Compatibilizers for recycled polyethylene

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INTRODUCTION

There are strong environmental pressures on industry to recycle waste polymers, particularly those used in packaging applications. Polyethylenes (PE), in the form of high density polyethylene (HDPE) moulding grades, and low density polyethylene (LDPE) or linear low density polyethylene (LLDPE) film grades, currently command more than half of the polymer recycle market. They form the major polymeric part of post consumer waste streams, along with significant amounts of polypropylene (PP), polystyrene (PS), polyvinyl chloride (PVC) and polyethylene terephthalate (PET), and small amounts of other polymers such as polyamides, polycarbonates and barrier polymers. Despite undergoing sorting processes the PE recovered from post consumer waste inevitably contains significant amounts of these other polymers.

The mechanical properties of recycled PE blends can be significantly impaired, in particular their impact and ultimate tensile elongational behaviour. For example, the effect of adding minor levels of polymeric ‘contaminants’ on the Charpy impact strength of HDPE is shown in Figure 1. While adding LDPE hardly affects impact strength, PS, PVC and PET cause a rapid fall off even at low addition levels (<5%), requiring the introduction of compatibilizers to recover performance. Unless otherwise stated, impact provides the yardstick by which the performance of the compatibilizers discussed in this chapter is evaluated. However compatibilizers are not always required. For example, thin walled articles such as household detergent containers fail by ductile
tearing mechanisms, and their impact performance tends to be relatively insensitive to the incorporation of other polymers, as a result of which significant levels (up to 10%) can at times be tolerated in recycling without property loss.

COMPATIBILIZATION MECHANISMS

Immiscible polymer blends form dispersions of two or more phases, in the same way as oil and water, resulting in an uneven and poorly bonded structure in the final product. It is well known that polymers with suitable molecular structures can be used as compatibilizers, which when added at the melt blending stage act as emulsifiers, produce finer and more even phase dispersion. They tend to locate preferentially at the phase boundaries and increase the adhesion between phases. A third effect is to stabilize the dispersed phase particles against growth during annealing, again by modifying the phase–boundary interface. In practice it is likely that all these effects will occur to some extent with addition of a particular compatibilizer, leading to greatly improved end-use performance. Examples illustrating the emulsifying and stabilizing effects of compatibilizers are shown in Figures 2 and 3.