PROPERTIES OF CELLULOSE/TURMERIC POWDER GREEN COMPOSITE FILMS

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Cellulose was dissolved in an environment friendly aq.(7%NaOH/12% urea) solvent that was precooled to -12 °C. Turmeric powder was added in different proportions and the composite films were cast on glass plates and regenerated in dilute sulfuric acid bath. The films were uniform and transparent of yellow color. The effect of turmeric powder loading on the tensile, optical, thermal degradation and cell viability was studied. The tensile properties, optical transparency and cell viability were found to be higher for the composite films. The films were thermally stable up to 350 °C.

Keywords: Green composites, tensile properties, cell viability, turmeric powder

INTRODUCTION

Due to their unique properties, like low cost, higher strength to weight ratio, ease of manufacture etc., polymers in general and polymer composites in particular find many applications in every filed. Unfortunately, they are not biodegradable and hence pose many environmental problems.[1] In order to find a solution to this white pollution, the trend is now shifting towards developing environment friendly green composites employing natural materials. In this direction, many natural materials, like polylactic acid,[2] starch,[3] soy protein isolate[4] and wheat protein isolate[5,6] have been tried as biodegradable matrix materials. Unfortunately, these are expensive. In order to find a cheaper alternative, cellulose has been considered as matrix, since it is abundantly available in nature. The films of cellulose can be made only by the regeneration process. The dissolution of cellulose is a complex process. Conventional solvents like CS_2 are toxic and, considering environment issues, not preferred. In the present work, we used an environment friendly solvent[7] for the dissolution of cellulose to make films and composites. Compared to the conventional solvents for cellulose, this new solvent of aq.(7%NaOH/12% urea) has many advantages, such as non-toxic nature, low evaporation, rapid dissolution, low energy consumption etc.[8-10] The conventional substrates used for cell growth in the medical field are non-biodegradable. In order to make the biodegradable films for packaging and cell growth, we used turmeric powder as filler. Turmeric (*Curcuma longa*) is a rhizomatous perennial plant of the ginger family, Zingiberaceae. It is native to tropical south Asia. In most of the Asian countries, it is widely used as a food additive and a natural dye. It has anti-septic, anti-bacterial and anti-tumor properties. Even today, it is used in rural India as a home remedy for cuts, burns, eczema etc. In the present work, we loaded cellulose films with 5 to 25% turmeric powder and studied the tensile properties, optical clarity, cell viability and thermal stability of the composites with filler content.

EXPERIMENTAL

Materials

Cotton linter pulp supplied by Hubei Chemical Fiber Co. Ltd. (Xiangfan, China) was used as received. The degree of polymerization (DP) provided by the manufacturer was ca. 620. NaOH and urea were supplied by Shanghai Chemical Reagent Co. Ltd., China, and they were used without further purification. The dried turmeric roots obtained from a local market in Anantapur town of Andhra Pradesh State, India, were ground into powder and sieved to separate fine powder.

Dissolution of cellulose

Cellulose solution was prepared as per the procedure described elsewhere.[7-10] The solution of aq.(7%NaOH/12% urea) was prepared and cooled to -12 °C. Cellulose was added (4 wt%) to the precooled

solvent and stirred vigorously at room temperature. A clear solution of cellulose was obtained within 2 minutes of stirring. This solution was centrifuged at a speed of 7200 rmp and temperature of 5 ^{o}C for 15 minutes to separate any undissolved cellulose and impurities. This stock solution was stored at 5 ^{o}C till it was used.

Preparation of turmeric powder/cellulose composite films

The turmeric fine powder was dried in an oven for 24 hours to remove moisture, if any. The dried powder was added to the cellulose solution in 5, 10, 15, 20 and 25 wt% by weight of cellulose and mixed thoroughly. Up to 25 wt% turmeric powder was found to dissolve completely in the cellulose solution with orange yellow color due to the alkalinity of the solvent used. The turmeric/cellulose solutions were degassed to remove any air bubbles. The films of ~0.1 mm thickness were made by evenly spreading the respective solutions on a glass plate, using a spreader and subsequently regenerated in 5% dil. H_2SO_4 bath for 5 minutes. The regenerated neutralized films were bright yellow in color, and were washed thoroughly in distilled water and dried.

Tensile test

The tensile strength, modulus and %elongation at break of the films were determined using an Instron 3369 Universal testing machine at a cross head speed of 5mm/min at 23 ^{o}C and a relative humidity of 50%. Ten specimens were used in each case and their average values are reported. The standard deviation was also calculated for each set and reported along with tensile values.

Optical clarity

In order to assess the optical clarity of the composite films, their UV-visible spectra were recorded on a TU-1901 spectrophotometer.

Thermal degradation

To assess the thermal stability of the composite films, their thermograms were recorded on a PerkinElmer TGA-7 instrument in a nitrogen atmosphere at a heating rate of 10 ^{o}C/min. The samples were predried and conditioned before the commencement of the experiment.

Cell viability

To assess the biocompatibility of the composite films, their cell viability was tested using normal and Tesla (cancerous) cells. The standard biochemical method as described elsewhere[11-14] was adopted for this purpose.

Microscopic analysis

Scanning electron micrographs of the surface and cross-section of the brittle fractured and gold coated specimens were recorded on a JEOL JM 6700F microscope. An accelerating voltage of 5 kV and current of 10 μA were used for operating the scanning electron microscope.

RESULTS AND DISCUSSION

A photograph of the flowers wrapped with cellulose/turmeric powder composite films loaded with 5 to 25 wt% of turmeric powder is presented in Figure 1.

From Figure 1, it is evident that the films are transparent of yellow color and the turmeric powder is uniformly distributed in the matrix. In order to assess the optical clarity of the composite films under study, their UV-visible spectra are presented in Figure 2.

From Figure 2, it is evident that the composite films show an absorption band at around 443 nm, which region is complimentary to the yellow color. In the other visible region, the composite films had transparency either higher or close to that of pure cellulose films. From Figure 1 and Figure 2, it is also evident that the films have sufficient optical clarity for usage as package films.

The tensile properties of the composite films are presented in Table 1. From this table, it may be noted that the tensile modulus and strength of the composites are slightly higher than those of the matrix and increase with filler content.

As turmeric powder contains around 3% curcumin,[15] a diphenyl compound that is responsible for the color and medicinal properties of turmeric, the increase in tensile properties is expected. Unfortunately, attempts to load the cellulose films with turmeric powder beyond 25% were unsuccessful due to dissolution problems. The % elongation at break was also found to increase with filler content. As curcumin also has CH_2 and OCH_3 groups[15] in its structure, such an increase in elongation is expected.

The micrographs of both the surface and cross-section of the composite film with 25 wt% turmeric powder loading are depicted in Figure 3. From these micrographs, it is clearly evident that the film is uniform without any lumps of turmeric powder. A similar observation has been also made for other concentrations.

In order to investigate the biocompatibility of the composites under study, their cell viability is presented in Figure 4. From Figure 4, it is evident that the cell viability for normal cells was good (>80%) and increased with turmeric powder content.

Further, the growth of the normal cells was higher than for the cancerous cells and the survival for cancer cells decreased with increasing turmeric content. This behavior is due to the anti-tumor property of the turmeric powder. Further, this observation clearly indicates the biocompatibility of the films under study. Thus these films can be considered as substrates for cell growth in tissue engineering.

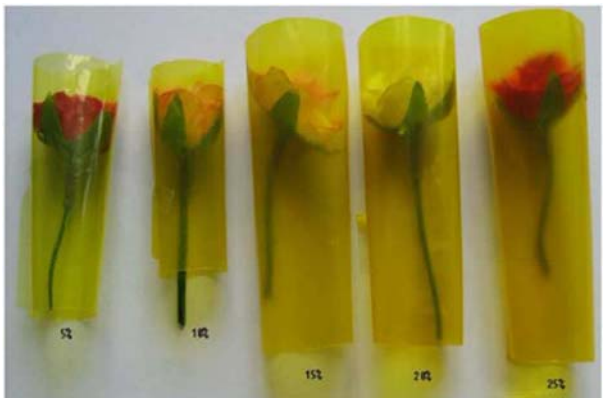


Figure 1: Photograph of flowers wrapped with cellulose/turmeric powder composite films

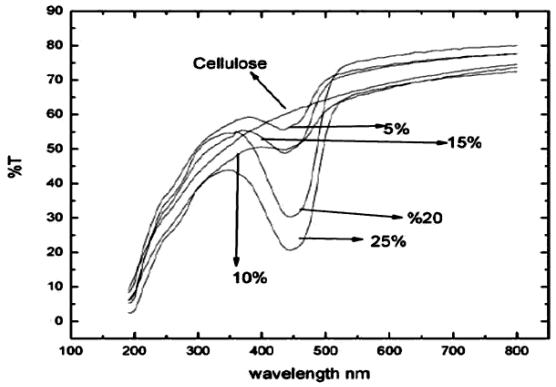
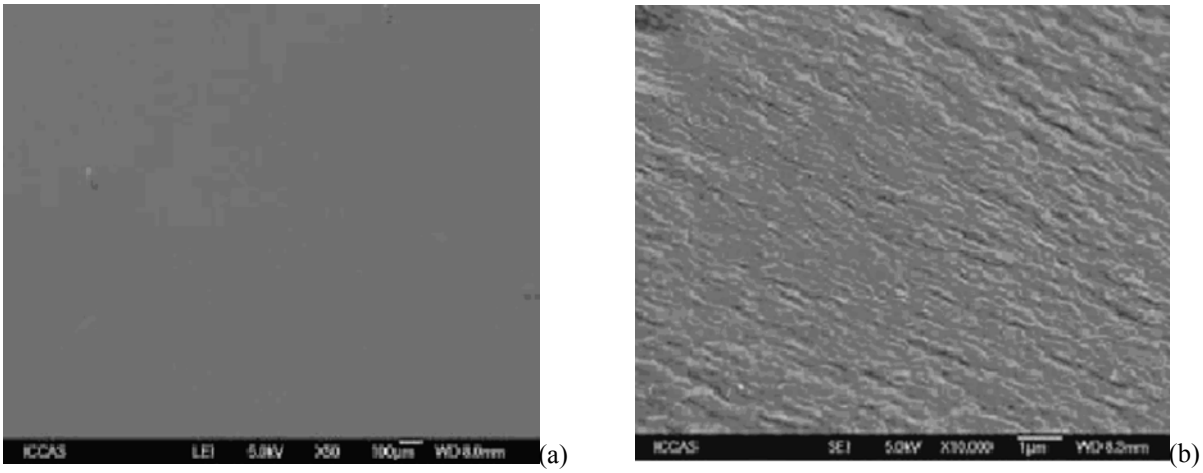


Figure 2: UV-visible spectra of cellulose/turmeric powder composite films

Table 1
Tensile properties of cellulose and cellulose/turmeric powder composite films

Specimen	Tensile strength (MPa)	Tensile modulus (MPa)	% Elongation at break
Pure Cellulose	70.0	4445	5.6
(S.D.)	(0.2)	(36)	(0.19)
5% Turm./Cell.	70.4	4505	5.7
(S.D.)	(0.1)	(47)	(0.11)
10% Turm./Cell.	72.3	4575	7.8
(S.D.)	(0.2)	(25)	(0.16)
15% Turm./Cell.	73.6	4675	8.6
(S.D.)	(0.4)	(37)	(0.23)
20% Turm./Cell.	74.7	4756	8.8
(S.D.)	(0.6)	(49)	(0.41)
25% Turm./Cell.	76.8	5190	11.3
(S.D.)	(0.5)	(52)	(0.39)

(S.D.): Standard deviation



(a) (b)

Figure 3: Scanning electron micrographs of (a) the surface and (b) cross-section of cellulose film loaded with 25 wt% turmeric powder

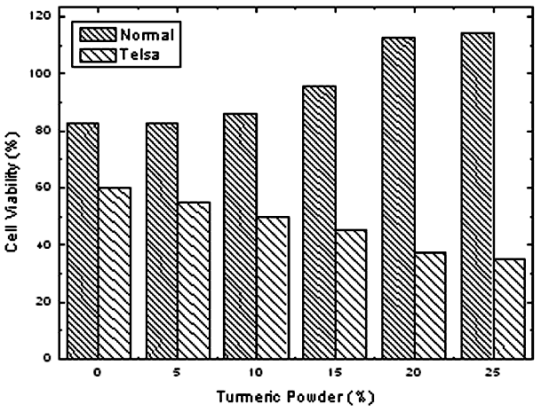


Figure 4: Cell viability of cellulose/turmeric powder composite films

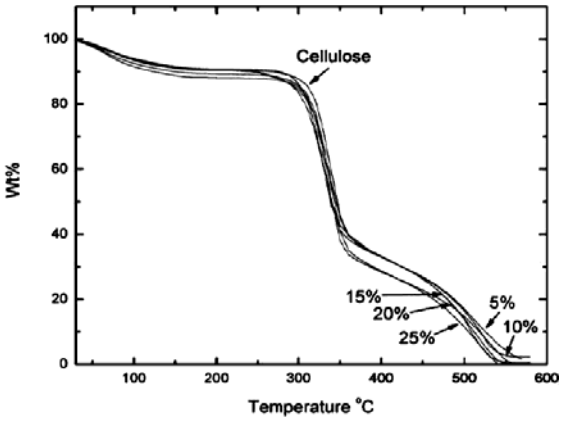


Figure 5: Primary thermograms of cellulose/turmeric powder composite films

In order to assess the thermal stability of the composite films under study, their primary thermograms are presented in Figure 5. For comparison, the thermogram for the cellulose matrix is also presented in the same figure. From the thermograms, it is evident that both cellulose and the composite films were stable up to 350 ^{o}C. The thermal stability of the composite films indicated that these can be sterilized for medical applications. However, after 350 ^{o}C the thermal stability of the composite films was lower than that of the matrix and decreased with filler content in the composites.

CONCLUSION

Turmeric powder/cellulose green composite films were prepared first by dissolving cellulose in a green solvent of aq.(7 wt% NaOH/12 wt% urea) precooled to -12 ^{o}C, reinforcing them with different amounts (5 to 25%) of turmeric powder and subsequently regenerating the spread films in aq. 5 wt%H_2SO_4 bath. The effect of fiber loading on the optical clarity, tensile properties, cell viability and thermal stability was studied. The tensile strength, optical clarity and cell viability were found to increase for the composite films with increasing filler content. The optical clarity, tensile properties and cell viability indicate that these green composite films made from natural components are suitable materials for food packaging and also as substrates for normal cell growth.

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