Processing-induced properties in glassy polymers : property development in miscible systems

Processing-induced properties in glassy polymers: property development in miscible systems

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Introduction

In previous work [1] we showed that the yield stress of an amorphous polymer, i.e. polycarbonate, can be quantitatively predicted directly from processing conditions. To do so, the kinetics of aging measured well below the glass transition temperature, T_g, are applied to the temperature history received during processing to give a prediction of the distribution of properties throughout a product. In this study we investigate the applicability of this modelling approach to other polymer systems.

Materials

For this purpose a commercially available miscible system of polycarbonate with polyester[1] has been selected, Xylex®(GE Plastics, Bergen op Zoom, the Netherlands). Three compositions are investigated: the pure polycarbonate (Lexan 141R) taken from [2]; a 50/50 weight percent blend of Lexan and Xylex (LX-50/50) and the pure Xylex (Xylex 8300). DMTA results are shown in the figure below.

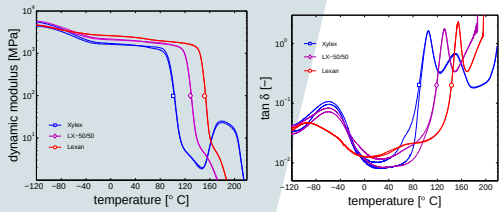

Figure 1 *Dynamic modulus (left) and loss angle (right) of the materials used*

Modelling approach

The kinetics of the yield stress are captured by the following set of equations:

$$a_T(T) = \exp\left(\frac{\Delta U_a}{R}\cdot\left(\frac{1}{T}-\frac{1}{T_{ref}}\right)\right) \quad (1)$$

$$\sigma_y(t) = c_0 + c_1\cdot\log(t_{eff}+t_a) \quad (2)$$

$$t_{eff} = \int_0^t a_T^{-1}(T(\xi))d\xi \quad (3)$$

The evolution of the yield stress is assumed to begin when the glass transition temperature, T_g, taken from the loss angle of the DMTA measurements, is passed.

Experimental

Tensile tests under constant strain rate are performed on samples taken both parallel and perpendicular to the flow direction during processing.

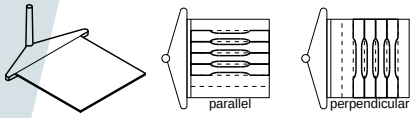

Figure 2 *Injection molded part and tensile bars made thereof*

[1] exact composition under patent protection

Results

Annealing experiments are performed from which mastercurves can be constructed using time-temperature-superposition, which can be described by Equation (2). Results are shown below.

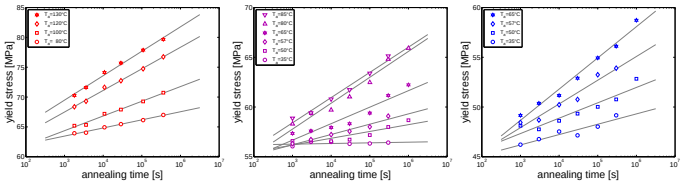

Figure 3 *Annealing results for the pure Lexan (left); the LX-50/50 (middle) and the pure Xylex (right)*

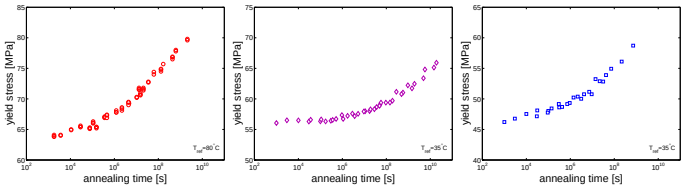

Figure 4 Corresponding mastercurves for the pure Lexan (left); the LX-50/50 (middle) and the pure Xylex (right)

Predictions of the yield stress versus mold temperature are shown below for all materials investigated. Moreover, modelling parameters showed to follow the rule of mixtures.

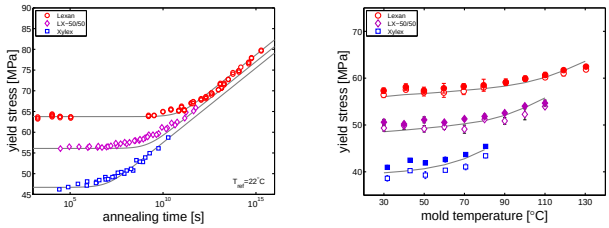

Figure 5 *Combined mastercurves (left) and numerical vs. experimental results for the yield stresses vs. mold temperatures (right)*

Conclusions

The modelling approach presented in previous work is shown to be applicable to different polymer systems. The experimental versus numerical results are in excellent agreement. The modelling approach follows the rule of mixtures.

References:

[1] Govaert, L.E., Engels, T.A.P., Klompen, E.T.J., Peters, G.W.M., Meijer, H.E.H.: Processing induced properties of glassy polymers: Development of the yield stress in polycarbonate. (IPP, XX(2), 170-177, (2005))

[2] Klompen, E.T.J., Engels, T.A.P., Govaert, L.E., Meijer, H.E.H.: Modelling of the post-yield response of glassy polymers: influence of thermomechanical history. (Macromolecules, 38(16), 6997-7008, (2005))

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