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Synthesis, characterization and swelling behavior of superabsorbent wheat straw graft copolymers

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ABSTRACT

Swelling behavior is an important characteristic for superabsorbents. A wheat straw-based superabsorbent (WS-SAB) was prepared by graft copolymerization of acrylic acid, acrylic amide and dimethyl diallyl ammonium chloride onto the cellulose of wheat straw, and its swelling and deswelling behavior was investigated. The product had a water absorbency of 133.76 g/g in distilled water and 33.83 g/g in 0.9 wt.% NaCl solution. Fourier transform infrared spectroscopy and scanning electron microscopy indicated that the monomers were successfully grafted onto the wheat straw. The largest swelling capacity was at pH 6. The effect of ions on the swelling was in the order: $Na^+ > K^+ > Mg^{2+} > Ca^{2+}$ and $Cl^- > SO_4^{2-}$. The swelling capacity did not change after several times of water absorption and release.

1. Introduction

Superabsorbent hydrogels are three-dimensional crosslinked hydrophilic polymers with the ability to absorb large quantities of water, saline or physiological saline solutions compared to ordinary absorbing materials (Chang et al., 2010). With excellent hydrophilic properties and high swelling ratio, they are used in agriculture, hygienic products, waste-water treatment, drug-delivery and coal dewatering (Xie et al., 2011; Kosemund et al., 2009; Paulino et al., 2006; Guilherme et al., 2007; Wang et al., 2009; Yu et al., 2005). Many kinds of materials are used for preparing superabsorbents, but most of those materials are acrylic acid and acrylamide-based products. However, these types of superabsorbent are expensive and can be hazardous to the environment (Kiatkamjornwong et al., 2002). A low absorption rate at high concentrations of electrolytes and undesirable water-keeping capacity also restrict the application and development of superabsorbents.

Some natural resources such as polysaccharides and inorganic clay minerals have also been used to produce polymer hydrogels (Li et al., 2007; Liu et al., 2008). Cellulose is often used in the biomedical field, and cellulose-based superabsorbents have been prepared using radiation-induced and chemical crosslinking (Chang et al., 2010). Wheat straw contains a high content of cellulose, so it could be chemically modified and used as backbone material for superabsorbents (Rémond et al., 2010).

Superabsorbents using wheat straw have been synthesized (Liang et al., 2009; Xie et al., 2011; Guo et al., 2006), but most of the products were single-ion superabsorbents. In some cases, the product was synthesized indirectly through the introduction of carboxymethyl cellulose. On the basis of the previous work (Ma et al., 2011), a new amphoteric superabsorbent was prepared and the swelling and deswelling behaviors of the new wheat straw-based superabsorbent (WS-SAB) in water and saline solution were studied. The WS-SAB was produced directly through graft copolymerization of the monomers (acrylic acid (AA), acrylic amide (AM) and dimethyl diallyl ammonium chloride (DMDAAC)) into the network of the cellulose in wheat straw.

2. Experimental

2.1. Materials

Wheat straw was obtained from Liaocheng, Shandong Province (China). Acrylic acid (AA, analytical reagent), acrylic amide (AM, chemically pure), dimethyl diallyl ammonium chloride (DMDAAC, chemically pure) and N,N′-methylenebisacrylamide (MBA, analytical reagent) were dissolved in distilled water before use. Other agents were of analytical grade and all solutions were prepared with distilled water.

2.2. Preparation of the wheat straw-based superabsorbent (WS-SAB)

Dried wheat straw was ground in an electromagnetic mill and sifted through an 80-mesh sieve. The particles were submerged

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