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# REACTIVE PREPARATION OF PPE/PA-6 BLENDS VIA THE APPLICATION OF $\epsilon$ -CAPROLACTAM AS A REACTIVE SOLVENT

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## INTRODUCTION

Solutions of polymer/reactive solvent (monomer) undergo phase separation upon polymerization of the reactive solvent with respect to the incompatibility of most polymers. Studies of chemically induced phase separations created possibilities for controlling the morphology of the final polymer blends and enabled preparation of special morphologies impossible to prepare via conventional mixing, e.g. extrusion.

The concept of reactive solvent was used for the introduction or enhancement of processability of polymers (Fig. 1) and/or the improvement of final properties of polymer blends.

Processability of intractable PPE was introduced via the application of epoxies as reactive solvents [1]. The extension of processability of PE and fine morphologies via the application of styrene and BMA as reactive solvents have been observed [2].

HIPS is commercially prepared from a styrene/rubber solution [3].

Significant attention was given to the toughening of epoxies by applying a neat epoxy resin as reactive solvent for PC, PEI, PPE, PSF, rubbers etc. [3].

Lactams is another interesting group of reactive solvents. The size of lactam ring, thus polarity of reactive solvent can favor solubility of polymers, e.g. less polar lauryllactam is a better solvent for PE, while more polar  $\epsilon$ -caprolactam is a better solvent for PPE, PSF, PEI etc.

$\epsilon$ -caprolactam can be polymerized by anionic ring opening polymerization [4], which generally proceeds faster than the step growth polymerization of epoxy or the radical polymerization of styrene, BMA.

Anionic polymerization of  $\epsilon$ -caprolactam in an extruder above the melting point of PA in the presence of PSF, PEI and PPE has been already reported [5].

This paper will report on reactive processing PPE/  $\epsilon$ -caprolactam systems into PA6/PPE blends at processing temperatures below the melting point of PA6, which could be of potential interest for casting or RIM technology.

## EXPERIMENTAL

Polymer blends PA6/PPE containing up to 75 wt% of PPE have been prepared from homogeneous systems PPE/ $\epsilon$ -caprolactam via an anionic ring opening polymerization. Initiators sodium caprolactamate (NaL) and bromomagnesium-caprolactamate (LMB), catalyst hexamethylene-1,6-dicarbonyl-caprolactam (V5),  $\epsilon$ -caprolactam were provided by DSM Research, Geleen, the Netherlands. PPE of  $M_w$  32 000 from GE Plastics, Bergen op Zoom, the Netherlands was used.

Blends containing up to 30 wt% of PPE were prepared by the mixing of solutions monomer/catalyst/PPE and monomer/initiator/PPE and consequent casting. Systems with PPE content higher than 30 wt% were initially homogenized in an extruder and consequently molded. Polymerization was performed in a mold.

## RESULTS

The morphological study of blends revealed phase separated morphologies of continuous and dispersed phases. In a low concentration range of PPE, up to approximately 6 wt% PPE, for the slowly polymerized system (V5/LMB), PA6 is a continuous phase (Fig. 2.). Blends with higher PPE concentrations (8 and 12 wt %) showed morphologies of PPE continuous phase and dispersed PA6 (Fig.2.).

Virtually complete phase separation of samples containing up to 20 wt% PPE was confirmed by DMTA. Two distinct  $T_g$  peaks of PPE 220° C and PA6 75° C were identified. Monomer/oligomer residue in these samples did not exceed 2 wt %.

Final blend morphology is under static preparation conditions determined in a complex way by:

-reaction kinetics (reaction temperature, initiator and catalyst combination)  
-viscosity of initial solution PPE/ $\epsilon$ -caprolactam solution ( PPE concentration)

High PPE content in initial solution (70 wt %) prevents coalescence and fine morphologies are observed (Fig. 3).

The phase inversion point can be shifted by reaction kinetics and by agitation. Fast polymerized system (NaL/V5) with 10 wt% PPE has still a morphology of PA6 continuous matrix with PPE dispersed particles (Fig.4.a) Agitation of the system during the initial stage of polymerization results in HIPS-like morphologies with PA 6 matrix, PPE dispersed phase with discrete PA 6 particles (Fig.4.b).

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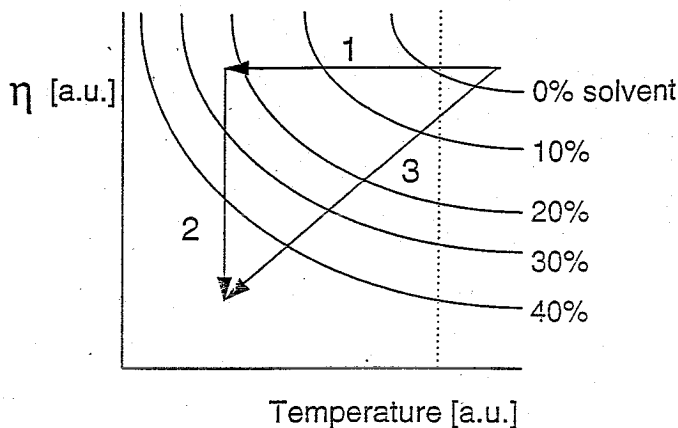
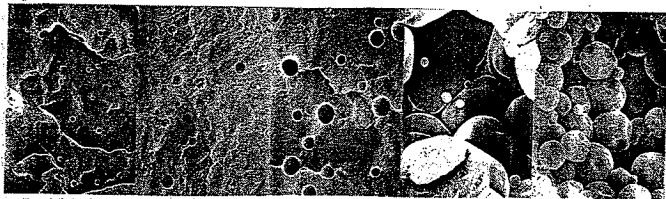


Fig. 1. Processing of polymers with reactive solvents (1) intractable polymers, (2) tractable polymers, (3) combined benefits



PPE: 1%      2%      4%      8%      12%

10  $\mu\text{m}$  ———

Fig.2. SEM of PPE/PA 6 blends, PPE phase is extracted by chloroform

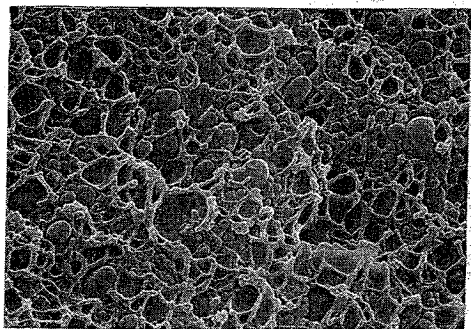
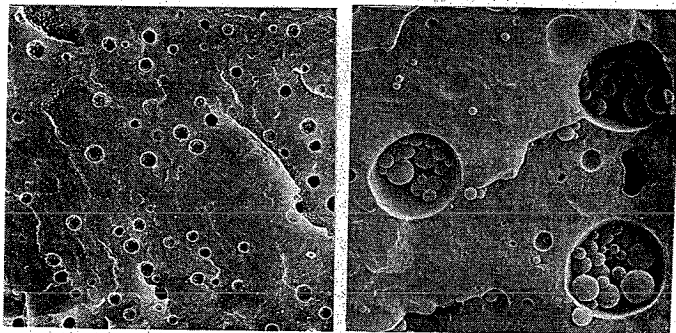


Fig.3. SEM of PPE/PA 6, 70 wt% PPE,      2  $\mu\text{m}$  ———



a. 10  $\mu\text{m}$  ———

b. 2  $\mu\text{m}$  ———

Fig. 4. SEM of PPE/PA 6 blend, 10 wt % PPE, PPE phase extracted with chloroform (a) fast polymerization, static conditions, (b) slow polymerization, stirred during initial part of polymerization