Amorphous or atactic polypropylene

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INTRODUCTION

Amorphous polypropylene (aPP) is characterized by a random steric orientation of the methyl pendant groups on the tertiary carbon atoms along the molecular chain. The random sequence of these methyl substituents is linked to an atactic configuration. Due to its fully amorphous nature, aPP is easy soluble (even at ambient temperatures) in a great number of aliphatic and aromatic hydrocarbons, esters and other solvents in contrast to the isotactic PP (iPP) of semicrystalline feature.

PRODUCTION [1–2]

Until recently, aPP was obtained as a byproduct during polymerization of propylene for iPP. In the early slurry polymerizations processes, the amount of aPP ‘coproduced’ was between 2 and 10 wt.% depending on the iPP grade and Ziegler–Natta catalyst type used (see also the chapter ‘Industrial polymerization processes’). The removal of aPP from the kerosene or low boiling hydrocarbon diluents (e.g. hexane, heptane) via evaporation made the related processes rather costly. It should be emphasized here that the aPP obtained by this way was never fully amorphous and atactic, but a mixture of PPs with various tacticity and molecular weight (MW). The characteristics and quality of the aPP grades depend mostly on the target iPP polymerized, including also its sensitivity to some changes in the polymerization process.

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The second- and higher-generation catalysts with improved stereo-specificity resulted in much smaller aPP yield so that it should not be removed from the iPP products anymore. Due to this development, the aPP grades offered by the iPP producers at that time (e.g. Epolene® of Eastman, USA; AFAX® of Hercules, USA; Daplen® APP of Chemie Linz, Austria; Vestolen® APP of Veba, Germany; Tippllen® APP A, B and C of Tisza Chemical Works, Hungary) disappeared from the market. In the meantime, however, work was undertaken to find useful and cost efficient uses for aPP and, for some of them, aPP became indispensable. As aPP became less available, the markets with successful aPP use created a considerable demand. So, some companies instead of closing older plants converted them to produce aPP as the main product. However, the history of aPP was not completed by aPP turning from a useless byproduct to a desired, well-selling target polymer. A new age of the aPP history is due to recent R&D activities in the field of metallocene-catalyzed polymerization. This revolutionary polymerization technique allows us to produce aPP types of high molecular weight (HMW) being in the range of several hundreds kg/mol. By contrast, the mean MW of the aPP byproducts is one order of magnitude less (few tens kg/mol; Table 1). The increase in the MW is associated with the appearance of new properties, such as rubberlike elasticity.

PROPERTIES

Commercialized byproducts

At ambient temperatures, aPPs are waxy, slightly tacky solids of white or yellowish color. They become softer and more tacky with increasing temperature. The iPP producers recognized early that the commercial success of aPP depends on whether or not their quality is consistent, i.e the properties can be guaranteed within acceptable limits. The easiest way to fulfil this requirement was to select and offer aPP fractions which were extracted from iPP grades produced in larger quantities. For example, the Tippllen APP A, B and C grades of Tisza Chemical Works using the Hercules slurry technology were byproducts of fiber and injection-moldable homopolymers and injection and extrusion moldable iPP block copolymers, respectively. Despite this product philosophy, the properties of the commercialized aPPs had a rather large scatter. The rationale behind this fact was that the quality control including the necessary feedback was tailored for the main iPP and not for the aPP coproduct. As mentioned earlier, the aPP grades are not fully amorphous. Depending on the polymerization and aPP/iPP separation techniques, the crystalline content of the aPP may reach 15 wt.%. The crystalline