Swelling Behaviors of Composite film with Alternating Fibre Reinforcement and Aqueous Media.

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Abstract. The swelling behaviour can affect the mechanical properties of the composite film and altering their ability to recover adsorbed substances. These problems are particularly important in the case of porous polymers. Therefore, several researchers have tried to improve the swelling properties by reducing the hydrophilic properties of gelatine and chitosan with adding reinforcing fillers. In this paper, the addition of the hydrophobic properties of pith and cortex of Napier grass in the chitosan/gelatin composite film will be investigated. The composite films were prepared via solution casting method will be evaluated based on the swelling behaviour in the alkali, neutral and acid solution. The result shows that type of reinforcement material and aqueous media used would affect the swelling behaviour of composite film. The results also suggest that the chitosan/gelatin composite films with incorporated cortex of Napier grass are the most water-resistant in neutral followed with acid and alkali.

1. Introduction
The swelling process can be explained as an increasing in size or weight of a solid due to with the absorption of solvent [1]. The swelling affects their mechanical properties and altering their ability to recover adsorbed substances [1]. These problems are particularly important in the case of porous polymers [1]. Meanwhile, a strong chemical chains bond designed in the composite film can help the composite film to not dissolve in solvents [2]. Owing to these unique swelling properties, the materials have been useful in various applications, including diapers, drug-delivery systems, soft contact lenses and implants [3]. Thus, realizing the important role of swelling properties in composite film application, the aim of the present study was to develop a new chitosan/gelatin composite films with
incorporated pith and cortex of Napier grass stems (NS) to improve the swelling behaviour, as well as to investigate the sensitivity to pH environment.

Despite the fact, the composite film can be designed using natural or synthetic polymers. The synthetic polymers could harm human health and wildlife at the same time [4]. Therefore, several researchers have tried to improve the swelling properties by blending gelatine and chitosan with other high strength polymers [4]. The hydrophilic properties of chitosan and gelatine causes the composite film to allow easy absorption of water molecules from the surrounding medium [5]. Hence, the combination between hydrophobic properties of pith and cortex of NS in contrast to hydrophilic nature of chitosan and gelatine will be investigated to form a good compatibility of materials in the composite film. The NS is one of the good choices as it is classified as second generation source of renewable energy [6]. The pith and cortex are represents ratio 4:21 of NS dry total weight, respectively [6].

In addition, according to Prinsen et al., the water-soluble material are different in each fraction of the NS, with the pith having higher water-soluble material (10.4 ± 0.1 %) than the cortex (8.8 ± 0.4 %) [7]. In the meantime, the cortex which represents bark are responsible for water absorption in tree organism to prevent the trees from losing moisture in dry air conditions [8]. In this paper, the effect on the swelling behavior of composite film will be investigated in the alkali, neutral and acid solution. Their insolubility and resistance to both acids and bases, along with their high sorption capacity, makes them a very versatile material [1]. Apparently, this is the first investigation for characterization of the swelling behavior of chitosan/gelatin composite films with incorporated pith and cortex of NS in different aqueous media. Overall, this comparison study can provide a new information for enlarge the use of NS in industrial composite films.

2. Methodology

2.1. Material Preparation
The NS originates from Asia tropical and can be located in northern peninsular Malaysia. The process of the removal of residue and wax at the NS were done by cutting it into 4-6 cm, crushed and submerged in water for 2 months. Subsequently, the soaked NS were washed under tap water for five times before it was dried for 2 days in a room temperature. Consequently, the total weight of each NS was measured and the recorded ratio of the cortex to pith of NS was 4:21 [6]. Generally, if the total weight of each NS was measured using an analytical balance is 150g, then the pith and cortex will be separated as 24 and 126g, respectively. To prepare powder form for the dried pith and cortex of NS, the separated pith and cortex of NS were grounded and sieved several times.

2.2. Composite Films Preparation
The composite film was prepared via solution casting method by mixing the chitosan and gelatine solution. Primarily, the chitosan powder was dissolved in 100 ml of 2 % (v/v) acetic acid for 12 hours to prepare the chitosan solution. Secondly, the gelatine powder was dissolved in 100 ml water for 30 min to prepare the gelatine solution. Subsequently, 1 wt. % of pith and cortex powder was mixed separately in 40 and 60 mL of the gelatine solutions and chitosan solution, respectively for 1 hours. Consequently, 0.5 mL of glycerol was added and stirring process continued for 24 hours. Finally, 30 mL of composite film solutions were poured into the glass petri dishes and dried for 1 day before peeled it off. The chitosan/gelatin composite films with incorporated pith and cortex of NS were prepared.

2.3. Sample Characterization
The ISO 62 method was employed to perform the swelling behaviour test. In the swelling studies, the samples with square pieces of 4 cm² was placed in oven at 80 °C until fixed dry weight is obtained. The samples were placed in 100 mL of either neutral, alkali and acid aqueous media for 24 hours. The excess aqueous media on the samples was removed by using a filter paper before measured the weights of wet samples. The swelling percentage were calculated using the following equation [9]:

\[
\text{Swelling Percentage} = \left( \frac{W_{wet} - W_{dry}}{W_{dry}} \right) \times 100
\]
3. Results and Discussion

The swelling percentage of the chitosan/gelatin composite films with incorporated pith and cortex of NS in the alkali, neutral and acid solution are presented in Fig. 1. As shown in Fig. 1, the results show significant differences in the liquid uptake rates for the composite film due to the type of reinforcement material and aqueous media used. Besides, the chitosan/gelatin composite films with incorporated pith of NS exhibited rapid water uptake within 24 hours in the alkali, neutral and acid solution. The result also shows that the chitosan/gelatin composite films with incorporated pith of NS had highest liquid uptake in the alkali solution. Moreover, the addition of cortex of NS in chitosan/gelatin composite films had reduce the liquid uptake due to the decrease number of free –OH groups that interact with water molecules [10]. These also indicate that the addition of cortex of NS forming a good compatibility between the hydrophobic and hydrophilic materials in the composite film [11]. This may be due to the hydrophobic properties of pith and cortex of NS in contrast to glycerol, chitosan and gelatine which has hydrophilic properties.

Furthermore, this signifies that the addition of pith and cortex as reinforcement material significantly improved the material bonding [12]. According to Marichelvam et al., additional of fibre into the chitosan and gelatine films had decreased the composite films’ hydrophilicity [12]. Furthermore, a high water absorption of food packaging materials may limit the ability of the composite film to act as a food-protective barrier [13]. Nevertheless, the composite film’s water resistance is depended on its application and intended use. This is because high-solubility composite film also can be used in biochemical and commercial applications such as laundry detergent pod [5]. Thus, quantifying the amount of total soluble matter in different pH medium is extremely important criterion for ensuring applicability [14].

![Swelling behaviour of the chitosan/gelatin composite films with incorporated pith and cortex of NS in the alkali, neutral and acid solution.](image)

4. Conclusions

The swelling behavior of the chitosan/gelatin composite films with incorporated pith and cortex of NS in the alkali, neutral and acid solution were analyzed. There were significant differences in the water
uptake rates of the composite film due to type reinforcement material and aqueous media used. The addition of cortex of NS had forming a good compatibility between the hydrophobic and hydrophilic materials in the composite film. The results suggest that the chitosan/gelatin composite films with incorporated cortex of NS are the most water-resistant in neutral, followed with acid and alkali. This shows the possibility of chitosan/gelatin composite films with incorporated pith and cortex to be used in diverse applications which aiming to maximize the use of NS.

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