

Mechanical Properties of Cellulose/Chitosan and Sericin/Chitosan Blend Films

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Abstract

Cellulose/chitosan and sericin/chitosan blend films with various mixing ratios were prepared and tensile properties, solubilities to the aqueous solution of acetic acid and the degree of swelling by the distilled water were measured. The interaction between the components of blend film and the blending effect were investigated.

Introduction

Functional materials made of natural resources such as cellulose, chitosan or fibroin have been studied by many authors [1-5]. Cellulose and chitosan are water absorbable and have disadvantage in the water resisting property. In this paper, tensile properties of cellulose/chitosan are compared with sericin/chitosan, and the water resistance of these blend films are investigated.

Experimental

(1) Materials

Microfibrillated cellulose (Celish KY-100G, Daicel Chemical Industries, Ltd.) was dispersed in distilled water. The cellulose content was 0.8wt%. Chitosan (41941-9, Viscosity (Brookfield, 1% solution in 1% acetic acid) 800-2000cps, Aldrich Chemical Company, Inc.) was dissolved into 2vol% aqueous solution of acetic acid. The chitosan content was 1wt%. Glyoxal or glutaraldehyde was used for the crosslinking agent of cellulose/chitosan blend. Sericin (provided by Gifu Prefectural Institute for Bioindustrial Technology) was dissolved by distilled water in a 90°C oil-bath. Sericin content in the aqueous solution was 0.5wt%.

(2) Preparation of Films

The aqueous dispersion of cellulose (cellulose content 0.8%) was mixed with the chitosan dissolved in the 2vol% acetic acid aqueous

solution (chitosan content 1wt%) at the specified ratio. The mixture was stirred for 4hrs, vacuum degassed by the aspirator, and cast onto a polystyrene petri dish. The petri dish was dried on the 70°C hot plate and the cellulose/chitosan blend film of 0.03-0.04mm thickness was obtained.

Sericin/chitosan blend film was obtained by the similar process as mentioned above from the aqueous solution of sericin (sericin content 0.5wt%) and the chitosan-acetic acid aqueous solution. The petri dish made of teflon was used in stead of polystyrene, because sericin is very brittle to remove.

(3) Tensile test

The shape of test piece is 40mm in length, 5mm in width and the thickness is 0.03-0.04mm. Chuck length is 20mm, and tensile speed is 5mm/min.

(4) Solubility

Test pieces in the size of 15mm × 10mm × 0.03-0.04mm was dried in a 50°C vacuum oven for 24hrs. The weight before dissolution W_0 was measured. The test piece was immersed in the 5vol% aqueous solution of acetic acid for 24hrs. Then the test piece was washed thoroughly by distilled water and dried in a 100°C vacuum oven for 24hrs. The weight after dissolution W_S was measured, and the solubility S_0 was calculated by: $S_0 = (W_0 - W_S) / W_0$.

(5) Degree of Swelling

Test pieces in the size of 15mm × 10mm × 0.03-0.04mm was dried in a 50°C vacuum for 24hrs. Then the weight before swelling W_0 was measured. The test piece was immersed in 20°C distilled water for the specified time, and the weight after swelling W was measured. The degree of swelling S_w was calculated by: $S_w = (W - W_0) / W_0$.

Swelling time for cellulose/chitosan blend films was fixed for 24hrs, when the degree of swelling reaches leveling off. On the other hand, swelling

time for sericin/chitosan blend films was fixed for 1hr. Because the swelling of sericin/chitosan was significantly large, the weight after the swelling more than 1hr cannot be measured.

Results

- (1) Cellulose film is stiff (Young's modulus $E = 3.0\text{GPa}$) and brittle (elongation $\epsilon = 5\%$). Chitosan film is soft ($E=2.1\text{GPa}$) and ductile ($\epsilon = 30\%$). Tensile strength of cellulose (80MPa) is a little higher than chitosan (70MPa).
- (2) Cellulose/chitosan blend film with chitosan content 40wt% exhibits higher tensile strength (102MPa) than each of both components.
- (3) Sericin is very brittle. Sericin/chitosan blend film, in which the sericin content is higher than 70wt%, cannot be made. Sericin/chitosan film with chitosan content 40wt% exhibits maximum tensile strength (85MPa), which is higher than the chitosan film.
- (4) Chitosan is soluble to the 5vol% aqueous solution of acetic acid, while cellulose and sericin are not soluble. The solubility of cellulose/chitosan blend film (chitosan content lower than 40wt%) is lower than the rule of mixture. In these blends, the chitosan component was protected by the cellulose component from the attack of acetic acid. On the other hand, the solubility of sericin/chitosan blend film is higher than the rule of mixture. Sericin component, which is originally not soluble, is dissolved by acetic acid with chitosan component.
- (5) By adding the crosslinking agents to the cellulose/chitosan blend film, the swelling by distilled water is significantly restrained. And the wet tensile strength of the blend film was more enhanced especially by adding the glutaraldehyde compared to the glyoxal.

References

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