Ain Shams University
Faculty of Science
Chemistry Department

Development of Novel Polymer Based Nanocomposites for Energy Applications

A Thesis
"Submitted for the degree of Master of Science As a partial fulfillment for requirements of the master of Science"

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Approval Sheet

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Signature

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Abstract

For the first time, a facile approach is reported here to fine-tuning the surface of sodium titanate ($Na_2Ti_3O_7$) nanowires widely by successfully nanoblending of the low cost and versatile nanowires into hyperbranched polyester matrix without any pre-functionalization for its surface by using expensive chain-like molecules (e.g., organosilanes).

TiO_2 nanowires (NWs) were prepared by hydrothermal treatment of TiO_2 nanoparticles in alkaline medium, while hyperbranched polyester, HPES-OH, was prepared by polycondensation. The adjustable nanocompositing showed a better workability in not only *in-situ* polymerization of 4,4-bis(4-hydroxyphenyl) valeric acid (AB2-monomer) but also ex-situ nanoblending of the hyperbranched polyester with the nanowires. The Chemical structure of HPES-OH was confirmed by ^{1}H and ^{13}C NMR spectroscopy, fourier transform infrared (FTIR) and its molar mass was determined using gel permeation chromatography (GPC). Meanwhile, the resultant nanocomposites were investigated using transmission electron microscope (TEM), scanning electron microscope (SEM) and X-ray diffraction (XRD), fourier transform infrared (FTIR), thermal gravimetric analysis (TGA) and contact angle measurements.

The unusual surface versatility of the resultant nanocomposites, compared to that of pure TiO_2 NWs, was found to be favorable for photo-assisted degradation of environmental hazardous pollutants such as phenolic, amide and naphthyl compounds. The chemical oxygen demand (COD) analysis confirmed the mineralization of the wastewater via photocatalytic degradation reaction. The results showed that not only the photocatalytic performance of the obtained nanocomposites was much higher than that of the pure TiO_2-NWs, but also the degradation time was reduced to large extent. This can be attributed to reduction in the crystallite size that was occurred due to the modification reaction. Durability of HPES-OH/TiO_2 nanocomposites was also investigated. The results confirmed that the modified TiO_2 NWs can be utilized for more than one time, which suggests developing a strong adhesion between the NWs and HPES-OH through the formation of 2D structure.

The importance of this study arises from the incorporation of titanium dioxide with different morphologies in various of applications especially in photocatalysis which considered a feasible, low cost, environmentally friendly and sustainable technology for environmental applications including air purification, water treatment, Self-cleaning materials, coatings and packaging materials, hydrogen fuel production,…..*etc.* However, the production of TiO_2 nanocomposites with high performance, low cost and long durability with respect to the photocatalytic properties is still a challenge. Consequently, new materials based on titanium dioxide have been developed in this work and found new uses for TiO_2 photocatalysis. Moreover, among all possible ways of forming the nanocomposites, such preparation strategy introduced in this study was proven to be the most easy, facile, low cost, precise, economic, effective, generalized and industry-viable approach for mass-production of different types of nanocomposites in particularly for large scale industries such as packaging materials and coatings.

Keywords

Hyperbranched Polymer

Titanium Dioxide Nanowires

Nanocomposites

Photocatalysis

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