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The Characterization of a Bauxite Waste From The Bayer Process

Nevin Yalçın, Vahdettin Sevinç

Abstract --- **The Bayer process for the alumina from bauxite produce a high quantity of waste in the form of mud. This waste -red mud- present serious problems on environmental pollution. A possible solution for these wastes would be the utilization at the ceramic industry. Because of this, the characterization of a bauxite waste has been performed using various techniques. The particle size distribution lied between 1 and 30 μm. The mean density was 2.85 g.cm^{-3}. The total weight loss was found as 7,07 % at 900°C from TG and DTG curves. The results of XRD investigations showed that the red mud consist of hematite and sodium aluminium silicate hydrate crystalline phases.**

Index Terms --- **Bauxite waste, red mud, mineralogic analysis**

I. INTRODUCTION

Bauxite waste-red mud- is a by-product of the Bayer process which is used for the production of alumina from bauxite, and is generally discarded as a waste [1]. The particle size distribution lies between 1 and 30 μm. 70 % of the particles are finer than 5 μm. The amorphous content is very high. There are rod-like crystals coated with amorphous material. Spheroidol particles are also common features of the microstructure and the larger part of them are found in agglomerates form [2]. The red mud chemically comprises of a mixture of the following oxides; Fe_2O_3, Al_2O_3, SiO_2, TiO_2, Na_2O, K_2O, MgO which comprise the constituents of hematite, sodium aluminium silicate hydrate, sodalite, rutile, etc. mineral phases [3,4].

Red mud present serious problems from the view point of storing on environmental pollution. There fore, there is a need for an economical methods to solve or minimise the side effects of these problems. Several studies have been suggested that it has potential use in the following fields; building blocks, floor and wall tiles, sanitary ware, adsorbent, flocculant, catalyzer, filler, abrasive, pigment and cement material, the production of pig iron and alumina. A thorough evaluation of red muds can be accomplished by a perspective of recovering all values contained in red mud with in the limits of process economy. Studies in this area is currently underway in the world [5-12].

The accumulated amount is nearly 3 millions tonnes in Seydişehir-Turkey and there is not yet an economic way or an application of plant scale to utilize the red mud.. Although some work has been done on using red mud for construction material in Turkey, a detailed characterization of red mud was not presented [8]. The aim of this work is to characterize and study the physical, chemical, mineralogical properties of the red mud.

II. EXPERIMENTAL PROCEDURE

The bauxite waste-red mud- was obtained from Seydişehir Aluminium Plant (Konya, Turkey, producing 200.000 tons of alumina per year) [13]. The waste was homogenized through agitation, being determind its density, humidity content and size of particle. Afterwards, the mud was dried at 105°C for 3 hours and was screned to 75 μm in grain size. The obtained sample was submitted to chemical and mineralogic analysis, determination of density, thermal analysis, structural observation.

The red mud sample was fused with Na_2CO_3 – K_2CO_3 in the 1100° C at the plutinum crucible and was dissolved with HCl.

Chemical analysis was performed using an atomic absorption spectrophotometer (Rank Hilger, Atom Spek H-1580), a digital photometer (Dr. Lange LP 2W) and wet chemical methods.

The specific surface area of red mud was measured using the Brunauer, Emmett and Teller (BET) method with an adsorpmeter (Model Flow Sorb II-2300 Micromeritics)

Density measurement was done by a picnometer and particle size measurement performed by a sedigraph (5000 D Micromeritics). For the particle size measurement, the samples were dispersed ultrasonically in a 0,5 % solution of $Na_4P_2O_7$, 10 H_2O.

N.Yalçın , V.Sevinç : Sakarya University, Arts and Sciences Faculty, Chemistry Department, Serdivan - Sakarya, 54180, TURKEY

Thermal analysis was carried out by a simultaneous thermal analysis instrument (Netzsch-429). 100 mg of sample were placed in a platinum cup for the analysis. The curves were recorded under air atmosphere. The heating rate was 10°C/min. The interval of study was 20-1200° C.

X-ray diffractometry (XRD) diagram of the sample was obtained with a diffractometer (Philips PM 9901/ 00).

The infrared spectrum (IR) of the sample in a KBr matrix was carried out with a FTIR spectrometer (Mattson FTIR Spectrometer).

III. RESULTS AND DISCUSSION

The homogenized red mud sample of the original bauxite has a humidity content between 40 and 50% and a mean density of 2.85 $g.cm^{-3}$. The specific surface area value of the red mud is 20.9 $m^2.g^{-1}$.

Granulometric analysis

The particle size analysis of the red mud is given in Figure 1.The data on particle size analysis has indicated that the mean size of particle is relatively fine, 88 % of the particles are finer than 10 μm.

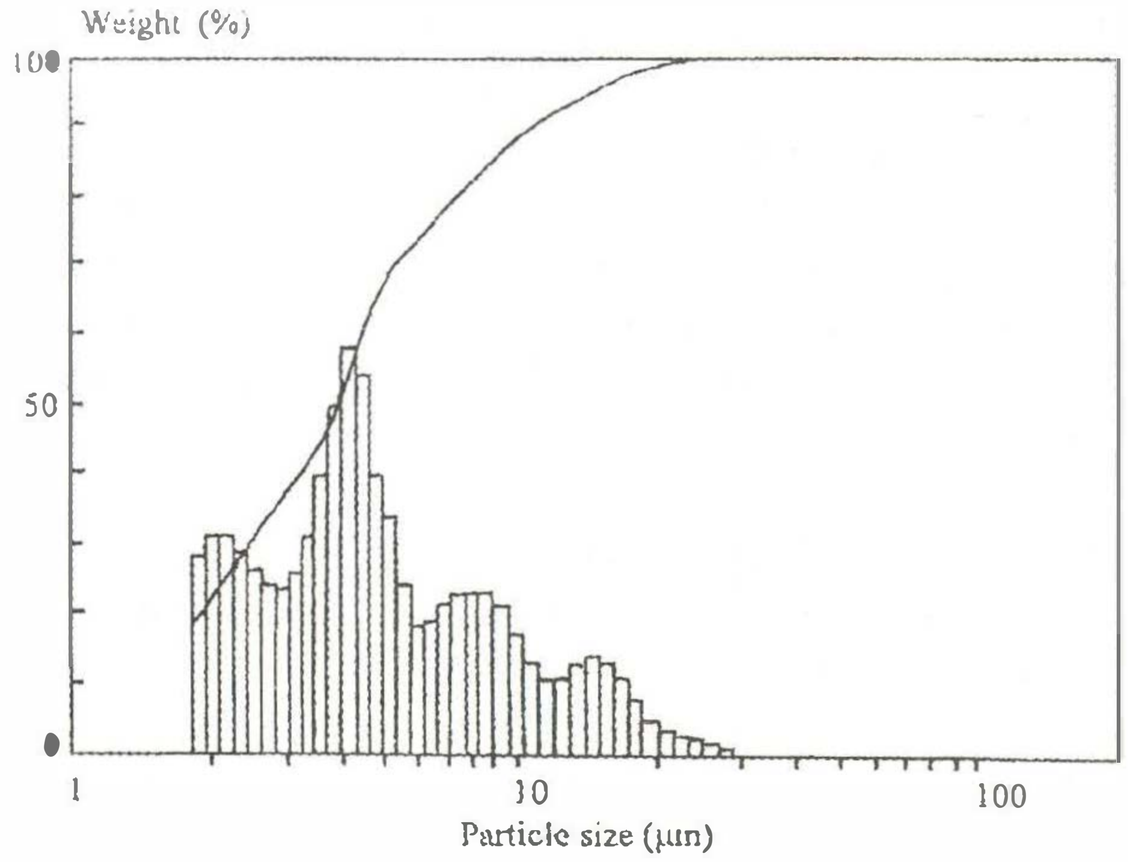

Figure 1. Particle size analysis of Seydişehir (Turkey) red mud

Chemical Composition

The chemical analysis of the red mud is given in Table 1. The chemical analysis of bauxite waste was performed in the original sample. For the average value was made five tests.The percentages of Fe_2O_3, Al_2O_3, SiO_2 and Na_2O are more than others.

Table 1. Chemical analysis of Turkish red mud

Compounds	Content (Wt %)
Fe_2O_3	35,73
Al_2O_3	23,29
SiO_2	12,08
TiO_2	5,08
Na_2O	10,26
K_2O	0,28
CaO	2,81
MgO	0.76
CO_2	2,40
SO_3	1,34
Loss on ignition (1000°C)	8,45

Thermal analysis

The thermal analysis of the red mud is shown in Figure 2. The TG/DTG curves for the bauxite waste sample were recorded after desiccation at 105°C / 3h. From these curves of the red mud , the total weight loss was found to be 7.07% at 900°C. As can be observed in the TG and DTG curves, in the 25-900°C range, there is a continuous loss of weight due to the volatilization of water, SO_3 and CO_2. The formation peaks of free water, water of crystallization, SO_3 and CO_2 observed at about 290°C, 530°C,750°C and 890°C respectively.The peak to 750°C corresponds to the decomposition of iron sulphate probably [14]. But this mineral was not searched at the XRD analysis. Carbonate decomposition with CO_2 was evoluated below 900°C
[15,16].

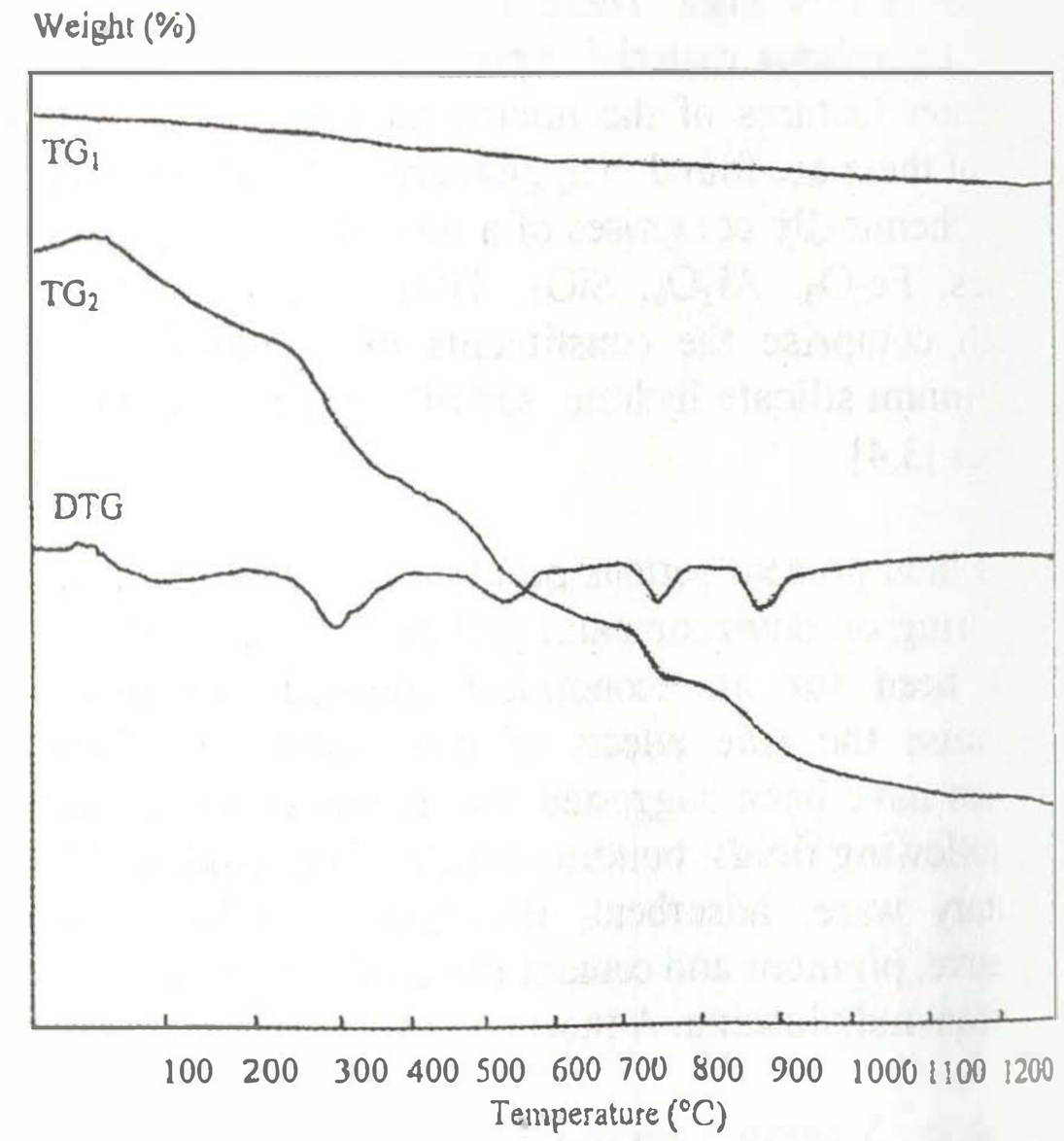

Figure 2. Thermal analysis curves of red mud

Mineralogy

Table 2 shows the results obtained from the X-ray diffraction diagram of the red mud. The presence of hematite (α- Fe_2O_3) and sodium aluminium silicate hydrate (1.01 Na_2O. Al_2O_3. 1.68 SiO_2. 1.73 H_2O) has been identified.

Besides these phases, sodalite ($Na_4Al_3Si_3O_{12}$ (OH)), sodium silicate (Na_2SiO_3), sodium aluminium oxide ($NaAlO_2$), iron titanium oxide (Fe_2TiO_5) calcium silicate ($CaSiO_3$), sodium titanium oxide ($Na_2Ti_3O_7$), sodium carbonate (Na_2CO_3) phases were detected.

Table 2. XRD analysis of red mud

Mineral names	Formula
Hematite	α - Fe_2O_3
Sodium aluminium Silicate hydrate	1,01 Na_2O. Al_2O_3. 1,68 SiO_2. 1,73 H_2O
Sodalite	$Na_4 Al_3 Si_3 O_{12}$ (OH)
Sodium silicate	Na_2SiO_3
Sodium aluminium oxide	$NaAlO_2$
Iron titanium oxide	Fe_2TiO_5
Calcium silicate	$CaSiO_3$
Sodium titanium oxide	$Na_2Ti_3O_7$
Sodium carbonate	Na_2CO_3

Infrared Spectroscopy

Figure 3 shows the infrared spectrum (IR) of a sample of bauxite waste in a KBr matrix.

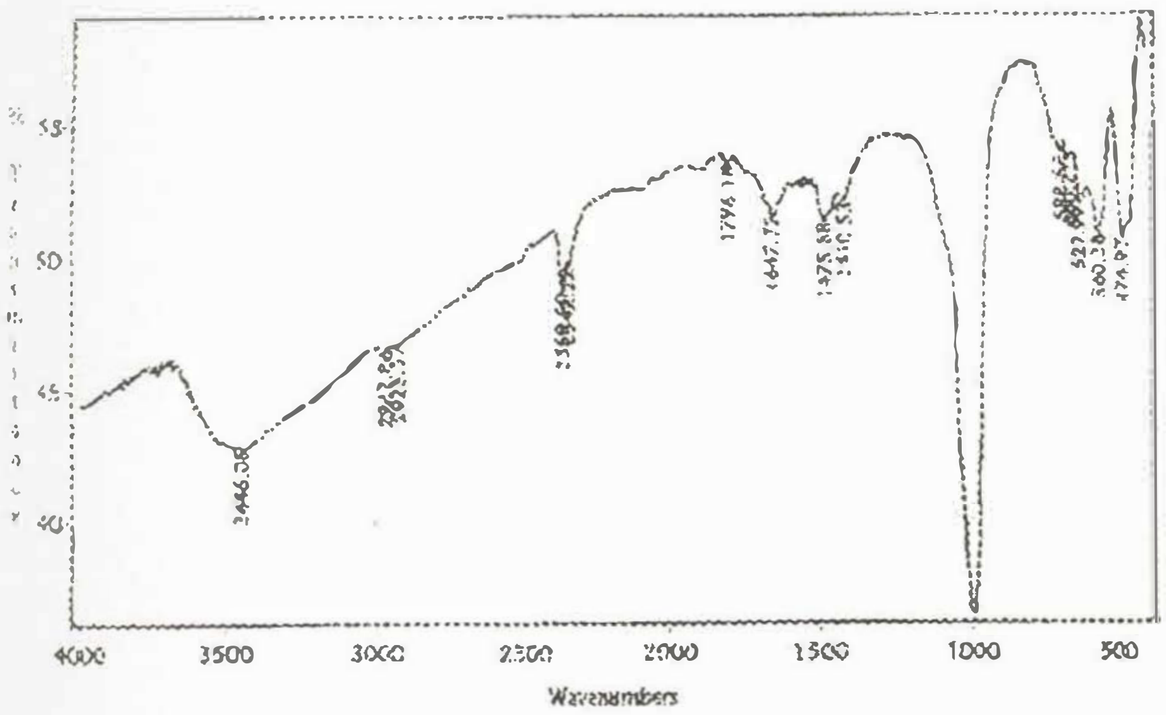

Figure 3. Infrared spectrum of red mud

In the 2000-4000 cm^{-1} region a wide absorption appears which can be assigned to the stretching modes of water molecules absorbed on the bauxite waste surface or to envelope of H-bonded surface OH groups. The band at 1647 cm^{-1} is due to the H_2O bending mode. 2360-2342 cm^{-1} bands are due to from the background of the instrument also. The bands at 1475 cm^{-1} and 1410 cm^{-1} show the organic matter in red mud. The 1000 cm^{-1} band is the strong Si-O band, which can be assigned in the 900-1200 cm^{-1} region. The 688 cm^{-1} band show the sulphates. 660, 560 ,474 cm^{-1} bands are attributed to hematite [14].

CONCLUSIONS

The original bauxite-red mud sample has a humidity content between 40 and 50 % and a mean density of 2.85 $g.cm^{-3}$, 88 % of the sample having a smaller size than 10 μm. The results of chemical and mineralogic analyses have demonstrated that Fe_2O_3, Al_2O_3, SiO_2, TiO_2, CaO and Na_2O represent the oxide majority components and hematite, sodium aluminium silicate hydrate the principal present crystalline phases. Concerning the TG/DTG curves, the formation peaks of free water,water of crystallization, SO_3 and CO_2 observed at about 290°C. 530°C, 750°C and 890°C respectively. The infrared spectrum showed the characteristic bands of the matters in the red mud.

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