

Nucleation induced by elongational flow

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Introduction

Crystallization of semi-crystalline polymers can be enhanced strongly by chain orientation during melt flow. Elongational components may cause extraordinary large molecular orientations, specially for molecules from the high end-tail molecular-weight distribution. They act as nuclei during crystallization, since relaxation time of these molecules is very large.

Objectives

- determine the influence of deformation history on crystallization kinetics
- develop/extend crystallization models that incorporate the influence of deformation history

Cross Slot Flow Cell

A stagnation flow with a strong elongational component is created by moving a ring with two cams, using a motor. Temperature history in the flow cell is controlled by three oil-baths.

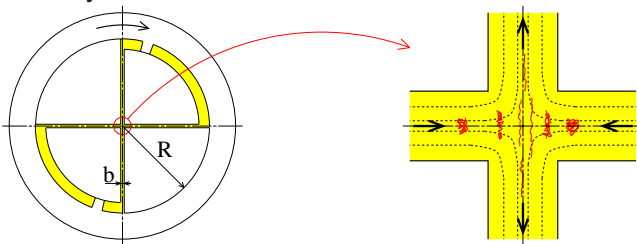


Figure 1: Left: Cross slot flow cell ($R = 50$ [mm]; $b = 2$ [mm]). Right: Enlarged detail around the stagnation point. Red lines illustrate the stretching of polymer chains in the hyperbolic flow field.

Material and Methods

Wide Angle X-ray Diffraction (WAXD) measurements were performed at the micro-focus beam line of the ESRF (Grenoble, France) on iPP (DSM StanylP 13E10; $M_w = 501$ [kg/mol] and $M_w/M_n = 6.0$ [-]) at the stagnation point of the cross slot, using a beam size of about 10 [μm].

Experimental Conditions

- annealing for 60 minutes at 220 [$^{\circ}\text{C}$] to erase crystal and flow memory
- cooling to 148.4 [$^{\circ}\text{C}$]
- creating flow ($\dot{\gamma} \approx 0.08$ [s^{-1}])
- following isothermal crystallization by WAXD

References:

- [1] EDER, G. AND JANESCHITZ-KRIEGL. Crystallization. IN MEIJER, H.E.H., EDITOR, *Processing of Polymers*, VCH, 1997.
- [2] SWARTJES, F.H.M. *Design, Development and Realization of a Cross-slot Flow Device*. ISBN 90-5282-925-X, 1999.
- [3] VLEESHOUWERS, S., MEIJER, H.E.H. *Rheol. Acta*. 35:391-399, 1996.

Results

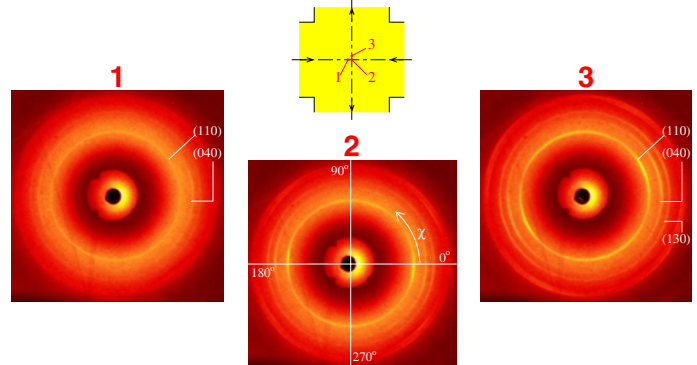


Figure 2: 2D WAXD patterns around the stagnation point.

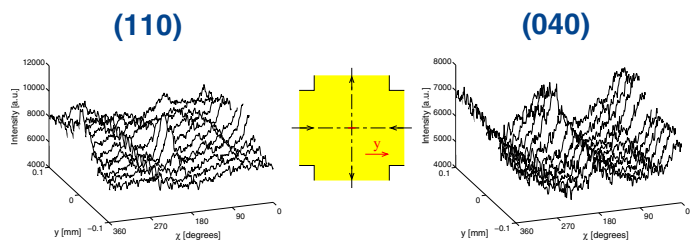


Figure 3: WAXD intensity vs orientation angle and distance from the stagnation point on inflow center line.

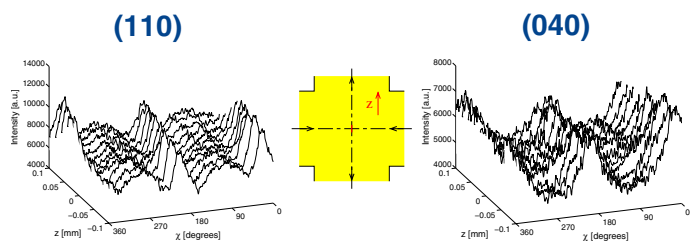


Figure 4: WAXD intensity vs orientation angle and distance from the stagnation point on outflow center line.

Conclusions

- Close to the stagnation point orientation is found in both (110) and (040) reflections, parallel to outflow direction.
- The area in which this structure can be found is about 80 [μm] in inflow and at least 0.2 [mm] in outflow direction.
- This area correlates with the first normal stress difference.

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