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Synthesis and Characterization of Silk Sericin / Acrylic Acid / Acrylamide Superabsorbent Polymer

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Abstract

A composite superabsorbent material was synthesized based on silk sericin, acrylic acid and acrylamide by using N, N-methylenebisacrylamide (MBA) as the crosslinker and ammonium persulfate (APS) as the initiator reagent. The water absorbency and water retaining properties of the composite under different preparation conditions were investigated. The absorbency of silk sericin / acrylic acid / acrylamide (SS/AA/AM) superabsorbent polymer polymer in deionized water, tap water and 0.9% NaCl solution were 285337 g/g, 191220 g/g, 3643g/g, respectively. SS/AA/AM material has excellent re-absorbent abilities and can be reused. The product showed different water absorbency in aqueous chloride salt solutions with the order of $Na^+ > Ca^{2+} > Mg^{2+} > Al^{3+}$. FTIR spectra results indicated that silk sericin was successfully grafted with acrylic acid and acrylamide molecules. The study on the absorbent material based on sericin is useful for further research on biodegradable superabsorbent polymer.

Keywords: Absorbent Material; Silk Sericin / Acrylic Acid / Acrylamide; Water Absorbency; Water Retaining Capacity

1 Introduction

Superabsorbent Polymer (SAPs) is a kind of functional macromolecule material with the ability of absorbing water or other biological fluid hundreds of times the weight of itself [1]. It has a remarkable property of dewatering none or little under pressure, and can be stored in the dry state for its higher reabsorbent capacity after drying [2]. Superabsorbents may have found many application fields owing to the water absorbing characteristics. Some of their applications include hygienic products, horticulture, agriculture, drug-delivery systems, as well as water blocking tapes and coal dewatering [3]. However, the traditional superabsorbent polymers usually have poor biodegradation property which induces the environmental pollution greatly [4], so it is urgent to pay attention to materials with excellent biodegradation [5]. Only a few studies have been reported in the case of protein-based SAPs [6].

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Silk Sericin (SS) is a natural macromolecule protein from silkworm and is composed of 18 kinds of amino acids. SS contributes about 20-30% of total cocoon weight and acts as a protein glue to fix fibroin fiber together in cocoon. It is well known that sericin has superiorities including hygroscopicity, bacterial resistance, oxidation resistance, hydrophility, skin-affinity and biodegradation. However, most of SS dissolved in waste water from silk filature factory is discharged to the environment and results in pollution. Many researchers have focused on the development of hydrogel from sericin in order to process sericin into an applicable form as a medical biomaterial. Some researches have been performed to improve mechanical properties of sericin hydrogel by mixing with other macromolecules or crosslinking functional crosslinkers such as silk fibroin and PVA [7, 8]. It is suitable to be used for the design of biodegradable superabsorbent materials due to its good hydrophilic and biodegradable characteristics. The exploitation of superabsorbent materials based on silk sericin can not only enrich the type of absorbent materials, but also expand the usage of silk protein and improve the additional value of silk protein.

In this research, a novel superabsorbent polymer was prepared from Silk Sericin (SS), Acrylic Acid (AA) and Acrylamide (AM) through the graft copolymerization method, using Ammonium Persulfate (APS) as the initiator and N, N'-methylenebisacrylamide (MBA) as the crosslinker. The structure and properties of the superabsorbent polymer were further studied.

2 Materials and Methods

2.1 Chemicals and Reagents

Acrylic Acid (AA) and Acrylamide (AM) were purchased from Shanghai Lingfeng Chemical Reagent Corporation Limited. Ammonium persulfate (APS, analytical reagent, from Yixing Second Reagent Chemical Factory). N, N'-methylenebisacrylamide (MBA, analytical reagent, Shanghai Bioengineering Corporation Limited), absolute ethyl alcohol, NaCl, $MgCl_2$, $CaCl_2$ and NaOH (all from Hangzhou Chemical Reagent Corporation Limited and analytical grade) were employed as-received. The cocoons of silkworm Bombyx mori were kindly provided by Huzhou Cocoon Testing Station, China. Deionized water was used for the hydrogel preparation and swelling measurenents.

2.2 Preparation of Superabsorbent Polymer

As an example, the procedure for synthesizing superabsorbent hydrogel in water is described in detail. The cocoons were cleaned and cut into small pieces for sericin protein extraction. Sericin was obtained by degumming cocoon pieces with 30-fold boiling distilled water for 30 min. The obtained sericin solution was first filtrated with gauze and concentrated to a certain concentration (10%) with a rotary evaporator (Shanghai Jiapeng Co., China). A certain amount of AA (2.5 ml, 1.05 g/ml), titrated by 20% NaOH to 70% neutralization percentage, acrylamide (1.32 g), SS solution (10%, 20 ml), MBA (0.008 g) and APS (0.06 g) were poured into a 50 ml beaker, which was equipped with a magnetic stirrer and placed into a digital display stable temperature water bath. The mixture was stirred until a homogeneous solution was obtained. The temperature mixture was increased rapidly and controlled to a setting value (60°) within 10 minutes. After the reaction for 3 h, the product was cut into small pieces and then put into 50ml absolute ethyl alcohol for 2h to remove most of the water. Then the ethanol was decanted and another