

Properties of Cellulose Acetate and Polyethylene Composite Film

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ABSTRACT

Environmentally-friendly polymer composite films were manufactured from cellulose acetate (CA) and polyethylene (PE). To investigate the optimum manufacturing conditions for the composite, various tests such as thermal analysis, surface observation, IR spectra analysis, and elongation ratio of polymer composite films were carried out. The mixing ratio of each element and manufacture condition was found to be very important for the best goods.

Key words: Polymer composite film, Cellulose acetate (CA), Polyethylene (PE), Mixing ratio.

INTRODUCTION

Synthetic polymers have been widely used in modern society, but the pollution and the environmental damage caused by wastes cause severe troubles all over the world. Recycling the wastepaper, however, can provide a profit of cost reduction in the plastic composite industry. Recently, many efforts has been doing to develop bio-based composite materials, which can reduce the wide spread dependence on petroleum resource and can enhance the environment conservation as well. The manufacture, use and elimination of non-degradable composite structures, usually made of plastics such as polypropylene, polyethylene, polystyrene and epoxies, unsaturated polyester resins, polyurethane and so on, are considered critically (Mohanty et al. 2000, Kishi 1988). Environmental bio-friendly green composites from woody-plant based on the fiber and wood-derived plastics are novel materials for the 21st century and can be of great importance to the materials world (Mohanty et al. 2002).

Cellulose from woods is used in place of petroleum as a feedstock to make cellulosic plastics (Wilkinson 2001). Cellulose acetates are considered as potentially useful biodegradable polymers. Some of the applications of cellulose acetate polymers are film substrates for photography, toothbrush handles, selective filtration in the medical field, automotive coatings, etc (Edgar et al. 2001). A biodegradable polymer, in present, is classified into light-degradable polymers and a microorganism-degradable polymer by blending with starch (Y. S. Shin and B. Y. Shin 1994). Polyethylene (PE) is a widely used polymer as thermoplastic resin. Cellulose acetate (CA) is manufactured simply at low cost as a general polymer and has many advantages. Furthermore, it is considered as a cellulose derivative to be appropriate as degradable additives.

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In this research, various processing issues were investigated to study the physical and mechanical properties of cellulose acetate-polyethylene (CA-PE) composite films to find their best manufacturing conditions and applications.

MATERIALS AND METHODS

Sample preparation

Powdered cellulose acetate (D.S.: 2.3–2.5) and low-density polyethylene (LDPE) was supplied by Kokusan Chemical Co. and Samsung Chemical Co. Ltd., respectively.

Polymer composite film preparation

Definite proportion of cellulose acetate (CA) and polyethylene (PE) were mixed and MAH (maleic anhydride) was added for coupling agent and TBPB (t-Butyl Peroxy Benzoate) for the reaction in the mixing machine (BRABEND) system. Reaction temperature was controlled at 170–180°C. For the evaluation of the effect of composite element on films, various CA-PE mixtures (wt:wt) in the ratios of 50:50, 60:40 and 70:30 were used for composite film manufacture. Furthermore, the amount of MAH and TBPB were the proportion to the amount of CA containing 1% MAH and 0.5% TBPB for the reaction with blending.

Strength of polymer composite film

All polymer films prepared were tested by the basis on the Korean Industrial Standard (KS) as following conditions. Sample size for tensile strength was 20mm with 120mm length.

Model: Hounsfield tensile strength tester.

Temperature: 25 °C, Test clearance: 20mm, Test speed: 10mm/min.

FT-IR analysis of polymer composite film

The Fourier Transform Infrared (FT-IR) spectrum was also applied to the polymer film of each sample to measure the reaction existence of acetyl group in cellulose, the amount of hydroxyl group remains, and the existence of carbonyl group. For this analysis, each sample was prepared as KBr pellet after fine grinding with KBr. The samples were analyzed using a Galaxy 7020A spectrometer. Analysis conditions of FT-IR were as follows.

Analysis Instrument Model: Mattson Instruments Inc. Galaxy 7020A, Spectral range: 4000–400 cm^{-1} , Beam splitter: Coated on KBr, Detector: DTGS, Resolution: 0.25 cm^{-1} .

Thermal analysis of polymer composite film

To examine the potential of application and thermal characteristics of polymer film, DSC (Differential scanning calorimetry) method was applied in this study to investigate glass transition temperature (T_g). Analysis method was as follows.

Model: DSC, TMA, STA. Rhometric. Co (U.S.A), Sample weight: 5.017mg, Heating rate: 10.0 °C/min, Temperature range: 25–350 °C, Nitrogen flow rate : 1 ml/min.

SEM observation

Scanning Electron Microscope (SEM) observation on the surface structure in polymer resin was conducted to determine the combination conditions and polymer resin shape in microscopic part. An analysis condition was as follows-

Model: Hitachi, S-570, Resolution: 35Åcompensation, Magnification: 500~200,000 (WD=2mm), Ion coater: 50mm (Ekio Engineering, IB-3).

RESULTS AND DISCUSSIONS

Tensile strength

Tensile strength and elongation ratio of the polymer films were obtained from above test, and are listed in Table 1. Tensile strength of the polymer film was improved with 70:30 mixing ratio (CA:PE). On the other hand, the elongation ratio of that was increased in 50:50 mixing ratio (CA:PE).

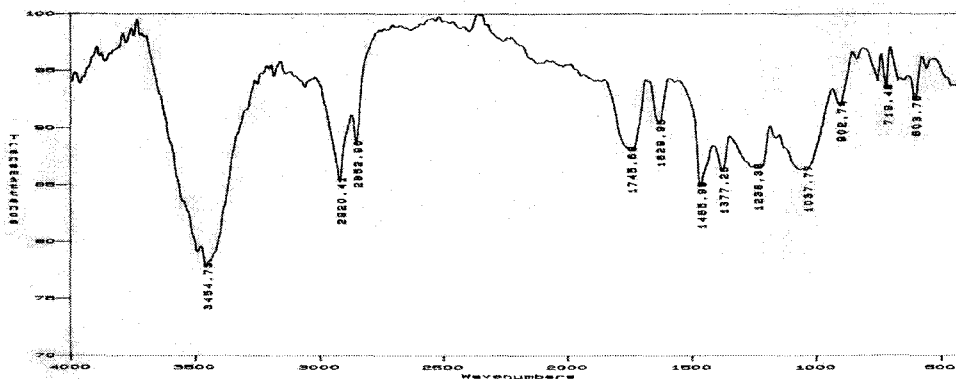
Table 1. Tensile strength and elongation ratio of films in each sample.

CA: PE (g)	Tensile strength (MPa)	Elongation ratio (%)
50 : 50	3.08	5.90
60 : 40	3.57	3.75
70 : 30	4.62	2.00

Table 1 shows that required strength and elongation ratio could be gain under control of the mixture ratio of CA and PE. Therefore, it can be concluded that various polymer films with target physical and mechanical properties can be manufactured from the control of the mixing ratio of the raw material mixture.

FT-IR spectra

Fig. 1 gives IR spectra of polymer films in each blending condition. The band at each condition was detected with some similarities in the spectrum. Fig. 1 shows the $-C=O$ stretching region of pure CA and its blend with PE in various compositions. The main $-C=O$ peaks of pure CA and its blend with various compositions appeared at 1700cm^{-1} band. And the $-C-H$ bonding belong to the maleic anhydride (MAH) appeared at 720cm^{-1} band. The spectra in mixing ratio of 70:30 (CA:PE), however, shows non-uniformity of blending. To solve this problem, mixing conditions such as mixing speed can be considered. Also, it was considered that the uniform blending could be obtained by adding more cellulose acetate.



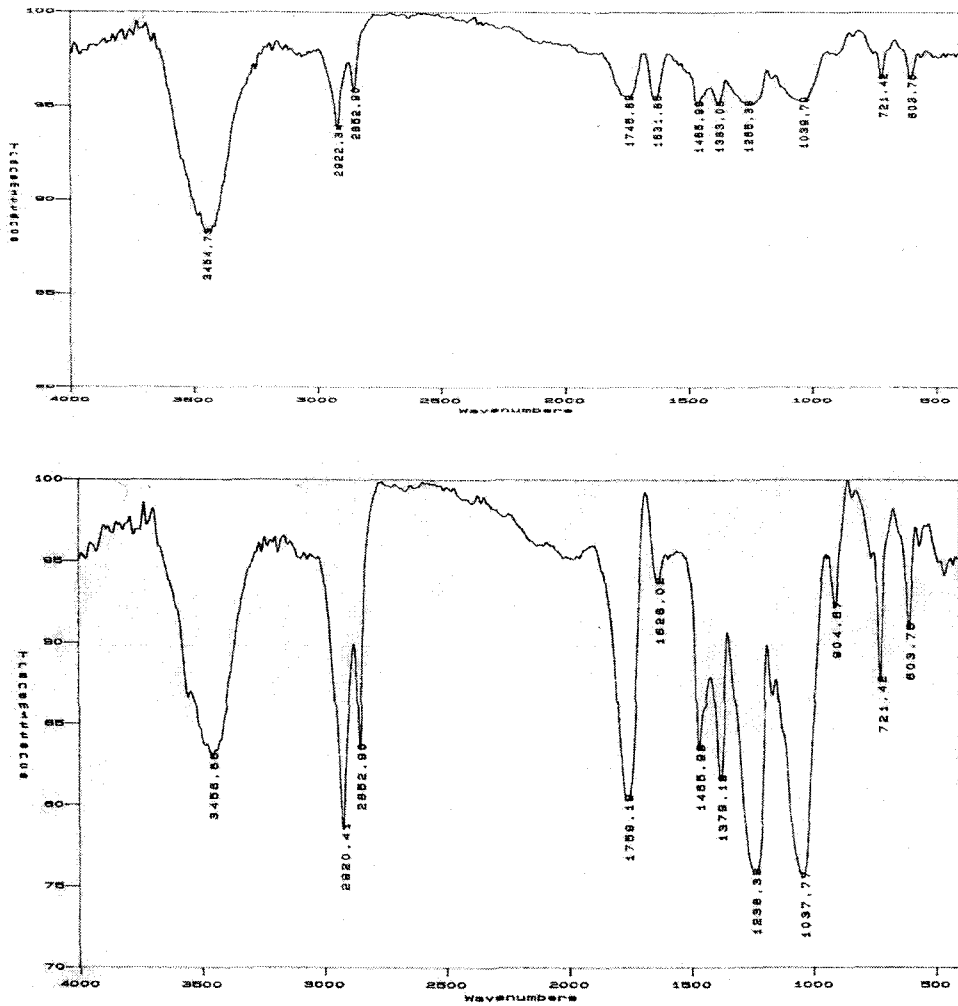


Fig.1. FT-IR spectrum of the composite films with cellulose acetate (CA) and polyethylene (PE) blending. Top: CA:PE=50:50, Middle: CA:PE=60:40, Bottom: CA:PE=70:30.

Thermal analysis

Fig. 2 shows that the melting (T_g) is started at about 50 °C in each condition and decomposing point is about 120 °C. From these thermal analysis curves, it can be considered that the weight of composite films is reducing by heat.

At the mixing ratio of 50:50 in Fig. 2, following phenomena were observed, gradual reduction of the weight of composite film at above 250 °C, a rapid reduction of composite weight at above 350 °C, and complete decomposition at 500 °C. At the mixing ratio of 70:30, the weight change of composite film showed gradual reduction at above 150 °C and a rapid weight reduction at above 340 °C and complete decomposition at 500 °C. In general, however, the T_g starts at about 230 °C. It is considered that the more the amount of CA is, the lower the T_g is.

Therefore, it is found that the decomposition of composite films begin at the temperature range with 150~250 °C. At the temperature above 350 °C, thermal disintegration occurs entirely. Eventually, complete decomposition of composite films, that is, complete combustion, begins at 500 °C.

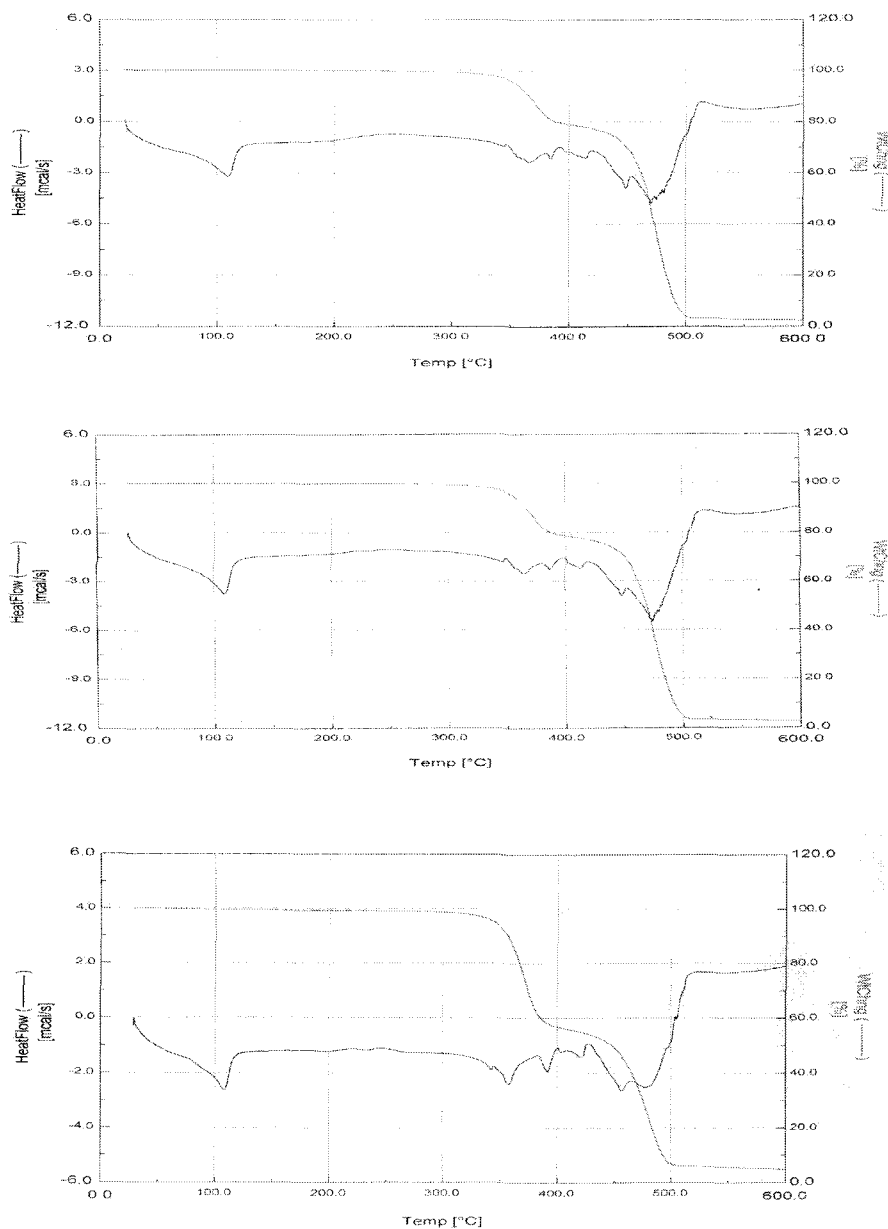
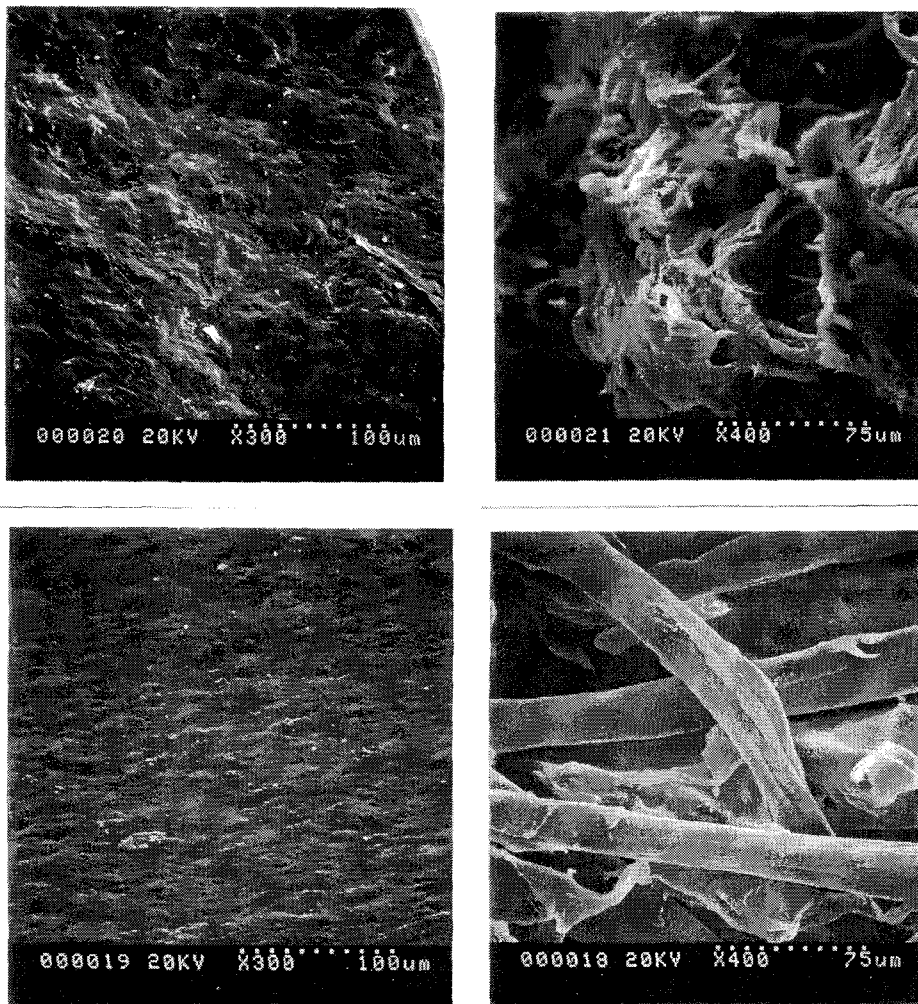


Fig.2. Thermal analysis of the composite films with cellulose acetate (CA) and polyethylene (PE). Top: CA:PE=50:50, Middle: CA:PE=60:40, Bottom: CA:PE=70:30.

SEM observation

In Fig. 3, scanning electron microscope (SEM) photographs are divided into two categories as 300 and 400 magnification. In the left ($\times 300$), considerable fiber blending was occurred together with fiber tearing. In the right ($\times 400$), there is an evidence of matrix resin adhering to the fiber. In the mixing ratio of 70:30, slight non-uniformity and rough surface was observed from FT-IR spectra.

As the amount of CA increases, surfaces of the films were very rough and no interfacial bonding was observed. However, in this case, there were traces of matrix resin that coated the cellulose acetate, which indicates that the adhesion between CA and PE acts on each other. It is considered that this phenomenon is dominated by the manufacturing conditions and combination style between matrix (PE) and fiber (CA).



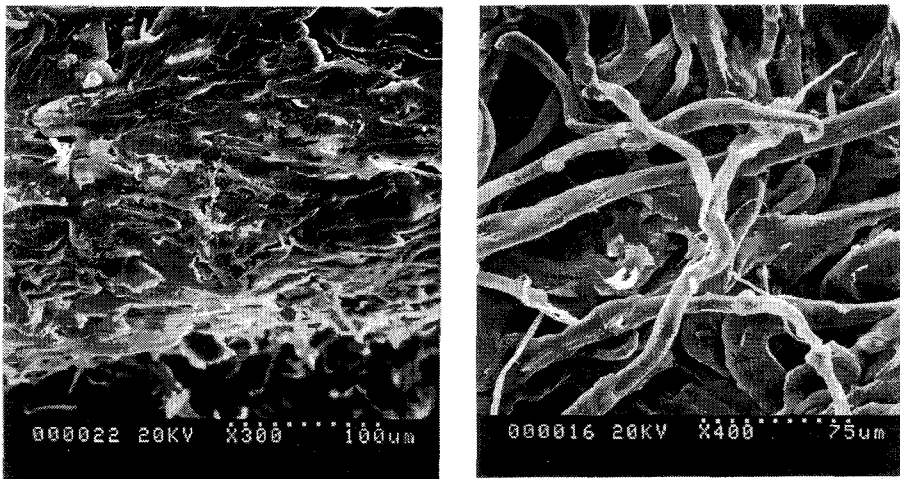


Fig.3. Scanning Electron Microscope (SEM) photographs on the surface of composite films. Top: CA:PE=50:50, Middle: CA:PE=60:40, Bottom: CA:PE=70:30.

CONCLUSIONS

This study was carried out to investigate the optimum blending conditions of polymer composite films with biodegradable CA. Experiments were performed to assess the surface condition, bonding state, thermal analysis, and elongation ratio with tensile strength. Polymer resins manufactured with each blending condition showed very good properties, which gives the potential of good products. However, complete enhancement of mechanical property, biodegradability, and forming of matrix and fiber have not determined yet. Furthermore, it is considered that study for environmentally-friendly biodegradable polymer resins should be conducted.

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