Effects of a condensed mode approach on polymerization process, morphology and properties of high-impact ethylene-propylene copolymers

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The amount of ethylene-propylene copolymer (EPC) is a decisive factor for the impact performance of multiphase impact copolymers (ICPs). It is well known that the stable production of ICPs with high EPC content is challenging, even in multi-reactor processes with highly porous catalysts, as the polymer powder can become sticky, resulting in production issues like fouling or sheeting. Slow diffusion of monomers into the core of the reactor powder particles during the EPC production stage has been identified as a root cause of powder stickiness, suggesting the use of induced condensing agents (ICAs) to enhance monomer diffusion inside the particles. Jiang *et al*. [1,2] have recently presented a condensed mode approach using n-hexane as an ICA in the EPC stage of an ICP polymerization process, reporting improved powder flowability and its effect on the comonomer content and molecular weight of the EPC phase.

In the present study, a set of bench-scale polymerizations was performed with Borealis' proprietary post-phthalate Ziegler-Natta catalyst (ZNC) [4] in the presence of either n-pentane (C5) or n-heptane (C7). To better understand the practical applicability of the approach in the Borstar PP hybrid process [3] and to check the generality of the concept, a more realistic bulk matrix polymerization in pure liquid ethylene was applied prior to the EPC production stage.

Our results showed that the ethylene response during polymerization and the comonomer distribution of the EPC phase remained the same, contrary to the claims in the literature. Both C5 and C7 were found to improve productivity. The mechanical performance, thermal properties, and molecular weight of the final polymers were unaffected. Samples containing high amounts of EPC and produced in the presence of C7 showed a pronounced improvement in powder flowability compared to samples containing lower amounts of EPC. In contrast, the powder stickiness of samples polymerized in the presence of C5 appeared comparable or even worse than the reference samples without ICA. AFM images revealed a distinct shift in the spatial distribution of dispersed EPC phases from the particle skin toward the core in case samples produced with the addition of C7. The condensed mode approach offers certain benefits, but only when high-boiling-point ICAs such as C6 or C7 are used in substantial amounts, which are costly to remove and thus may limit the practical applicability of the method.

Keywords: high-impact ethylene-propylene copolymer, condensed mode

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