RHEOLOGY-DRIVEN CONTINUOUS IN-MELT SEPARATION OF PET/PE BLENDS AND LAMINATES: A NOVEL APPROACH TO RECYCLING

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ABSTRACT

Multilayer, multicomponent films are widely used for their barrier properties, with more than 40 million tons of all plastic being produced annually being composed of multilayer polymer systems. This creates an enormous challenge as recycling of these multilayer systems is not technically feasible at large scales. In fact, the component plastics often have differing recycling pathways which prevents these films from being recycled. This work is aimed at developing a novel chemical-mechanical approach that leads to achieving in-process melt separation of polyethylene/polyethylene terephthalate (PE/PET) blends in twin-screw extrusion for posterior individual recycling. Herein, we pursue two strategies to achieve this goal:

1) We use various levels up to 1.00% w/w of pyromellitic dianhydride (PMDA) as a PET chain extender at 260 °C and demonstrate that significant chain-extension occurs up to 0.5% w/w/ of PMDA, while chain-branching becomes dominant above this PMDA level. The corresponding increase in PET viscosity, and consequently blend viscosity ratio, induces coalescence of the PET droplets, which can then be mechanically filtered out of the main PE melt stream. This work further studies the coalescing ability of the chain-extended PET vs. that of branched PET and determines the optimal PET modification levels to maximize droplet coalescence within the typical processing window in twin-screw extrusion of 2-3 minutes.

2) We use various levels up to 8% w/w of ethylene glycol (EG) to depolymerize PET at 260 °C and demonstrate that significant chain depolymerization occurs with a reduction of PET molecular weight (MW) greater than 95%. The corresponding decrease in PET MW allowed for the PET to be depolymerized to a level that was extractable with the aid of SC CO2. The resulting PET wax separated from the PET/LLDPE film was further depolymerized into monomeric form with the aid of zinc acetate. This work further studies the effect EG%, time, temperature, screw design, feed rate, and screw speed have on the depolymerization in a twin screw extruder. Two different reagents EG and BHET (Bis(hydroxyethyl)terephthalate) were used to look at the depolymerization efficiency, with EG being the more efficient depolymerization reagent.