

Characterization of the Mechanical and Thermal Properties of Poly(ϵ -Caprolactone) and Cellulose Acetate Blends

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Abstract – As part of an investigation into producing biodegradable polymers, we evaluated the mechanical and thermal properties of PCL/CA blends and the effect of a compatibilizer (PE-g-GMA) on these mixtures. The addition of 3% PE-g-GMA caused an increasing on both properties for the PCL/CA formulation 40/60.

THERE is increasing evidence that the inappropriate disposal of plastic materials in landfills is having an adverse environmental impact¹. Biodegradable materials are a suitable substitute for these plastics while also retaining desirable physical properties. However, the high cost of production has prevented their widespread industrial use, particularly since conventional polymers are only 15% to 85% of the price of biodegradable polymers. Poly(ϵ -caprolactone) (PCL) and cellulose acetate (CA) are among the most widely used biopolymers². PCL is a synthetic polyolefin that is extensively used in biomedical applications because of its biocompatibility³. In contrast, CA, a natural polymer obtained from cellulose, has a high tensile strength created by the ester links² present in the monomer, with these bonds favoring biodegradation of the polymer⁴. Since the PCL/CA system is naturally immiscible and incompatible³, the addition of a compatibilizer to such blends could improve their properties. The aim of this work was therefore to examine the mechanical and thermal properties of PCL/CA blends with or without the addition of polyethylene-graft-glycidyl methacrylate (PE-g-GMA).

The PCL/CA blends were prepared by casting using proportions of 80/20, 60/40, 40/60, and 20/80. Pure materials were represented by 100/0 and 0/100 for PCL and CA, respectively. The solutions were prepared by dissolving the material in 10% (w/v) acetone, with stirring at $60 \pm 5^\circ\text{C}$ for 6 h. The mixtures were then poured into culture dishes and the solvent was evaporated in an acetone-saturated atmosphere. The same procedure was used for blends containing 3 wt.% of PE-g-GMA, which was dissolved separately in 10% (w/v) cyclohexane with stirring at $100 \pm 5^\circ\text{C}$ for 6 h, after which both solutions were mixed. The proportion of PE-g-GMA incorporated into the blends was calculated relative to the amount of PCL in the blend. Thermal analysis was done using a DSC 204 TASC 414/3A differential scanner in an atmosphere of nitrogen, at a heating rate of $10^\circ\text{C}\cdot\text{min}^{-1}$. Two heating cycles (90°C and 250°C) were used for each film. The crystallinity of PCL was determined using a heat of fusion value (ΔH_f) of 139.5 J/kg^5 for 100% crystalline PCL. The mechanical properties were evaluated using type IV specimens (ASTM D-638/99), and were assessed in a DL 2000 NS 5921 universal testing system. The load cell had a capacity of 20 kgf and the speed of stretching was $50 \text{ mm}\cdot\text{min}^{-1}$.

PE-g-GMA did not significantly affect the melting temperature but increased the tensile strength of pure PCL and the 40/60 blend, while reducing that of CA (Fig. 1). Similarly, PE-g-GMA increased the elongation at break of PCL and the 80/20 and 60/40 blends, but reduced this parameter for pure CA and the 20/80 blend, with increased rigidity of the polymers (Fig. 2). These results indicate that the incorporation of a compatibilizer did not affect the miscibility of the system but affected the molecular orientation of its chains, as shown by the values obtained for the mechanical properties.

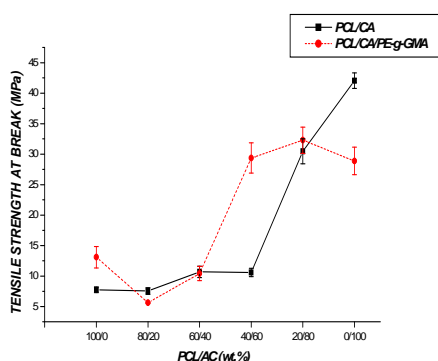


Fig. 1. Average values of tensile strength at break for PCL/CA blends with and without PE-g-GMA.

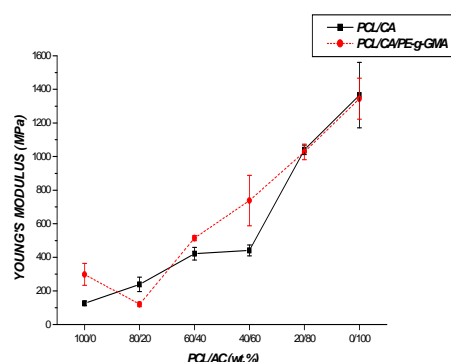


Fig. 2. Average values of Young's modulus for PCL/CA blends with and without PE-g-GMA.

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