World Academy of Science, Engineering and Technology
International Journal of Chemical and Materials Engineering
Vol:12, No:10, 2018

A Study on the Shear-Induced Crystallization of Aliphatic-Aromatic Copolyester

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Abstract : Shear-induced crystallization, originated from orientation of chains along the flow direction, is an inevitable part of most polymer processing technologies. It plays a dominant role in determining the final product properties and is affected by many factors such as shear rate, cooling rate, total strain, etc. Investigation of the shear-induced crystallization process become of great importance for preparation of nanocomposite, which requires crystallization of nanofibrous sheared inclusions at higher temperatures. Thus, the effects of shear time, shear rate, and also thermal condition of cooling on crystallization of two aliphatic-aromatic copolyesters have been investigated. This was performed using Linkam optical shearing system (CSS450) for both Ecoflex® F Blend C1200 produced by BASF and synthesized copolyester of butylene terephthalate and a mixture of butylene esters: adipate, succinate, and glutarate, (PBASGT), containing 60% of aromatic comonomer. Crystallization kinetics of these biodegradable copolyesters was studied at two different conditions of shearing. First, sample with a thickness of 60µm was heated to 60˚C above its melting point and subsequently subjected to different shear rates (100–800 sec-1) while cooling with specific rates. Second, the same type of sample was cooled down when shearing at constant temperature was finished. The intensity of transmitted depolarized light, recorded by a camera attached to the optical microscope, was used as a measure to follow the crystallization. Temperature dependencies of conversion degree of samples during cooling were collected and used to determine the half-temperature (Th), at which 50% conversion degree was reached. Shearing ecoflex films for 45 seconds with a shear rate of 100 sec-1 resulted in significant increase of Th from 56˚C to 70˚C. Moreover, the temperature range for the transition of molten samples to crystallized state decreased from 42˚C to 20˚C. Comparatively low shift of 10˚C in Th towards higher temperature was observed for PBASGT films at shear rate of 600 sec-1 for 45 seconds. However, insufficient melt flow strength and non-laminar flow due to Taylor vortices was a hindrance to reach more elevated Th at very high shear rates (600–800 sec-1). The shift in Th was smaller for the samples sheared at a constant temperature and subsequently cooled down. This may be attributed to the longer time gap between cessation of shearing and the onset of crystallization. The longer this time gap, the more possibility for crystal nucleus to re-melt at temperatures above Tm and for polymer chains to recoil and relax. It is found that the crystallization temperature, crystallization induction time and spherulite growth of aliphatic-aromatic copolyesters are dramatically influenced by both the cooling rate and the shear imposed during the process.

Keywords : induced crystallization, shear rate, aliphatic-aromatic copolyester, ecoflex
Conference Title : ICMPE 2018 : International Conference on Macromolecular and Polymer Engineering
Conference Location : Paris, France
Conference Dates : October 29-30, 2018

Open Science Index, Chemical and Materials Engineering Vol:12, No:10, 2018 publications.waset.org/abstracts/98704.pdf