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ORIGINAL RESEARCH

Preparation of gelatin-based films modified with nanocrystalline cellulose

Shuaishuai Yang[1] · Haichao Li[1] · Huizhen Sun[2]

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Abstract

Gelatin is a natural biological macromolecule derived from the collagen in the connective tissue of the skin, bone and other tissues. It has been widely used in medicine, food and industrial production and other fields for easy molding, excellent compatibility and biodegradability. However, physical and chemical disadvantages impede its further application, seriously. Therefore, modification of the gelatin films becomes more and more important. In this study, the gelatin/nanocrystalline cellulose (NCC) composite films were prepared by casting method with 4% glycerol as plasticizer. The effect of NCC on the properties of the composite films was investigated by the characterization of its morphology and mechanical, thermal, and optical properties and water adsorption. The results showed that mechanical, thermal stability and water absorption properties of the gelatin/NCC composite film were obviously improved. The composite films showed the highest tensile strength (13.56 ± 0.25 MPa) when the mass concentration of NCC was 0.6%. Adding NCC to gelatin benefited the thermal stability of composite films. The gelatin/NCC composite film of 0.4% NCC had the highest melting transition temperature (138.9 °C). The composite films exhibited the lower water absorption (271.1%) when mass concentration of NCC was 1.0%. Thus, these results indicated that NCC could affect the properties of gelatin-based composite films, and showed it has potential for application in food packing.

Keywords Gelatin film · Nanocrystalline cellulose · Composite film · Modify · Properties

Introduction

The nanocrystalline cellulose (NCC) is a material that has unique optical and mechanical properties. It can be prepared by hydrolysis of the amorphous areas of the cellulose to get higher crystallization areas. The method of the preparation mainly included inorganic acid hydrolysis, enzymatic hydrolysis, ultrasonic, oxidation and so on. As one of the strongest natural materials, the NCC has significant characteristics for the higher tensile strength (1500 MPa), Young's modulus (100–140 GPa), aspect ratio (70), specific surface area (150–250 m^2/g) in electricity and optics [1]. The NCC can be used to produce flexible displays, electrical papers and batteries for the future. Besides, it also can be used to prepare the biodegradable nanomaterials, such as composite films [2–4], medical supplies [5], optical materials [6–8], templates [9] and other applications [10]. Gelatin has good film forming, biocompatibility, degradability, etc., thus, it has been widely studied, but its shortcomings, such as poor toughness, low melting point, and poor stability have hindered its application. Therefore, it is the current direction of the research works to seek the modification methods of the gelatin film. In addition, it has a complete three-strand spiral structure, which is a single-strand molecule formed by the destruction of the natural collagen three-strand spiral structure [11]. It contains a large number of hydroxyl (–OH), amino ($–NH_2$) and carboxyl (–COOH) groups which are highly reactive and easy to be modified. Gelatin and NCC have excellent biocompatibility, which contained a large number of hydroxyl groups forming the hydrogen bond to enhance the binding power of the interface. These effects can optimize the properties of the gelatin-based composite films and promote its further application.

✉ Haichao Li
lihaichao@vip.163.com

✉ Huizhen Sun
sunhuizhen@hotmail.com

[1] College of Chemistry and Chemical Engineering, QingHai Nationalities University, Xining 810007, China

[2] Center of Ecology, Northeast Forestry University, Harbin 150040, China