Formation of an aluminum hydroxide nanofiber by a hydrolysis of aluminum nanopowder

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1. Introduction

Alumina fibers are widely used as an adsorbent, catalysis, and medical filters because of their high specific surface area. This characteristic of alumina depends strongly on the size and morphology of the aluminum hydroxides [1]. In this research the hydrolysis reaction of solid aluminum nano powders, as a starting material, was used to produce nano aluminum hydroxides with a high specific surface area [2-4]. The characteristics of the hydrolysis products were examined. The proper condition and formation mechanism of the fibrous aluminum hydroxides were also discussed.

2. Experiments

In order to prepare the nano aluminum powder for the starting materials, the pulse wire evaporation (PWE) method [5] was applied. After the preparation, nano aluminum powders of 1 g with a 100nm diameter were dipped into distilled water of 200 ml with various temperatures. They were ultrasonically dispersed and stirred. To investigate the effect of the hydrolysis temperature, it was varied from 30 °C to 80 °C. The effect of the pH, from pH3 (by 0.1M HNO_3), 6 (by distilled water), and 9 (by 0.5M KOH), was also investigated with a temperature variation. The produced aluminum hydroxide gels are gathered with a 0.2μm -sized filter. They were dried in an oven at 60°C for 12 hours. Transmission electron microscope (TEM, JEOL 200CX, Japan) was used for the observation of the morphology and size. X-ray diffraction (XRD, Rigaku D/MaxIII, Japan) was applied for a phase analysis. The BET (Belsorp-mini, Japan) was used for a measurement of the specific surface area by a nitrogen adsorption technique. Paperless recorder (DXA200,Yokogawa)was used for a measurement of the temperature changes during a hydrolysis.

3. Results and Discussion

As a results of the observation of the type and morphology, and the measurement of the specific surface area of the aluminum hydroxides obtained immediately after a hydrolysis from various temperatures from 30 ℃ to 80℃ in various pHs of the solutions (pH3, 6, and 12), it was found that the main phase is either boehmite or bayerite depending on the hydrolysis conditions. It can be seen that the amount of either the boehmite or bayerite was different depending on the reaction temperatures and pH. Boehmite is dominant at a high temperature and low pH, while the bayerite phase becomes dominant at a low temperature and high pH. Moreover, the bayerite shows a crystalline structure with a facet interface while the boehmite has a fibrous form with a high specific surface area. The maximum specific surface area of the fibrous boehmite is 409 m^2/g formed at 60°C in pH 12 as shown in Fig.3.

A highly exothermic hydrolytic reaction of the Al particles occurs with a slight temperature increase as soon as the particles are immersed in distilled water at various initial temperatures. Boehmite-producing reaction occurred for a relatively short time and became fast as the temperature increased above 50°C. The main phase at 50℃ are Al metals, boehmite, and bayerite. It can be explained that the sharp temperature increase resulted from the acceleration of the aluminum dissolution and boehmite growth. Under a high initial temperature, boehmite is transformed to crystallized bayerite after a sharp temperature increase, while under a low initial temperature, it requires are latively long time to be transformed.

4. Summary

The results obtained are summarized as follows;

(1) Boehmite produced in the high temperature and acid region showed a nano fibrous shape with several nm in diameter and several hundreds nm in length having high specific surface areas with a maximum value of 409 m^2/g.

(2) In order to obtain nano fibrous boehmite with high surface areas from nano metal powder, the hydrolysis reaction should be done at a high temperature over 50°C, high acidity under pH 6, and terminated before a transition to the bayerite phase.

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Reference

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