Research Article

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Hydrophobicity, UV resistance, and antioxidant properties of carnauba wax-reinforced CG bio-polymer film

Supplementary material

S1 Performance test

S1.1 Mechanical and thermal properties

Tensile strength (TS) and Elongation at break (EB) of the film was tested according to ISO method 527-2. All samples were cut as dumbbell-shaped with an overall length of 75 mm and narrow parelled-sided portion length of 30 mm. Tensile measurement was performed on a universal tester (Z005, Zwick, Germany) at 50 mm·min^{-1} tensile speed with an extensometer gauge length of 25 mm and the initial distance between grips was 62 mm.

Thermogravimetric analysis (TGA) curves of film were measured using a thermogravimetric analyzer (Q50, TA, America). 4.0 mg of the film sample was placed in alumina pans and was heated from 30°C to 500°C at a temperature programming of 20°C·min^{-1}. All samples were tested under nitrogen-protected conditions.

S1.2 Water resistance

The wettability of the films was measured by optical contact angle measuring instrument (OCA25, Dataphysics, Germany). A square film sample (1 cm × 1 cm) was put on the sample stage, and 7 μL of distilled water was added to the surface. The average contact angle (CA) for a period of 30 s was monitored and the test was conducted in triplicates.

The sample was freeze-dried and its initial weight was measured, which was recorded as W_0. Then the film was submerged in deionized water. After 48 h, the sample was taken out, the excess liquid on the surface was wiped with filter paper, and the weight of the sample was recorded as W_t. The swelling ratio (SR) of film was calculated according to formula (S1).

$$\mathrm{SR} = \frac{W_t - W_0}{W_0} \times 100\% \tag{S1}$$

The water solubility of the film was determined using the method of Yadav et al. (1). The weight of a dry film sample with a test size of 2 cm × 2 cm is recorded as M_0. At room temperature, the sample was immersed in a flask containing 20 mL of deionized water, and stirred for 24 h, then the film was removed and dried, the weight was tested and recorded as M_1. The water solubility (WS) of the film is calculated according to the following equation.

$$\mathrm{WS} = \frac{M_0 - M_1}{M_0} \times 100\% \tag{S2}$$

S1.3 UV and visible light transmittance

The transmittance of the film was measured using a UV spectrophotometer (TU-1901, Persee, China) with a wavelength range of 200–800 nm.

S1.4 Antioxidant activity

The antioxidant activity of the membrane was evaluated using the method described in ref. (2). A film sample with a size of 20 mm × 20 mm was immersed in a conical flask containing 20 mL of deionized water and oscillated continuously at 120 rpm for 48 h at room temperature. Mix 1.0 mL of extraction solution

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with 2.0 mL of DPPH methanol solution (0.1 mmol·L^{-1}) and let it react in a dark environment for 30 min. The absorbance of the solution at 517 nm was measured using a UV spectrometer (TU-1901, Persee, China). Free radical scavenging ability (RSC) is calculated according to formula (S3).

$$\mathrm{RSC} = \frac{A_0 - A_S}{A_0} \times 100\% \quad \text{(S3)}$$

where A_0 was the absorbance of DPPH solution and A_S was the absorbance of DPPH solution soaked in the sample.

S1.5 Statistical analysis

All data were presented as the mean values and standard deviations. SPSS 25 software was used to analyze the difference in mechanical properties, CA, SR and WS values using one-way analysis of variance (ANOVA) with a significance level of $P \leq 0.05$.

References

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(2) Xiong S, Li R, Ye S, Ni P, Shan J, Yuan T, et al. Vanillin enhances the antibacterial and antioxidant properties of polyvinyl alcohol-chitosan hydrogel dressings. Int J Biol Macromol. 2022;220:109–16.