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Characteristics of Chitosan Films

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Abstract: *Chitosan is a long-chain natural polymer derived from chitin by a process called deacetylation. Chitin is found in some marine crustaceans such as crabs and shrimps and is considered the most abundant natural polymer in nature after cellulose. Chitosan has unique and valuable properties such as biodegradability, bioactivity, and antimicrobial activity, in addition to being non-toxic, and can be prepared in different forms such as films, gels, and porous structures. In this research, chitosan films were prepared by the casting method, and then some physical properties (moisture, solubility, swelling degree) of these films were measured at room temperature. The results showed that the moisture content of chitosan films reached 11.84%, and this result may be relatively high, due to the hydrophilic nature of this polymer. The results also showed that there is a direct proportion between the percentage of solubility and swelling degree on the one hand and the duration of immersion of the films in distilled water (up to 24 hours) on the other hand. Knowing the physical properties of chitosan, such as moisture, solubility, and swelling, is of great importance in many industries in which this polymer is used, such as the pharmaceutical and food packaging industries.*

Keywords: Chitosan, film, moisture, solubility, swelling**.**

1. INTRODUCTION

Over the past few decades, natural polymers have gained more and more attention, mostly because of their availability, environmental concerns, and the expected depletion of petroleum resources. As a result, there is increasing interest in creating chemical and biological methods to produce natural polymers, modify them, and leverage their advantageous intrinsic qualities for a variety of uses across several industries [1,2].

Due to its abundance, adaptability, simplicity of modification, and special qualities, such as biodegradability [3], biocompatibility [4], non-toxicity [5], antibacterial nature [6], and hydrophilicity [7], chitosan holds a unique position among natural polymers. Because of this, chitosan is an extremely useful material with a wide range of applications in the fields of chemistry, pharmacology, agriculture, and the environment.

Chitosan is a naturally occurring polymer that may take on a variety of physical shapes, such as beads, fibres, gel, sponge, and nanoparticles, in addition to easily produced films. Chitosan films have excellent mechanical, oxygen barrier, and antibacterial qualities. They are also transparent, homogenous, and flexible [8]. As a result, they have proposed for numerous applications. For instance, food quality preservation has been achieved with the use of chitosan films as a packaging material [9-11]. Additionally, they are utilized in the production of contact lenses [12] and for wound healing in the form of bandages [13]. This work is aimed at evaluating the moisture content, solubility, and swelling degree of chitosan films formed by the casting technique.

2. MATERIALS AND METHODS

2.1 Materials

Chitosan of a degree of deacetylation of 88.1% determined by the UV method [14] was provided by the chitin-chitosan laboratory of Universiti Kebangsaan Malaysia (UKM). All chemicals were used without further purification, and freshly prepared solutions were used in all experiments.

2.2 Preparation of the solutions

Chitosan was oven-dried until a constant weight was observed. 10 g of chitosan were then dispersed in 1500 ml (0.1 M) of acetic acid, followed by gentle stirring and heating at approximately 60°C overnight to form a 6.7 g L^{-1} chitosan solution. The solution was then filtered to remove dust and other trace impurities. Air bubbles were eliminated by keeping the solutions at room temperature for a specified period of time.

2.3 Film casting and drying

The prepared homogeneous solutions were cast onto polystyrene Petri dishes for film formation and then dried in the oven at 40°C for 48 h. The resulting films were carefully peeled off and further dried by keeping them under an evacuated desiccator over fresh silica gel until use. All films obtained were transparent and free of air bubbles.

2.4 Film thickness

The film thickness was measured using a micrometer to the nearest 0.001 mm at various positions of the film. The average value was then taken. The film thickness was about 0.020 mm.

2.5 Molecular weight measurements

By using gel permeation chromatography (GPC) with a Waters 1515 HPLC Pump and a Waters 2414 Refractive Index Detector, the molecular weight of chitosan was found to be 5.5×10^5 g mol^{-1}. 1% acetic acid was employed as the solvent, and the column utilized was PL aquagel-OH 30 (8 µm, 300 × 7.5 mm).

2.6 Moisture Content Evaluation

Moisture content (MC) is an essential property that affects the mechanical and barrier characteristics of chitosan films. The moisture content was determined by weighing the film samples before and after drying at 50°C until a constant weight was achieved, and then the difference in weight was determined. The moisture content was calculated using the following equation:

$$\textbf{Moisture Content (\%)} = [(W_0 - W_d / W_0)] \times 100$$

where W_0 is the initial weight and W_d is the final dry weight.

2.7 Solubility Determination

The solubility of chitosan films is a critical parameter influencing their stability in aqueous temperature environments. It was determined by immersing the film samples in distilled water at room temperature for different times (1-24 h), followed by drying. The percentage solubility was calculated as:

$$\textbf{Solubility (\%)} = [(W_d - W_f / W_d)] \times 100$$

where W_d is the initial weight of the dry film, and W_f is the weight of the residual film after drying.

2.8 Swelling Degree Assessment

The swelling degree of chitosan films is a measure according to their water absorption capacity and is relevant for applications such as drug delivery and wound dressing. In this work, swelling degree was determined by immersing the film in distilled water for various times (1-24 h), followed by weighing the swollen film. The swelling degree was calculated as:

$$\textbf{Swelling degree (\%)} = [(W_w - W_d / W_d)] \times 100$$

where W_w is the weight of the swollen film, and W_d is the initial dry weight.

3. RESULTS AND DISCUSSION

3.1 Moisture Content

The results showed that the moisture content of chitosan films was 11.84%, due to the fact that chitosan has a hydrophilic nature. Finding the moisture content of chitosan films is of great importance in industry because it directly affects the physical properties and, consequently, the applications of this polymer. On the other hand, this result is consistent with the results of a previous study conducted by Bourbon et al. in 2011 [15].

3.2 Solubility

Solubility plays an important role in many industries, especially in food packaging, because it is a measure of the water resistance of a material. Figure 1 shows the percentage solubility as a function of time (hours) at room temperature. In general, there is an increase in solubility values with increasing time. The solubility percentages ranged from about 14 to 46%. When comparing these results with previous results [16], it was found that they are relatively higher, and this may be due to several factors, including the difference in the source and the degree of deacetylation of chitosan.

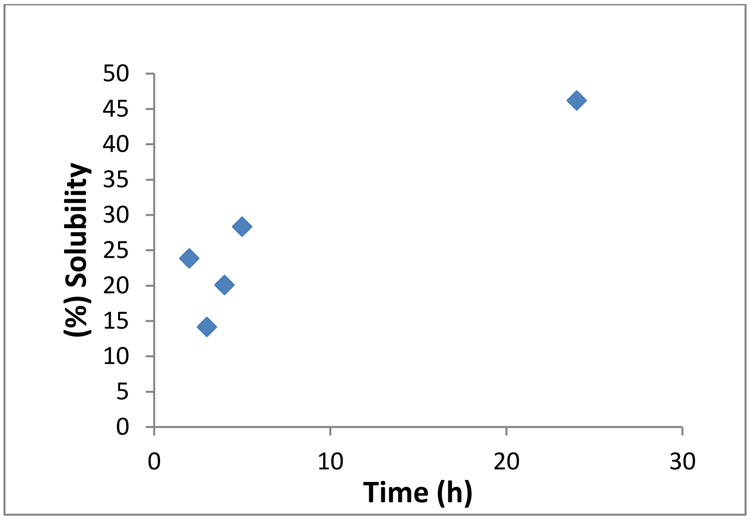

Figure 1: Water solubility of chitosan films versus time.

3.3 Swelling Degree

The swelling percentages of chitosan films after immersion for different periods in distilled water ranged between 482 and 642% (Figure 2). In general, it was found that the longer the films were immersed in distilled water (up to 24 hours), the higher the swelling percentage.

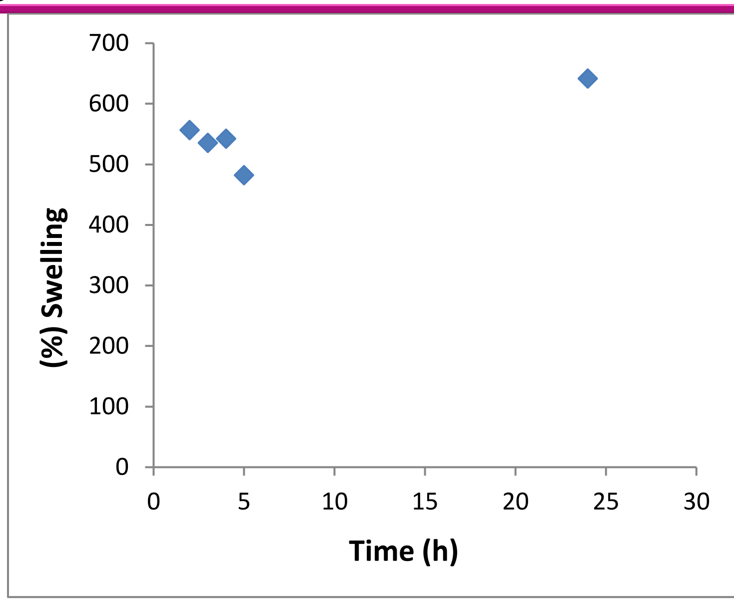

Figure 2: Water swelling degree of chitosan films versus time.

4. CONCLOSION AND RECOMMENDATIONS

Based on the results obtained from this research, it can be concluded that the solubility and swelling degree are directly correlated with the duration of immersion of chitosan films in distilled water (up to 24 hours) in general. It can also be concluded that this polymer has a hydrophilic property based on the relatively high percentage of moisture in the studied samples. Studying the physical properties of chitosan is of great importance in many industries in which this polymer is used, such as the pharmaceutical and food industries. Finally, the researchers recommend conducting focused studies related to other chemical and physical properties of this polymer alone or with other materials added to it.

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