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# Compatibilized Polypropylene/Ethylene–Propylene–Diene-Monomer/Polyamide6 ternary blends: Effect of twin screw extruder processing parameters

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ABSTRACT

Polypropylene (PP)/Polyamide6 (PA6)/Ethylene–Propylene–Diene-Monomer (EPDM) (70/15/15) ternary polymer blends compatibilized with Maleic-anhydride grafted EPDM (EPDM-g-MA) were prepared by melt blending using a twin screw extruder (TSE). Effect of TSE processing parameters including barrel temperature, screw speed and blending sequence on the mechanical properties of ternary polymer blends was investigated by application of Taguchi experimental design methodology. Three different levels of barrel temperature (220 °C, 230 °C, 240 °C), screw speed (90 rpm, 120 rpm, 150 rpm) and blending sequence (nominated as: S1, S2 and S3) were selected. The response variables were tensile properties and impact strength of the prepared samples which are directly affected by the blend microstructure. Investigation of the statistical–mathematical analysis results performed by the software depicted that the optimum processing conditions for the ternary blends investigated here, to achieve balanced tensile and impact properties, are 220 °C, 150 rpm and S2 blending sequence.



## 1. Introduction

Blending two or more polymers is a common approach to develop new polymeric materials with customized properties [1–3]. Generally, these systems are composed of two or more immiscible polymers and display a matrix/dispersed phase morphology. Investigation of ternary polymer blends was first reported at 1980s by Hobbs et al. [4] who studied morphology of blends consisting of three phases. They observed that in some ternary systems one of the minor phases forms a layer around the other phase (core–shell morphology) but in other systems the two minor phases separately disperse in the matrix of the major phase (separated dispersed morphology). Some researchers believe that most of ternary immiscible polymer systems form the stack formation. The vast majority of polymer blend literature is related to the study of a pure dispersed phase in a matrix. Another type of structure known as "composite droplet" is used to specifically describe the case of a dispersed phase that contains another immiscible polymeric phase. Most researchers classify the morphology of ternary blends as: (a) Stacked formation; (b) capsule formation; (c) isolated formation and claim that only when the dispersed polymer phase (1) is wettable between two other polymers as the second minor phase (2) and the matrix (3), the encapsulation of 2 by 1 might occur [5–7].

Morphology type and disperse phase size of blends could be affected by composition, melt viscosity, interfacial interactions and processing parameters. There are several reports in the literature studying the effect of blend composition, melt viscosity or interfacial interactions [8–13] but less attention has been paid to the processing parameters.

Huang et al. [14,15] prepared PP/ethylene 1-octene copolymer (EOR)/EOR-g-MAH blends with two mixing methods i.e. simultaneous mixing and master batch preparation (premixed method) and claimed that the order of mixing does not affect the disperse particle size. They reported that the order of mixing of the components seems to cause negligible difference in the average size of the particles or their polydispersity for the blends with a unimodal particle size distribution regardless of the matrix; however, for the blends having a bimodal particle size distribution, the order of mixing seems to affect the dispersed rubber particle size a little more but still not significantly. On the other hand, Huang et al. [16] found that the intensity of mixing or extruder type affects the average particle size and the twin screw extruder produces smaller particles with a more narrow distribution of sizes than the single screw extruder, as might be expected from the less intensive mixing of the single screw extruder.

Ha et al. [17] prepared PP/High Density Polyethylene (HDPE)/ethylene–octene copolymer (mPE) by melt mixing in a twin screw extruder with two different sequences of mixing: simultaneous mixing of the three components (method I) and premixing of mPE and HDPE followed by mixing with PP (method II). The domain size was mainly determined by the viscosity ratio of mPE to PP in method I and by the viscosity ratio of the binary blend (mPE/HDPE) to PP in method II. In simultaneous mixing, the

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