23	2.90	8.41	
6	αm = 79.33		$\Sigma(\alpha - \alpha_m)^2 = 33.5288$	

S², S - dispersion amount, middle square mistake for a chosen determination,
m - extraction degree and average extraction degree value of Fe₂O₃, %.

TABLEAU 2 : Statistical interpretation of the results of Al₂O₃ volume determination, after one hour of heating under 550 °C.

N°	Extraction degree of Al ₂ O ₃ γ %	γ - γm	(γ - γm) ²	Calculations
1	1.46	-0.0848	0.0072	
2	1.01	-0.5348	0.2860	
3	3.41	1.8652	3.4790	S ² = 1.22435
4	1.34	-0.2048	0.0419	S = 1.1065
5	0.504	-1.0408	1.0833	
6	γm = 1.5448		$\Sigma(\gamma - \gamma_m)^2 = 4.8974$	

S², S - dispersion amount, middle square mistake for a chosen determination,
m - extraction degree and average extraction degree value of Al₂O₃, %.

Chemical and phase compositions of diasporus bauxites are given in table 3.

TABLE 3

Chemical and phase compositions of diasporus bauxites

CHEMICAL COMPOSITION		PHASE COMPOSITION	
Compound's name	Ratio, % (mass.)	Mineral's name	Ratio, % (mass.)
Light gases and water	13.10	Diaspor	68.4
Al ₂ O ₃	59.11	Kaolinite	2.4
Fe ₂ O ₃	23.60	Hematite	23.0
SiO ₂	1.14	Anatase	3.1
TiO ₂	3.10		
Impurities	0.55	Water and impurities	3.1
Total	100.00	Total	100.00

As we see, these bauxites have a big silicium number (> 20) and do not include alkaline compounds, sulphides, carbonates, but they contain 23 % of Fe - what is characteristic to the bauxites treated by Bayer Méthod [4].

Influence of the acid concentration and nature in the dissolution process

Figure 1 and 2 show the dissolution process of hematite, gibbsite and the mixture of both of them in mineral acids according to the increase of the concentration and the temperature respectively. Even if HCl gives good results, it can not be used because of its high fugacity. This, in accordance with literature datas [5, 6, 7], encourages the choice of H₂SO₄.

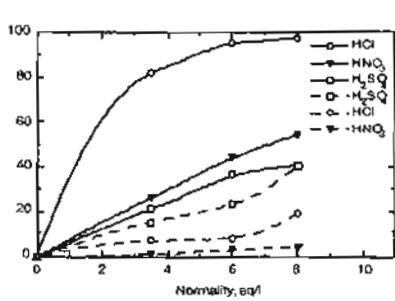
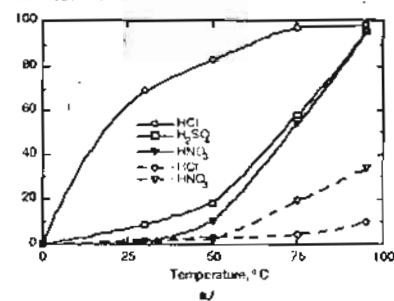
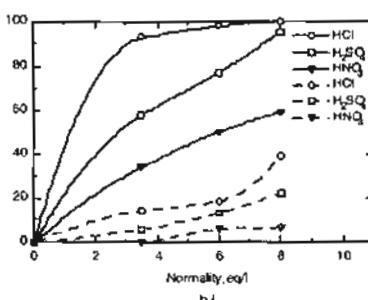
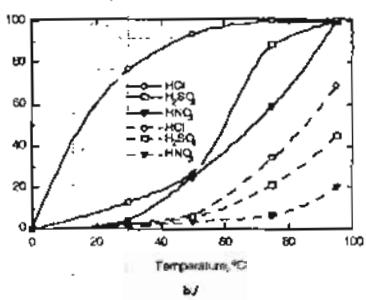
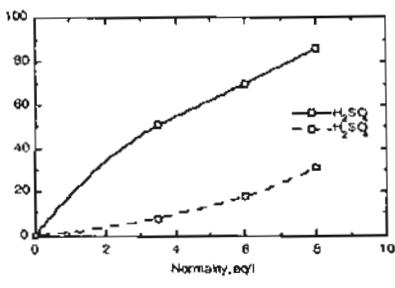
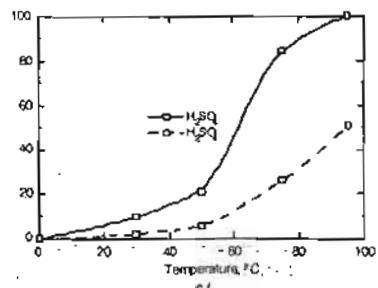


FIGURE 1 : Dissolution of hematite (—) and gibbsite (---) in mineral acids under different conditions and temperatures ; S : L = 1 : 10, dissolution time : 30 mn.

a/J individual compounds ;
b/J mixed hematite and gibbsite (brute state) ;
c/J mixed hematite and gibbsite (power state).

FIGURE 2 : Dissolution of hematite (—) and gibbsite (---) in mineral acids under different conditions and concentrations; T ≈ 75 °C ; S : L = 1 : 10, dissolution time : 30 mn.

a/J individual compounds ;
b/J mixed hematite and gibbsite (brute state) ;
c/J mixed hematite and gibbsite (power state).

Dissolution of diasporus bauxite

The results of the bauxites dissolution process are given in tableau 4 and figure 3.

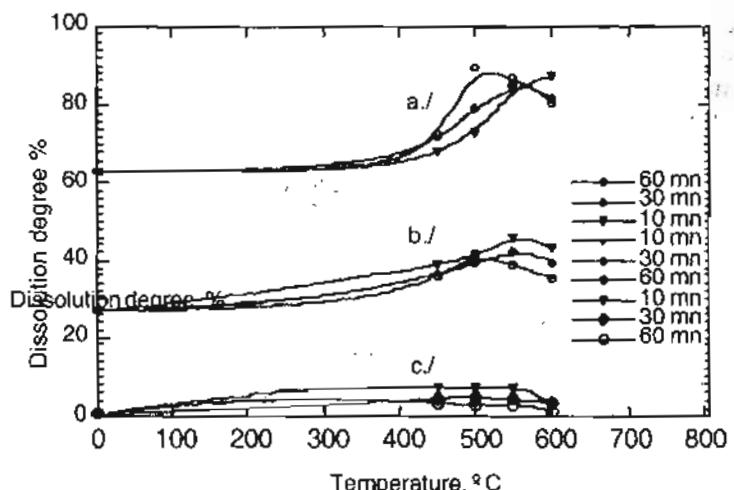
TABLE 4 : Dissolution of diasporus bauxites in a 4.2 M H_2SO_4 solution under 100 °C, during 4 hours, S : L = 1 : 2.8.

N°	Time heating (mn)	Temperature (° C)	Concentration in the solution, g/l of		Extraction degree, %		H2SO4 acid utilization degree, %
			Fe2O3	Al2O3	Fe2O3	Al2O3	
1*			57.99	1.93	62.79	0.81	27.03
2**			75.32	-	81.37	-	34.21
3	10	600	80.13	8.94	86.87	3.77	42.88
4		550	77.16	16.89	83.71	7.14	45.74
5		500	67.49	16.36	73.05	6.89	40.98
6		450	62.48	16.68	68.04	7.07	39.07
7		600	75.00	9.02	81.39	3.80	39.51
8		550	78.27	10.69	84.80	4.51	42.17
9		500	70.44	11.98	79.00	5.23	39.55
10		450	66.02	11.31	71.66	4.78	36.45
11**		550	74.73	-	81.09	-	33.13
12		600	74.49	3.46	80.79	1.46	35.43
13		550	75.68	7.82	86.72	3.48	38.99
14		500	82.14	7.54	89.31	3.10	41.65
15		450	66.86	9.02	72.64	3.81	35.91

* Dissolution of natural bauxites without heat preparation.

** Dissolution of α -Fe₂O₃ under S : L = 1 : 12

FIGURE 3 : Dissolution of diasporus bauxite in a 4.2 M H_2SO_4 solution under 100° C, during 4 h ; S : L = 1 : 2.8,



- a./ hematite removal ;
b./ H_2SO_4 acid utilization degree ;
c./ gibbsite removal.

Influence of heating. The heating of bauxite in a range of temperature from 450 to 600 °C intensifies the process of dissolution [2] and causes deshydratation, which is accompanied by an increase of the porosity of the bauxite [8]. During the heating process aluminium and iron oxides turn respectively to α -Al₂O₃ and Fe₂O₃ and the bauxite sample looses 8-12 % of its weight.

An increase of the heating time moves the optimal temperature field to lower temperatures. After one hour of heating at 500 °C, with 4M H_2SO_4 we have extracted up to 90 % Fe₂O₃ and only 3 % Al₂O₃. The utilization degree of the acid is less than 45 % (Tableau 4 and figure 3).

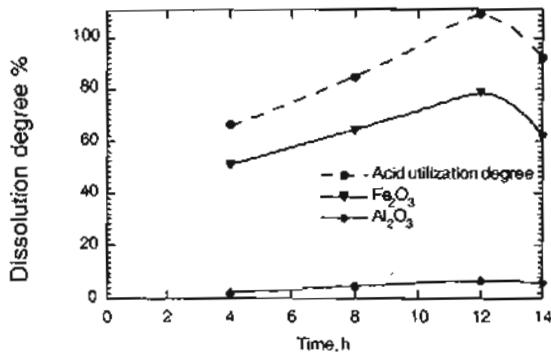
Influence of time processing. We have done a concreting investigation by dissolving the bauxite in 2M H_2SO_4 with a predication of a 100 % extraction of Fe_2O_3 , with a relative number S : L = 1 : 2.4, during 14 hours (Table 5 and figure 4). After 12 hours, up to 80 % (mass.) of hematite and 7 % (mass.) of Al_2O_3 have been extracted and the acid utilization degree is more than 108 %, what can be explained by alkaline salts formation. Up to 14 hours reverse reactions happen.

The obtained solution contains 101.8 g/l $Fe_2(SO_4)_3$ and near to 23 g/l $Al_2(SO_4)_3$.

TABLE 5 : Influence of time heating at 500 °C upon 60 mn dissolution process of bauxite in a 2 M H_2SO_4 at T = 100 °C; L : S = 1 : 2.4

Time heating, h	Concentration, g/l		Extraction degree, %		H_2SO_4 acid utilization degree, %
	Fe_2O_3	Al_2O_3	Fe_2O_3	Al_2O_3	
4	54.76	6.50	50.86	2.35	65.8
8	74.04	14.32	64.20	4.83	84.6
12	101.80	23.05	78.84	6.94	108.6
14	82.30	20.41	61.53	6.03	92.1

FIGURE 4 : Influence of time heating at 500° C during 60 mn on bauxites dissolution process in a 2M H_2SO_4 solution at T = 100° C ; L : S = 1 : 2.4



IV - CONCLUSION

The influence of some factors in the dissolution of Al_2O_3 and Fe_2O_3 has been studied. We have seen that the dissolution rate of these oxides increases according to the following rank : $\text{HNO}_3 < \text{H}_2\text{SO}_4 < \text{HCl}$.

The increase of temperature allows the dissolution process of individual oxides and bauxite.

The opportunity to obtain complex aluminium-iron coagulants have been shown dissolving bauxite with a 4M H_2SO_4 solution.

To decrease iron oxides (up to 7%), formerly heated bauxite at 500 °C during one hour must be dissolved during 8-12 hours in a 2M H_2SO_4 solution near to the stoichiometry of Fe_2O_3 at 100 °C. The obtained liquid phase contains 120 g/l of Fe_2O_3 and 12 g/l of Al_2O_3 and can be used in water cleaning process, as coagulant.

An other interesting opportunity of the work is the possibility to obtain pure Fe_2O_3 , when using acidic dissolution method at the very first steps of the Bayer scheme of obtaining alumina ; pure Fe_2O_3 is highly used in electronic industry.

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