Tammann's Approach for Investigation of Nucleation Kinetics Applied to Fast Scanning Calorimetry of Polymers

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Polymers are often enhanced by nano-fillers, mainly in order to modify it's optical and mechanical properties. Essentially by increasing the number of crystallites by adding heterogeneities, the product can be made optically transparent, stiff and reduce the production time by increasing the rate of crystallization. The same effect can be reached also by significant supercooling of the molten polymer. Then the homogeneous nucleation overrun the heterogeneous and end up with orders of magnitude finer structure. The comparison of these two crystal nucleation mechanisms and their interplay on example of poly (e-caprolactone) (PCL) was the aim of this study. In order to avoid crystallization on quenching to the temperature region of homogeneous nucleation, the cooling rates of 30,000 K/s should be realized for PCL, highly nucleated with multi-walled carbon nanotubes (MWCNT). The processes at such cooling rates can only be investigated by fast scanning chip calorimetry, which allows both cooling up to 10 MK/s, precise temperature profile realization with the accuracy of 1 ms and the quantitative heat capacity measurement. As soon as the sample is quenched, it crystallizes almost independently on the amount of the expensive nucleating agent, because of the large number of homogeneous nuclei. The observation is compared for different industrially important and bio- polymers: poly (butylene succinate) (PBSu), poly (butylene teraphtalate) (PBT) and poly (butylene naphtalate) (PBN). All show essentially the same effect, depending on the separation of homogeneous nucleation kinetics and crystal growth kinetics.