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Zinc-stearate-layered hydroxide nanohybrid material as a precursor to produce carbon nanoparticles

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ABSTRACT

Zinc-stearate-layered hydroxide nanohybrid was prepared using stearate anion as an organic guest, and zinc layered hydroxide nitrate, as a layered inorganic host by the ion-exchange method. Powder X-ray diffraction patterns and Fourier transform infrared results indicated that the stearate anion was actually intercalated into the interlayer of zinc layered hydroxide nitrate and confirmed the formation of the host–guest nanohybrid material. Also, surface properties data showed that the intercalation process has changed the porosity for the as-prepared nanohybrid material in comparison with that of the parent material, zinc hydroxide nitrate. The nanohybrid material was heat-treated at 600 °C under argon atmosphere. Stearate anion was chosen as a carbonaceous reservoir in the nanohybrid to produce carbon nanoparticles after heat-treating of the nanohybrid and subsequently acid washing process.

1. Introduction

Considerable attention is being focused on different types of anionic layered materials and their organic–inorganic nanohybrids, as they are considered good candidates for use in various areas of industry and medical applications [1–9]. This is due to their ability to intercalate various functional anions between their layers and other important physicochemical properties for technological applications as food additive [10] and controlled release [11] formulations, biosensor [12], ion scavenger [13–15], electrochemical performance [16], etc. Furthermore, they have frequently been used as precursors and templates to produce various metal oxides [17], catalysts [18], carbon [19], porous materials [20], etc.

Zinc layered hydroxide nitrate (ZLH) is an anionic synthetic layered material whose layers are constructed by hydroxide groups and water molecules [17]. Octahedral holes within the layers are occupied by only one type cation, zinc ions. This is against the other anionic layered materials, layered double hydroxides (LDHs) with at least two types of cations within the layers [11]. The nitrate groups are positioned between the layers freely and are not directly coordinated with the zinc ions in the ZLH [17]. The intercalation or ion-exchange process of the interlayer nitrates with other inorganic or organic anions can improve properties rather than their counterparts or it can produce new properties for the obtained nanohybrid materials [21]. Thus, due to the fact that, the layered materials, such as ZLH and its nanohybrids are suitable precursors for upcoming products, the kind of the intercalated anion between the layers may play a role in determining the properties of these materials and also the resultant products.

The aim of this study is to present the intercalation of stearate anion (SA) between zinc hydroxide nitrate layers for the formation of a new organic–inorganic nanohybrid material (ZLHSA) using simple ion-exchange method. Also, heat-treatment of the nanohybrid sample at 600 °C leads to produce carbon nanoparticles. Results from the powder X-ray diffraction (PXRD), Fourier transform infrared (FTIR), field emission scanning electron microscopy (FESEM) and also surface area studies are discussed.

2. Experimental

All solutions were prepared using de-ionized water. Zinc hydroxide nitrate was synthesized according to our previous work [17]. Briefly, in a typical experimental procedure, slow dropwise addition of 0.5 M NaOH solution into 0.2 M of $Zn(NO_3)_2$ solution with vigorous stirring under nitrogen atmosphere was done. The solution was kept at pH 7.0 (±0.05). The precipitate was filtered, washed three times with water and two times with acetone and dried in an oven overnight at 70 °C. The ZLH-stearate nanohybrid (ZLHSA) was obtained by contacting 0.5 g of the pre-prepared ZLH into 200 ml solution of 0.1 M SA (in acetone) for 2 h. The nanohybrid material, ZLHSA was heated at 600 °C in an electric tubular furnace under argon atmospheric pressure at a flow rate of 100 ml/min for 2 h at a rate of 5 °C/min and then cooled

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