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Using Electrospinning Technique for Preparation of Cobalt Hydroxide Nanoparticles

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Cobalt hydroxide or cobaltous hydroxide or cobaltous hydrate, has attracted increasing attention in recent years because of its novel electric and catalytic properties and important technological applications, for examples in advanced batteries, supercapacitors, solar cells, electrochromics, as an oil additive, it can improve tribological properties [1,2], etc. Cobalt hydroxide nanoparticles were prepared via in-situ electrospinning. Thus, electrospinning of polyethylene oxide solution with different cobalt nitrate concentrations were carried out in gaseous ammonia atmosphere. The reaction of cobalt nitrate with ammonia produces cobalt hydroxide. The reaction occurs during fiber formation. Transmission Electron Microscopy (TEM) showed that cobalt hydroxide $Co(OH)_2$ nanoparticles were formed on the produced nanofibers of 100–600 nm in diameter. The existence of the formed $Co(OH)_2$ was also proven by X-ray Diffraction (XRD) analysis and it showed that the $Co(OH)_2$ nanoparticles were produced. Thermogravimetric Analysis (TGA) results also confirmed the presence of $Co(OH)_2$ within the fibers. Experimental Section $Co(NO_3)_2.6H_2O$ (supplied by Merck Chemical Co.) with different concentrations was dissolved in 100 mL distilled water to produced Co+2 solution. Then, the following seven experiments (Exp. G1, G2, G3, G4, G5 (collectively called G-series in this article), P, and N) were carried out. G-series: 4.0 g of polyethylene oxide (with weight average molecular weight of 600,000 g/mol and supplied by Acros Organics Co.) was added to 100 mL of above mentioned cobalt nitrate solution with different concentrations (given in Table I) and left for two nights to obtain a homogenous PEO solution having cobalt ions. The polymer solution was put into a hypodermic syringe. A syringe pump (Stoelting Co., USA) was used to feed the polymer solution into a metallic needle with an inner diameter of 0.7 mm. A grounded aluminum foil as collector was placed at a fixed distance of 18 cm from the needle. The metallic needle and the collector were enclosed in a polymethyl metacrylate box (40′50′60 cm). The feed rate of the syringe pump was fixed at 0.7 mL/h. A positive potential of 18 kV was then applied to the polymer solution using a high-voltage power supplier (HV35P series, Fnm Co., IR) with a maximum voltage of 35 kV. During electrospinning,

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gaseous ammonia (from a cylinder purchased from Merck Chemical) was purged into the box with a rate of 10 L/min. Electrospun nanofibers were collected on the surface of the grounded aluminum foil. Results and Discussion A comparison of the appearance (color change) of the mats obtained from G-series with that of the P fiber mat suggested that the cobalt ions in the jet traveling the distance between the needle and the collector could precipitate in the gaseous ammonia atmosphere to produce cobalt hydroxide. In other words, in this process, one reaction occurs during fiber formation: the reaction of Co+2 ions with NH_3 which produces $Co(OH)_2$ nanoparticles on the nanofibers. Cobalt (II) hydroxide is obtained as a precipitate when an alkaline hydroxide is added to an aqueous solution of cobalt (II) salt. Since the reaction of nanoparticle formations occurs during fiber formation in electrospinning process, the precipitated nanoparticles have special morphology and crystalline structures (due to the applied voltage, elongation, etc.). Figure 1 displays the TEM images of fibers obtained from Exp. G1 (electrospinning of polyethylene oxide solution having 2.5% Co+2 based on PEO, in ammonia atmosphere) and as it shows, dark spots of $Co(OH)_2$ are heterogeneously dispersed on the fibers. These TEM images suggest that in the Exp. G1, $Co(OH)_2$ nanoparticles were heterogeneously synthesized on fibers through the reaction of cobalt ions with NH3. Fig.1 TEM images of nanofibers obtained from Exp. G1. Ref. Zhang, L.; Dutta, A.K.; Jarero, G.; Stroeve, P. Nucleation and growth of cobalt hydroxide crystallites in organized polymeric multilayers. Langmuir, 2000, 16, 7095. Patnaik, P.; Handbook of Inorganic Chemicals, McGraw-Hili, New York, 2002.