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Bundles of self-assembled boehmite nanostrips from a surfactant free hydrothermal route

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Abstract

Boehmite nanostrips with average diameter and crystallite sizes of about 19.5 nm and 4.5 nm were prepared through a surfactant free approach and were characterized with XRD, TEM and DTA/TG analyses. Nanostrips self-assembled to form bundles due to lateral surface adsorptions. The effect of Cl^- ions on enhancement of one-dimensional growth of boehmite nanostructures was investigated. The thermal analysis showed that chlorides reduced the formation temperature of α-Al_2O_3 phase.

Keywords: Nanostructures; Chemical synthesis; Thermal analysis

1. Introduction

During the last decade, one-dimensional (1D) nanostructures have attracted many researchers due to their weird properties and applications in nanoscience and nanotechnology [1,2]. Among extensive literature on the formation of 1D nanostructure compounds, alumina nanostructure phases (i.e. boehmite, γ- and α-Al_2O_3) have been reported in various morphologies such as nanotubes [3–5], nanowires [6], nanorods [7,8], nanofibers [9,10], lace-like nanoribbons [11] and plate-like nanostructures [12]. Although the thermodynamically stable α-Al_2O_3 phase can be obtained through a sequence of topotactic [13] and reconstructive [14] transformations (i.e. boehmite $\rightarrow \gamma \rightarrow \delta \rightarrow \theta \rightarrow \alpha$ [15]), the morphology remains unchanged and the final products have the same shape as the initial phases [16]. Therefore, boehmite nanostructures with novel morphologies are relevant precursors for obtaining α-Al_2O_3 nanoarchitectures. Here, bundles of boehmite nanostrips were prepared through a facile surfactant free hydrothermal route and were shown to transform to the α-phase at a lower temperature than what conventionally was reported in the literature (i.e. >1050 °C [17]).

One of the important challenges in thermal transformations of alumina ceramics systems has been attributed to the reduction of the formation temperature of α-Al_2O_3 phase in order to impede the grain growth occurrence during high temperature calcination processes [18]. Nucleation aids such as alumina (α-Al_2O_3) seeds [18], α-Fe_2O_3 [19], V_2O_5 [20] and fluorides [21,22] were reported to have significant influence on reducing the α-Al_2O_3 phase formation temperature. Also, it was indicated that the fluoride ions enhanced the directional growth of the alumina nanostructures [12]. Although several researchers have investigated the effect of chlorides on physicochemical [23], fibrils particle sizes [24] and hydrothermal preparation of boehmite nanostructures [25], no distinct investigation has been attributed to the effect of chloride ions on formation of one-dimensional alumina nanostructures and the α-Al_2O_3 phase transformation temperature. Therefore, the following surfactant free hydrothermal process was developed to investigate the oriented attachment [2,26] of nanocrystals which culminated in obtaining the 1D boehmite nanostructures under the influence of Cl^- ions. The thermal behavior of the obtained nanostructures was also characterized to determine the effect of chloride ions on α-Al_2O_3 formation temperature.

2. Experimental

All the raw materials were purchased from Merck, Darmstadt, Germany and used as received without further purification. In a typical experiment, 0.36 g $AlCl_3 \cdot 6H_2O$ powder was dissolved into 10 ml ethanol under vigorous stirring at room temperature. The mixture was fluxed until a homogenous solution

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