Synthesis of Aluminum Monohydroxide Nanofiber by Electrolysis of Aluminum Plates

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Abstract

Aluminum hydroxides were synthesized by a simple electrolytic reaction of aluminum plates. The aluminum monohydroxide, boehmite(AlO(OH)), was predominantly formed by the application of an electrical potential above 30V, while the mixture of the bayerite($Al(OH)_3$) and boehmite(AlO(OH)) phases were formed below 20V. The boehmite has a clear fibrous structure which is controlled on a nanometer scale. On the contrary, the bayerite consists of the typical hourglass or semi-hourglass shaped coarse crystals as a result of an aggregation of the various crystals stacked together. The specific surface area of the boehmite nanofiber was remarkably high, reaching about 300m^2/g.

Keywords : Nanofiber, Boehmite(AlO(OH)), Bayerite($Al(OH)_3$), Electrolysis, Specific surface area

1. Introduction

Alumina fibers are widely used as an adsorbent, catalysis, and medical fibers due to their high specific surface area. The alumina is generally obtained by calcinating the aluminum hydroxides and hence its particulate characteristics such as its size and morphology are very sensitive to those of the aluminum hydroxide [1]. Especially it has been stressed in our previous investigation that an aluminum monohydroxide, particularly boehmite AlO(OH), can be an excellent precursor for an Al_2O_3 nanofiber and a phase control of the boehmite AlO(OH) is a very important method to produce the desired Al_2O_3 nanofibers [2]. In this study, aluminum hydroxide nanofibers with a high specific surface area have been synthesized by using an electrolysis of aluminum metal plates in the distilled water, which is a very simple and fast procedure, and the particulate properties of the aluminum hydroxide nanofiber were investigated by varing the electrolysis conditions.

2. Experimental

Aluminum plates with the dimensions of 2.0×40×400mm^3 were immersed in distilled water (500 ml) with 0.2wt.% NaCl, and then the electrical potentials ranging from 10 to 30V were applied between the Al plate electrodes for an electrolysis. The electrolytic reaction was carried out for 30min. The produced gel has been drawn through a filtering by using a 0.2μm filter and subsequently dried in an oven at 60°C for 12h, which yielded the whitish solid precipitates. Transmission electron microscopy (TEM, JEOL 200CX, Japan) and X-ray diffraction (XRD, Rigaku D/MaxⅢ, Japan) were used to investigate the particulate properties and the structure of the final product. The BET method (Brunauer-Emmett-Teller method, Belsorp-mini, Japan) was also used to determine the specific surface area of the product.

3. Results and discussion

All the electrolytic reactions of the Al plates were accompanied by a formation of bubbles mixed with the water vapor due to a chemical dissociation of the H_2O molecules in the reactions with an Al plate, which produced an electrolytic precipitation of a whitish aluminum hydroxide gel that is dried further to form its solid product. Generally three different phases can be formed in drying these aluminum hydroxide gels, depending on the conditions. This is clearly observed in Fig. 1 that shows the X-ray diffraction patterns for the as-dried products prepared as a function of the electrical potential. It is notable that the boehmite(AlO(OH)) was predominantly formed at above 30V, while the mixture of the bayerite($Al(OH)_3$) and boehmite(AlO(OH)) phases were formed at below 20V. The result also shows a trend that the more the bayerite ($Al(OH)_3$), the smaller the electrical potential. It is also observed that all the diffraction peaks of the boehmite AlO(OH) exhibited a high degree of broadness, probably owing to the formation of nanocrystals, while the sharp diffraction peaks of bayerite $Al(OH)_3$ were found with showing well-crystalline and coarse crystals.

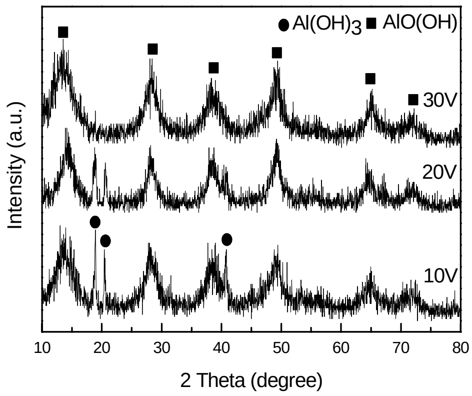

Fig. 1. XRD patterns of Al hydroxides by electrolysis at various voltages.

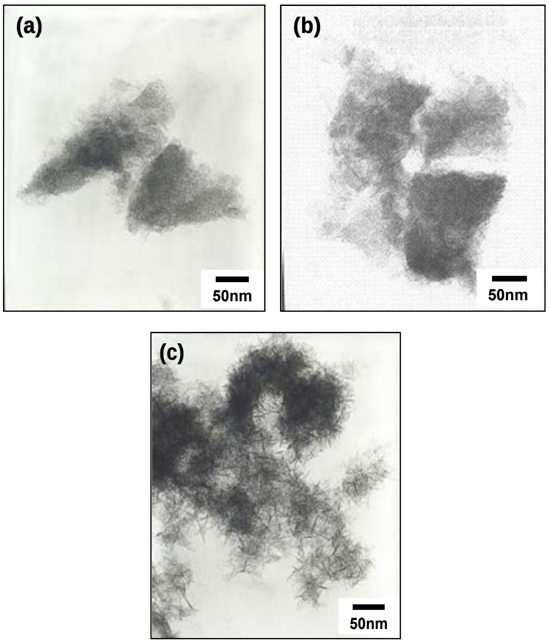

Fig. 2. TEM views for the as-dried Al hydroxides prepared as a function of electrical potential: (a) 10V, (b) 20V, (c) 30V.

Fig. 2 (a) to 2 (c) shows the corresponding TEM images for the as-dried final products. It reveals that the boehmite AlO(OH) has a clear fibrous structure which is controlled on a nanometer dimension. On the contrary, the bayerite $Al(OH)_3$ consists of the typical hourglass or semi-hourglass shaped coarse crystals as a result of an aggregation of the various crystals stacked together. Such morphological features between the two phases induced a big difference in the specific surface area, where the specific surface area was about $300m^2/g$ based on BET method for the nanofibrous boehmite formed at 30V.

4. Acknowledgement

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5. References

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