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ORIGINAL RESEARCH

Additive-free photosynthesis of acrylamide hydrogels initiated with CdS and TiO_2 as light visible nano-photocatalysts

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Abstract

Hydrogels are three-dimensional polymer networks which can be synthesized by different techniques, such as free-radical addition reaction which is the most well-known technique in functional vinyl monomer polymerization. Photopolymerization, as an attractive technique, has been used in radical polymerization of monomers and has revitalized interest in the idea that it congregates a wide range of economic and ecological expectations. Due to the spatial–temporal control and a mild curing process of polymerization, photoinitiator semiconductor nano-particles offer great advantages, such as effective and quantitative reaction. Cadmium sulfide nanowire, titanium dioxide (TiO_2) nanotube, and TiO_2 nanowire were used as visible photocatalysts for photopolymerization of acrylamide hydrogel without using any additive under the sunlight and purple LED irradiations. The effects of different synthetic parameters, including initiator type and concentration and type of light sources, were investigated to achieve hydrogels with maximum swelling capacity. The results showed that the swelling of hydrogel reached 80 g water/g hydrogel when the TiO_2 nanowire was used as the photoinitiator. The synthesized semiconductors and hydrogels were characterized by X-ray diffractometry, adsorption isotherm, infrared spectroscopy, thermogravimetric analysis, and transmission electron microscopy. According to the results, the new initiators led to semiconductor-based hydrogels, achieved with high swelling property through a high-speed high-efficient photopolymerization reaction in a safe manner.

Keywords Hydrogel · Photopolymerization · Semiconductor · CdS nanowire · TiO_2 nanowire · TiO_2 nanotube · Purple LED · Sunlight

Introduction

Hydrogels are three-dimensional polymeric networks containing hydrophilic functional groups that can absorb a large amount of water from aqueous solutions [1]. Stimuli-responsive hydrogels change their volume abruptly in response to changes in the environmental conditions, like pH [2], temperature [3], light [4], magnetic field, and ionic strength [5]. These features have opened applications for hydrogels in soil conditioning [6], drug delivery system [7], food additive [8], separation [9], and barrier material [10]. The most well-known technique for synthesizing hydrogels is through free-radical polymerization of vinyl functional monomers. In free-radical polymerization, the active centers can be generated by heat, photoinitiators, γ-radiation, and electron beams [11–13]. Photopolymerization congregates a wide range of economic and ecological expectations, especially for the development of coatings, adhesives, microelectronics, and biomaterials [14–16]. Photopolymerization is usually carried out at low temperatures, so the chain transfer processes are restricted. Spatial and temporal control of the polymerization can be achieved through proper adjustment of light source. Most common photoinitiators are among transition metal complexes [17–19]. Semiconducting photoinitiators are widely used in radical photopolymerization as light-sensitive components. Photoinitiators, such as ZnO [20–22], TiO_2 [22–24], CdS [25, 26], carbon nitride [27, 28], and Fe_2O_3 [29, 30] semiconductors, have been used in

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