Abstract

Conducting polymers (CPs) combine the electrical properties of semiconductors and material properties of organic polymers. Polypyrrole (PPy) and polyaniline (PANI) are the most studied CPs due to their relatively high electrical conductivity (typically several units S cm^{-1}), environmental stability, ease of preparation, good processability and low cost.

Organic dyes have similar properties as surfactants, with an interesting ability to form various organized templates in water that could during synthesis tailor PPy morphologies to various nanostructures with high yield and improved electrical conductivity.

Herein, PPy was prepared in the presence of cations dyes, safranin and phenosafranin, and anionic dye, methyl red, to obtain various nanostructures. The effect of dye concentration, oxidant-to-pyrrole mole ratio and other polymerization conditions on the physicochemical properties of the produced PPy was carefully investigated. Pyrrole was polymerized in the frozen reaction media at −24 °C in the presence of safranin, Acid Blue 25 (AB) or methyl orange (MO). Prepared one-dimensional nanostructures exhibited high yield and improved conductivity; the highest conductivity of 175 S cm^{-1} was obtained when safranin was used.

Polypyrrole nanotubes prepared in the presence of MO were carbonized at 650 °C in an inert atmosphere followed by coating with pristine PPy or PPy prepared in the presence of MO or AB. The obtained products with high specific surface area and conductivity were used as electrochemical catalysts for the oxygen reduction reaction.

Poly(*p*-phenylenediamine) (PPDA) was prepared by the oxidative polymerization of *p*-phenylenediamine in the presence of various contents of maghemite. PPDA/maghemite composites have been used as adsorbents for the removal of Reactive Black 5 (RB) from water. The incorporation of magnetic nanoparticles provides easy separation of composites by applying a magnetic field and it improves the adsorption capacity. The adsorption isotherms and kinetics were analyzed by using various models.

Polyaniline/poly(vinyl alcohol) (PANI/PVAL) macroporous aerogels were prepared by the *in-situ* cryopolymerization of aniline in the presence of PVAL and Ni_2SrCr_xW hexaferrite, followed by freeze-drying. Aerogel with high coercivity was used as an adsorbent for the removal of RB from water, with a removal efficiency of 99%.

Polypyrrole–nanofibrillated cellulose (NFC) cryogels were prepared under frozen conditions in the presence of low contents of NFC (0.2 – 2 wt%). The sponge-like, lightweight

aerogels prepared by freeze-drying, possess excellent mechanical properties and high conductivity. Moreover, PPy–NFC aerogels have high adsorption capacities towards Cr(VI) ions, due to their high specific surface area and excellent ion-exchange capability.

Within this study, for all the prepared materials, the DC electrical conductivity was determined by the van der Pauw method, morphology and supramolecular structures were examined by scanning and transmission electron microscopies, molecular structures were confirmed by Fourier-transform infrared, Raman and nuclear magnetic resonance spectroscopies and thermal stabilities were studied by thermogravimetric analysis.

Keywords

Conducting polymers;

Conductivity;

Cryopolymerization;

Dye adsorption;

Magnetic composites;

Morphology;

Organic dyes;

Poly(*p*-phenylenediamine);

Polyaniline;

Polymerization temperature;

Polypyrrole.