

Flow-induced crystallization of PP/PE copolymers

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Flow-induced crystallization of PP/PE copolymers.

J.W. Housmans, G.W.M. Peters, H.E.H. Meijer

Eindhoven University of Technology, Department of Mechanical Engineering

Introduction

The major disadvantages of PP are low temperature brittleness and opacity. A way to improve these properties is to use PP/PE random copolymers (RACO's) that also have the advantage of a decrease of the processing temperatures [1]. This study deals with the influence of ethylene content on crystallization behavior and the characterization of these materials for future modeling purposes.

Materials and methods

- A PP homopolymer and three PP/PE RACO's with different ethylene contents (Borealis, Linz).
- All grades have the same molar mass ($M_w \sim 310$ kg/mol) and polydispersity ($D \sim 3.4$) [2].
- Oscillatory experiments to determine the linear viscoelastic response.
- Short term shear experiments, see Fig. 1.

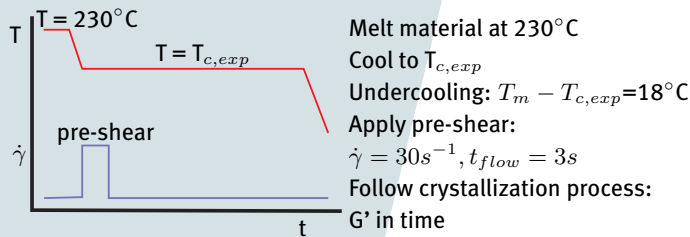


Figure 1 Short-term shear experiment.

Results

The introduction of ethylene monomer in PP leads to:

- a decrease in crystallinity.
- a depression of the glass-transition (T_g), melt (T_m) and crystallization temperature (T_c , Table 1).

Table 1: Basic characteristics of the PP grades.

Type	Ethylene [mol%] ¹⁾	T_g [°C] ²⁾	T_m [°C] ²⁾	T_c [°C] ²⁾	X_c [%] ^{2,3)}
HD234CF	0	-2	163	112	45
RD204CF	3.4	-4	147	105	39
RD226CF	5.2	-5	143	101	37
RD208CF	7.3	-11	138	95	33

¹⁾ From [2], determined using NMR spectroscopy.

²⁾ Determined using DSC, $\dot{T} = 10^\circ\text{C}/\text{min}$

³⁾ $\Delta H_m = 209$ J/g for 100% crystalline PP, [2].

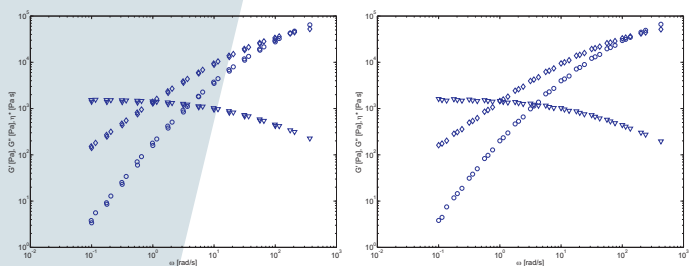


Figure 2 Linear viscoelastic response of HD234CF (left) and RD208CF (right), measured at different temperatures and shifted to $T_{ref} = 220^\circ\text{C}$. $\circ = G'$, $\diamond = G''$, $\triangle = \eta^*$.

Although a clear influence of ethylene is seen on e.g. T_m , the linear viscoelastic behavior is not altered (Fig. 2).

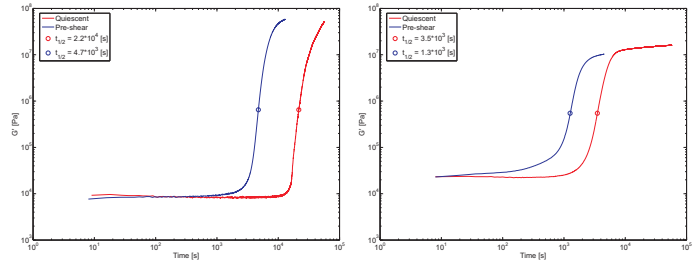


Figure 3 Crystallization behavior for HD234CF (left) and RD208CF (right). Red = without flow, blue = with flow (pre-shear: $\dot{\gamma} = 30\text{s}^{-1}$, $t_{flow} = 3\text{s}$), \circ : defines $t_{1/2}$.

Conclusions

As known from earlier studies [3], the crystallization process is accelerated when shear is applied, Fig. 3 (left). Crystallization of PP is also greatly influenced by the addition of ethylene when compared at the same undercooling, i.e. the half-time of crystallization ($t_{1/2}$) is decreased with almost 1 order of magnitude, Fig. 3.

Future work

A rheological classification of flow induced crystallization is proposed, which identifies different flow regimes [4]. The characteristics can be summarized in a plot (t_{flow} , $t_{1/2}$), see Fig. 4 [5]. How this graph is influenced by the addition of ethylene will be the subject of future research.

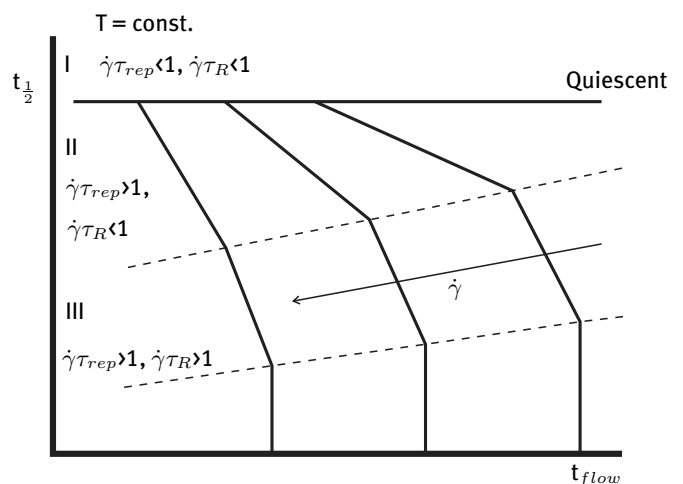


Figure 4 Rheological classification of flow induced crystallization.

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