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Investigation the Effects of Different Composition of Chitosan/ Clay on the Nanocomposite Film Properties

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Abstract

The effect of nanoclay concentration on the water vapor permeability (WVP), water vapor transmission (WVTR), mechanical properties of the nanocomposite films was evaluated. Concentrations of nanoclay greatly affect the WVP of biopolymer films at identical concentrations of chitosan. The lowest WVTR was observed in nanocomposite with 2%wt chitosan and 3%wt nanoclay. By adding nanoclay bentonite, the tensile strength (TS) of the nanocomposite films about 20% to 60% were improved.
Further increasing clay content to 3 wt%, the WVP and elongation decreased and TS of nanocomposites film increased in chitosan 2 wt%. It is implied that three percentage of nanoclay not only decreased the WVP by aiding the role of chitosan but also modified the rheological properties of nanocomposite film.

Keywords: Chitosan, Mechanical properties, Nanoclay, WVP

1. Introduction

Among the active biomolecules, chitosan has a great potential for a wide range of food applications due to its biodegradability, biocompatibility, antimicrobial activity, non-toxicity and film-forming capacity. Chitosan biopolymer has several advantages over other types of disinfectants and synthesis polymer such as biodegradability, gas barrier (increasing shelf life), and antimicrobial (increasing of spoilage time). But it has some demerit include of low mechanical properties, high water vapor permeability (Vargas et al., 2009).

One of the promising ways to modify biopolymer properties such as inherent water sensitivity, relatively low stiffness and strength, and low thermal stability, is to make hybrid films with biopolymers and nano sized materials, which are known as nanocomposite films.

The objectives of this study were to prepare composite films based on chitosan & nanoclay to gain some of the high mechanical strength of nanoclay and some of the superior biological properties of chitosan, to enhancing the water vapor barrier properties and mechanical properties.

2. Materials and Methods

2.1. Materials

Chitosan medium molecular weight with 75% deacetylation degree and 50,000 g/mol molecular weight were used. Nanoclay hydrophilic bentonite, was used in this experiment. Bentonite clay consists of about 1 nm thick layers and stacked in 5-10 µm multilayer stacks.

2.2. Preparation of film

A clear chitosan aqueous solution (2 and 3 wt %) was prepared by dissolving powdery chitosan corresponding to desired weight ratio of acetic acid (1%, v/v). The glycerol (3% v/v) and Tween-20 (1% v/v) were added and the solution were stirred for 10 hrs at 55°C. Nanoclay solutions with two compositions (1, and 3 %wt) were prepared by dispersing appropriate amounts of clay powder in distilled water and vigorously stirring for 12h.

The nanocomposite chitosan/clay solution was cast by pouring certain amount of the solution onto AL plate. The nano-composite films were kept in a desiccator with silica gel at room temperature before use.

2.3. Measurements

Sample codes denoted the materials were used. nanoclay bentonite (NB), chitosan with medium molecular weight (CM).

- Water vapour permeability (WVP) was measured by using Cups consisted of cylindrical shape and cover ring to sealing. Cups were filled with calcium chloride, covered with a film, sealed with paraffin and placed in a desiccator chamber which conditioned at 37°C, 75% RH (JIS, K7 129, Japan, Yoshino et al., 2002).
- The weight of the cup was measured intermittently at intervals of 12 h, up to 48 h. The WVP of the nanocomposite films was calculated using the equation 1.

$$WVP=(WL)/(tAP) \qquad (1)$$

Where, W = increase in cup weight (g), L = thickness of film (m), t = measuring time (s), A = measuring area (m^2), P = pressure difference in between outside and inside of the cup (Pa).

- The water vapor transmission rate (WVTR) was calculated using the equation 2.

$$WVTR=(W1-W2)/(tA) \qquad (2)$$

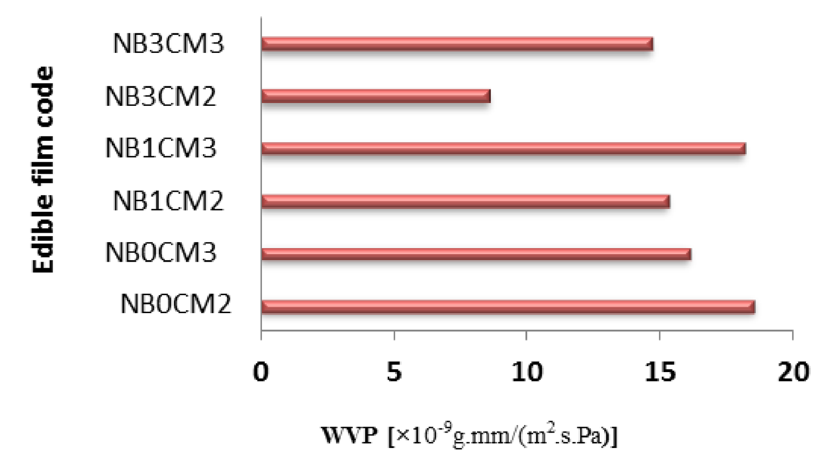
Tensile strength (TS) from each type of film will be measured by using of rheomete. Samples were cut from the nanocomposite films by using a standard sample cutter (JIS Z1702, Japan, Yoshino et al., 2002).

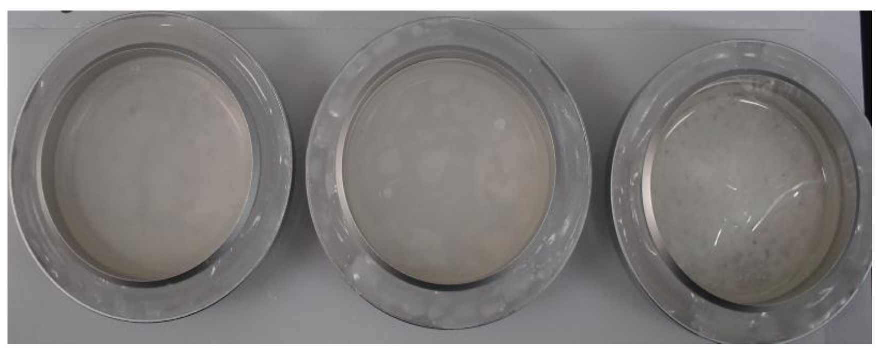
- Percentage of elongation (E%) at break of the film was calculated as the ratio of initial length to the final length at the rupture point to the initial length.

3. Results and Discussion

3.1 Water vapor permeability

Figure 1 shows that various concentrations of nanoclay greatly affect the WVP of biopolymer edible films at certain concentration of chitosan. The highest WVP is observed in samples with 1% nanoclay and 3% chitosan. it might be due to the surface properties and internal structure of the film. Therefore, it can deduce that the WVP decreased as the clay content increased in polymer matrix.





Nano composite ----- Pure Chitosan

Fig. 1: Water Vapor Permeability (WVP) of the nanocomposite biopolymer-based films and its condition after 7 days

The sample was covered with pure chitosan was damaged completely but the sample covered with nanocomposite (2% chitosan and 3% nanoclay) is still safe (Fig. 1).

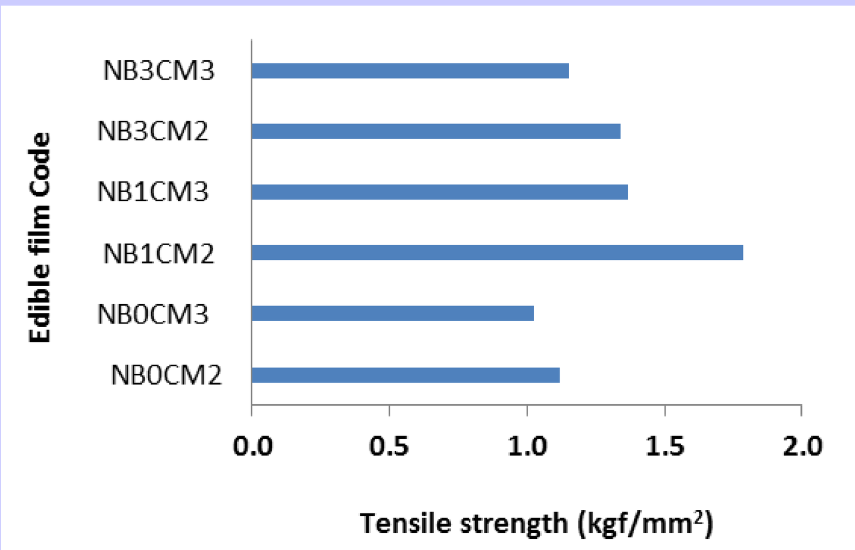
It can be interpreted that nanocomposite film with nanoclay be able to keeping the food for long time.

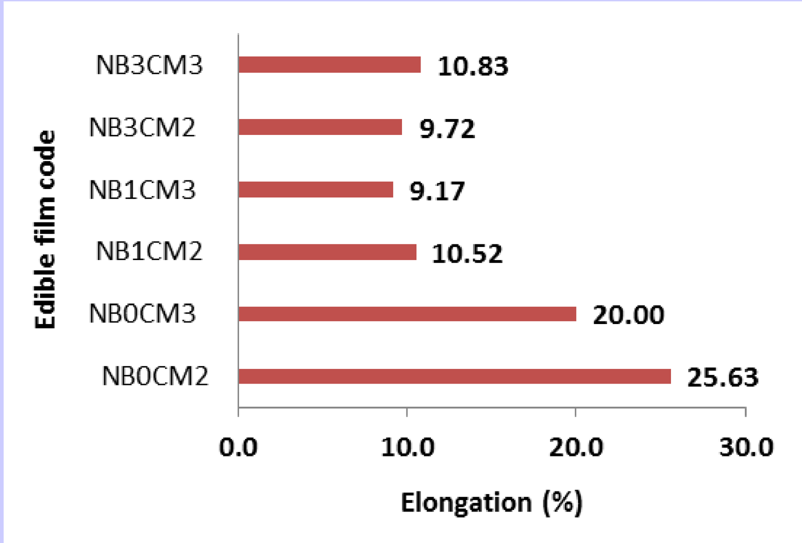
3.2 Tensile strength

Tensile testing provides an indication of the strength and elasticity of the ediblefilm.

Tendency of TS exhibited increasing with increase the percentage of nanoclay bentonite but the increasing value is different.

Further increasing clay content, the TS of nanocomposite films increased in compare of pure chitosan film but the amount of TS was higher for 1 wt% clay.





3.3 Elongation at break point (E%)

The elongation of the films decreased slightly with addition of nanoclay for samples with chitosan 2 wt%.

Low values for elongation imply brittleness and minimum elasticity in the edible film which was confirmed by Bourtoom (2008).

Conclusions

- **Various concentrations of nanoclay greatly affect the WVP of biopolymer films at identical concentration of chitosan.**
- **By adding nanoclay bantonite, the TS of the nanocomposite films about 20% to 60% were improved.**
- **Nanoclay with high concentration not only decreased the WVP by aiding the role of chitosan but also modified the rheological properties of edible film.**
- **It can deduce that by adding nanoclay, interactions between nanoclay and chitosan, leading to the formation of a new material with better mechanical and water vapor permeability properties than pure chitosan.**

4. References

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