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CELLULOSE ESTER / POLYOLEFIN BINARY BLENDS : RHEOLOGY, MORPHOLOGY AND IMPACT PROPERTIES

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INTRODUCTION

Due to depletion of fossil resources and global environmental respect awareness, interest in bio-based plastic materials is tremendously growing. Direct extraction of vegetal polymers like cellulose followed by a chemical modification to bring new properties is one of the paths to produce a bioplastic. Progressively replaced by oil-based polymers in the sixties, thermoplastic cellulose esters are now reconsidered for various materials applications. To improve mechanical weaknesses of cellulose esters based materials, the technique of blending has been widely used. Various blending candidates of cellulose esters have been studied, but mostly with the goal to make the material biodegradable. For this purpose Polyestercarbonates, Polylactides and Polyhydroxyalcanoates were used. To our knowledge, small interest has been paid on durable cellulose ester based blends. More particularly, only few studies have considered the good mechanical properties of cost-effective and easy-available polyolefins as blending partners of cellulose esters.

In this work, blends of cellulose acetate butyrate (CAB) and various polyethylenes (PE) were prepared in the molten state in a batch mixer. CAB is considered as the matrix and PE is the rubbery dispersed phase. The general objective is to improve CAB mechanical properties and among them, impact properties.

EXPERIMENTAL

Materials

Cellulose Acetate Butyrate CAB 531-1 with $M_w = 40.000 \text{ g.mol}^{-1}$ was purchased from Eastman. Glass transition temperature (T_g) and melting temperature (T_m) of CAB are 110°C and 150 – 160°C, respectively. Five **Polyethylenes** with densities ranging from 0.95 to 0.86 were tested as the dispersed phase: HDPE 53050E from Dow, Eni Polimeri Europa's Eraclene MR80 HDPE, Dow's Dowlex SC2108 LDPE, LDPE Innovene LL0209AA from Innovex and Engage 8842 Ultra Low Density Polyethylene (thermoplastic elastomer) from Dow. Volume fraction of Polyethylene ranges from 5% to 30%. Three **Maleic Anhydride Grafted Polyethylene** compatibilizers corresponding to each type of PE (HDPE, LDPE and ULDPE) were added with a volume percentage of 5% or 10%.

Preparation

CAB, PE and the compatibilizer were melt-mixed in an **internal mixer** Haake Rheomix 600 for 15 minutes at 100 rpm. Temperature was set on 170°C but due to viscous dissipation, self-heating occurs, increasing the temperature of about 15°C. Counter-rotating “roller” rotors were used and temperature of molten blend as well as torque was measured in time.

Characterisation

Scanning Electron Microscopy images were obtained with a Zeiss Supra 40 Field Emission Gun on cryofractured surfaces. Back-scattered electrons are detected and the contrast is due to differences in atomic number in each phase. **Dynamic oscillatory rheometry** measurements were performed on a strain controlled ARES rheometer (TA Instruments). Parallel plate geometry was used to study blends visco-elastic response. **Impact testing** was performed on an Instron Ceast 9050 at room temperature with an impact speed of 2.9 m.s^{-1} . Thermoformed samples were notched and tested with the Charpy mode following the ISO179-1/1eA method.

RESULTS AND DISCUSSION

First, **rheology** measurements were performed on single components. Viscosity ratios (η_{PE}/η_{CAB}) were calculated for each CAB-PE blend. The influence of shear rate and temperature on these ratios was determined. It allowed us to predict the dispersibility of each polyethylene in CAB.

Blends were then prepared and **morphologies** were observed. From fine to coarse nodular morphologies were obtained with a very good agreement with the rheological tests. As an example, we give in Fig. 1 the morphology of a blend containing 85wt% CAB mixed with 10 vol% of Dow LDPE Dowlex SC2108 and 5 vol% of compatibilizer. Nodules have a diameter of about $1 \mu\text{m}$.

Charpy impact tests were then performed on notched thermoformed samples. Resistance to impact are given in Fig. 2. Compared to low value of pure CAB (about 1 kJ.m^{-2}), resistance of blends are 5 to 6 times greater, whatever the polyethylene.

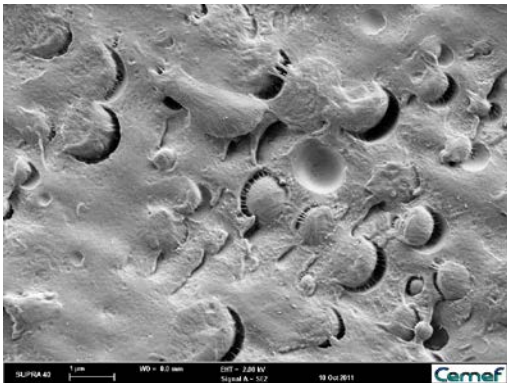


Fig.1. Nodular morphology of blend consisting of a matrix in Cellulose Acetate Butyrate, 10 vol % of Low Density Polyethylene and 5% compatibilizer

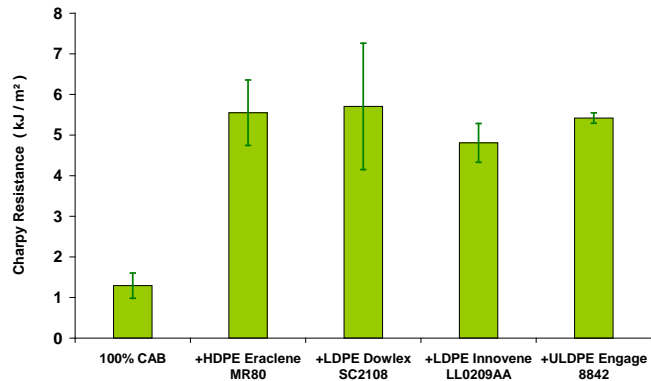


Fig.2. Charpy impact Resistance of pure CAB and of blends of CAB with 10 vol % of Polyethylenes with the corresponding compatibilizer

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