Structure and Morphology of Alumina Materials Prepared by Aluminum Nitrate Nonahydrate Decomposition

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The paper studied the mechanism of $Al(NO)_3 \cdot 9H_2O$ decomposition in argon atmosphere and alumina phase formation in the range of 100-1200°C.

Thermogravimetry dependences of $Al(NO)_3 \cdot 9H_2O$ decomposition, as well as XRD and IR spectroscopy data of products of its thermodestruction allowed to find out that chemical state of precursor at growth temperature to 1200°C changes according to scheme:

$Al(NO_3)_3 \cdot 9H_2O$ (100-140°C) → $[Al(OH_2)_6]^{3+} \cdot 3NO_3^-$ (140-152°C) → $[AlOH(OH_2)_5]^{2+} \cdot 2NO_3^-$ (152-210°C) → $AlONO_3 \cdot H_2O$ (210-525°C) → AlOOH (525-1000°C) → γ-Al_2O_3 (1100°C)→ α-Al_2O_3.

The peculiarity of this process is that amorphous and crystalline motifs of boehmite AlOOH consist of globules of 6-10 nm in diameter at temperatures above 210°C (fig. 1). The globules of amorphous phase consist of randomly combined alumina monomer chains –AlO(H)–O–AlO(H)– of 1-5 nm in length. Mesoporous aluminum hydroxide with a pore size of 2.4-4.9 nm, pore volume of 0.138 $cm^3 \cdot g^{-1}$, and specific surface area of 175 $m^2 \cdot g^{-1}$ is formed at 350-525°C.

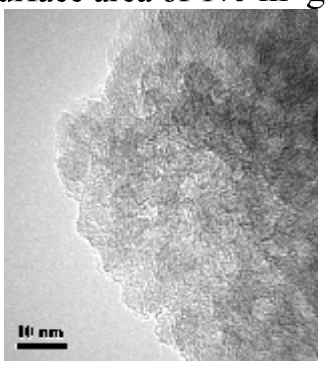

Fig. 1. Globular structure of phase AlOOH, formed at 480°C.

The calcination of precursor at 850°C forms a mesoporous γ-Al_2O_3 with pore size of 5.0 nm, pore volume of 0,084 $cm^3 \cdot g^{-1}$, and specific surface area of 72 $m^2 \cdot g^{-1}$. The increase of γ-Al_2O_3 lattice parameter on 2 % is due to the Laplace pressure that occurs in particles of nanometer scale. The countering to approachment of aluminum atoms in the structure of the oxide material reduces interatomic interaction in Al – O-chains and leads to their extension.

α-Al_2O_3 prepared at 1100°C has a heterogeneous porous structure and contains mesopores of 8-40 nm in size. Their volume is 0.070 $cm^3 \cdot g^{-1}$ and specific surface area 13 $m^2 \cdot g^{-1}$.