

Crystallization of polyethylene at large undercooling

Evgeny Zhuravlev¹, VadlamudiMadhavi², Arnold Lustiger², René Androsch³, Christoph Schick¹

¹ University of Rostock, Institute of Physics, Wismarsche Str. 43-45, 18051 Rostock, Germany

² ExxonMobil Research & Engineering Company, 1545 Route 22 East, LD 152, Annandale, New Jersey 08801, USA

³ Martin-Luther-University Halle-Wittenberg, Center for Engineering Sciences, 06099 Halle/S., Germany

Extremely fast crystallization of high-density polyethylene and random copolymers of ethylene with up to 16 mol% 1-octene was observed for the first time by ultra-fast scanning calorimetry. In order to account for the inherently high crystallization rate of polyethylenes, in non-isothermal and isothermal crystallization experiments cooling rates up to 1,000,000 K/s and crystallization times as short as 10 μ s, respectively, were employed. It was possible to supercool the melt of high-density polyethylene down to 57 °C, and the melt of a random ethylene/1-octene copolymer with 16 mol% 1-octene down to -33 °C, without prior crystallization. At these temperatures, the characteristic time of the primary crystallization process is of the order of magnitude of 100 μ s. Complete vitrification of the liquid would require cooling even faster than 1,000,000 K/s. Compared to the homopolymer, the cooling-rate dependence of the crystallization temperatures and the temperature dependence of the characteristic time of primary crystallization of random ethylene/1-octene copolymers both are nearly parallel shifted to lower temperatures. Fast crystallization under condition of reduced linear crystal growth rate is possibly caused by boosting homogeneous nuclei density up to 10^{27} m^{-3} and urgently requires further investigation.