Study of the Peptizability of Boehmite and Its Application for the Formation of $\gamma$-$Al_2O_3$ in Spherical Shape

Tran Vinh Hoang
Tran Dai Lam
Pham Thanh Huyen
Nguyen Han Long
Faculty of Chemical Technology, Hanoi University of Technology
Dai Co Viet Street, Hanoi, VIETNAM

This paper shows the results of the peptizability of boehmite and its application for the formation of $\gamma$-$Al_2O_3$ in spherical shape. The obtained $\gamma$-$Al_2O_3$ in spherical shape have high mechanical strength and high surface area. The water vapor adsorption ability of sphere of $\gamma$-$Al_2O_3$ has also been determined. The $\gamma$-$Al_2O_3$ in spherical shape can absorb moisture up to 65% of their weight.

Keywords: Adsorption, boehmite, peptizability, and $\gamma$-$Al_2O_3$.

INTRODUCTION

$\gamma$-$Al_2O_3$ is a mesoporous material which has high acidity, activity, and good mechanical and thermal strength. Hence, $\gamma$-$Al_2O_3$ is widely used as adsorbent and catalyst in the refinery and in petrochemical technology, in particular; and, in the chemical industry in general (Leach 1984, Farraruto and Barholomew 1999). However, in order to use it in chemical processes, besides the study to increase its surface area (Huyen, Long, and Hoang 2005), the formation of $\gamma$-$Al_2O_3$ in spherical shape is very important.

One of the most important properties of boehmite is its peptizability to be the binder for other materials that do not have this ability. So the application of boehmite as the binder has greatly increased the value and the application range of $\gamma$-$Al_2O_3$ and other materials.

The refinery and petrochemical industry is being developed in Vietnam. Each year, a large amount of $\gamma$-$Al_2O_3$ in spherical shape is imported to be used as the absorbent in the drying of natural gas. So finding a procedure to synthesize $\gamma$-$Al_2O_3$ in spherical shape from cheap and available domestic raw material is very necessary.

EXPERIMENTAL

$\gamma$-$Al_2O_3$ has been synthesized from available domestic raw materials, such as waste aluminum, Tan Binh aluminum hydroxide, and industrial aluminous material.
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Other chemicals include: NaOH, H$_2$SO$_4$, H$_2$O$_2$, organic additives, and peptized reagents. These chemicals are first used in pure form and then in industrial form to determine the reiteration and prepare them for large-scale manufacturing.

The procedure to synthesize $\gamma$-$\text{Al}_2\text{O}_3$ and to form the finished product is shown in Figure 1.

The procedure to form the sphere of $\gamma$-$\text{Al}_2\text{O}_3$ is as follows: first, the viscosity of peptized solution is adjusted to a suitable value by adding distilled water; and, then it is forced through holes with different sizes to form spheres of different diameters. These drops fall slowly through a column containing different layers of oil and ammonia. At the bottom, the spheres are separated, dried, and calcined.

RESULTS AND DISCUSSION

Characterization of Obtained Boehmite and $\gamma$-$\text{Al}_2\text{O}_3$ by XRD

The obtained boehmite and $\gamma$-$\text{Al}_2\text{O}_3$ are characterized by X-Ray Diffraction (XRD) on a D8 Advance (Bruker) at Petrochemical and Catalysis Material Laboratory, Hanoi University of Technology (PCM–HUT). The analysis regime is as follows: Cu K$_\gamma$ radiation ($\gamma$=1.5406Å), voltage of 40kV, electric current of 40mA, temperature of 25°C, 2$_\gamma$ =10 - 70°, step 0,1° and so on.

Figure 1. Procedure for the Synthesis and Spheroidization of $\gamma$-$\text{Al}_2\text{O}_3$

Figure 2. XRD Patterns of (a) Boehmite and (b) $\gamma$-$\text{Al}_2\text{O}_3$
Figure 2 shows that obtained boehmite and \( \gamma-Al_2O_3 \) contain only single phase characterized for boehmite and \( \gamma-Al_2O_3 \). This confirms that the obtained products are very pure. The XRD pattern of peptized boehmite gel after drying at 120°C is exactly the same as that of boehmite. This means that the peptized reagent has completely been decomposed at 120°C.

**Influence of Technological Parameters on the Spheroidization of \( \gamma-Al_2O_3 \)**

Through preliminary studies, it was found out that when the content of peptized reagent was greater than 10%, the obtained gel after calcination was very hard and brittle and the adsorption ability of the product was very low, so it is not suitable to be used as a binder. Moreover, according to Leach (1984) and Khahn (1976), the greater the peptized content, the lower the surface area of \( \gamma-Al_2O_3 \). With the data obtained from the studies on the influence of peptized reagent content on the mechanical strength and adsorption ability of spheres of \( \gamma-Al_2O_3 \), it has been realized that the content of peptized reagent is optimal between 6% and 7%.

The results obtained in the spheroidization of \( \gamma-Al_2O_3 \) with different kinds of oil and at different heights of oil and ammonia column are presented in Table 1.

<table>
<thead>
<tr>
<th>Column</th>
<th>Height (mm)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peanut oil</td>
<td>-</td>
<td>No spheres formed</td>
</tr>
<tr>
<td>Bean oil</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Kerosene</td>
<td>10</td>
<td>flattish shape</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>flattish shape</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>spherical shape</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>spherical shape</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>flattish shape</td>
</tr>
</tbody>
</table>

When the drops of peptized boehmite fall through the oil column, under the surface tension force, these drops tended to form a spherical shape. When they fall through the ammonia column at a height of greater than 100mm, the outside layer will be neutralized and hardened. These hardened drops fall to the bottom of the column and are neither distorted nor stuck together (Richardson 1992). If the height of the ammonia column is less than 100mm, the peptized boehmite drops cannot be neutralized completely, so they are stuck together.

So, by using a kerosene column with a height of 30–40mm and an ammonia column greater than 100mm, \( \gamma-Al_2O_3 \) in spherical shape with various diameters were obtained.

With the peptized boehmite gel, an extrudates container could also be formed by extrudation. The obtained extrudates were then dried and calcined to get the finished products.

Figure 3 shows the photo of spheres and extrudates of \( \gamma-Al_2O_3 \) with a diameter of 3mm.
From the above results, this procedure can be applied to form the spheres and extrudates of other materials, such as zeolites, for use as catalysts or adsorbents to increase the value and the application range of these materials.

Study on the Adsorption Ability of Product

The results that present the relationship between adsorbed moisture content/γ-Al₂O₃ weight (A%) and time on stream are shown in Figure 4.

![Figure 4. Moisture Adsorption Ability of γ-Al₂O₃ in Spherical Shape](image)

Figure 4 shows that spheres of γ-Al₂O₃ adsorb moisture quickly at the beginning (<3 days), then the adsorption slows down and reach the saturated level after 30 days with the adsorbed moisture content taking up to 65% of the γ-Al₂O₃ weight.

These initial results prove that spheres of γ-Al₂O₃ meet the necessary requirements to be applied as the appropriate adsorbent in the drying of natural gas.

CONCLUSIONS

The results showed that γ-Al₂O₃ could be synthesized from cheap and available domestic raw materials.

The optimal technological parameters for the spheroidization of γ-Al₂O₃ have been found. The obtained spheres of γ-Al₂O₃ have various desired diameters, high mechanical strength, and high surface area. It has increased the application value of γ-Al₂O₃.

Spheres of γ-Al₂O₃ have good adsorption ability, so they can be used in the drying of natural gas.

REFERENCES


