Shear flow dependence of the specific volume of isotactic polypropylene

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Introduction

The (bulk) specific volume of polymers is of importance because it is one of the main properties affecting the final dimensions and shape of products. The influence of shear flow on the specific volume was investigated at non-isothermal conditions and elevated pressure, using a custom designed dilatometer [1]. In addition, WAXS analysis was performed *ex situ* to study the influence on the crystalline morphology.

Experimental

The materials used in this study are two commercial isotactic polypropylenes characterized by: $\overline{M}_w = 365\ kg/mol$, $\overline{M}_w/\overline{M}_n = 5.2$ (iPP-1) and $\overline{M}_w = 500\ kg/mol$, $\overline{M}_w/\overline{M}_n = 6.0$ (iPP-2).

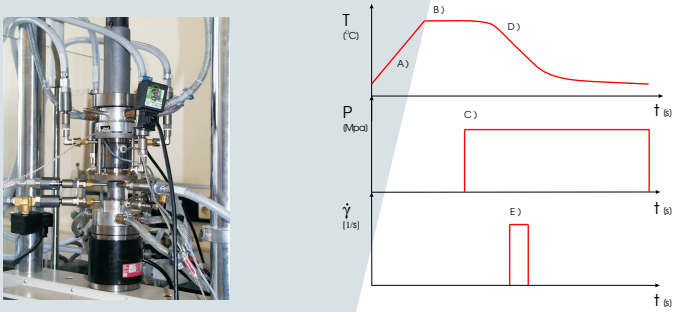

Figure 1. *The custom designed dilatometer (left) and a schematic representation of the employed experimental procedure (right).*

Results

Shear flow experiments are performed with $\dot{\gamma} = 38.5\ 1/s$ during 3.0 s at various temperatures T_γ. All measurements are performed at a constant pressure of 40 MPa and a characteristic cooling rate of 1.4 $^oC/s$. The applied shear flow is quantified using the dimensionless *Deborah* number [2]:

$$De = a_T\ a_P\ \tau\ \dot{\gamma} \qquad (1)$$

with τ based on the largest value of the spectrum determined from SAOS rheological characterization.

	iPP-1		iPP-2	
T_γ $[^oC]$	De_{rep} $\cdot 10^4$ [-]	De_s $\cdot 10^1$ [-]	De_{rep} $\cdot 10^4$ [-]	De_s $\cdot 10^2$ [-]
133	1.2921	4.6312	6.9009	1.7429
153	0.7440	2.6666	4.2595	1.0758
193	0.2504	1.7549	1.3174	0.3327

Table 1. *Deborah numbers associated to reptation (De_{rep}) and stretching (De_s) of the chains in the HMW-tail.*

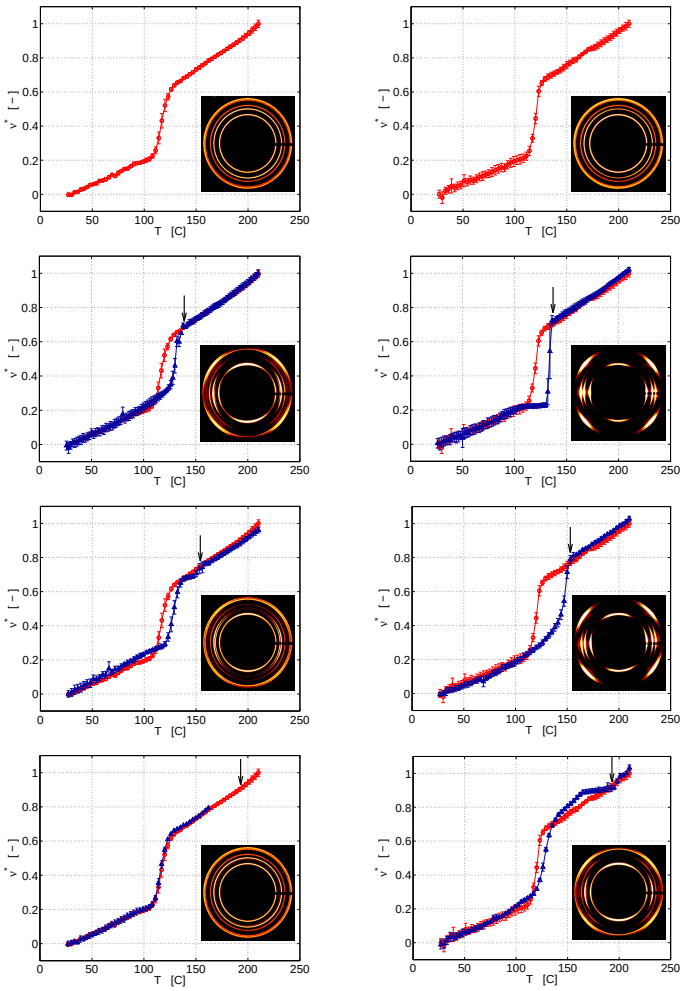

Figure 2. *Influence of shear flow on the normalized specific volume ν^* of iPP-1 (left column) and iPP-2 (right column). Experimental conditions according to table 1.*

Conclusions

- A pronounced influence of flow on the specific volume is found which can be positively linked to orientation of the crystalline morphology
- The influence of flow increases with increasing *Deborah* number, and if large enough, even influences the evolution of specific volume when applied above the experimental melting point

References:

[1] Van der Beek M.H.E. , Peters G.W.M., Meijer H.E.H.: *International Polymer Processing* (submitted)

[2] Van Meerveld J., Peters G.W.M., Hütter M.: *Rheologica Acta* 43(5), pp. 406 (2004)

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