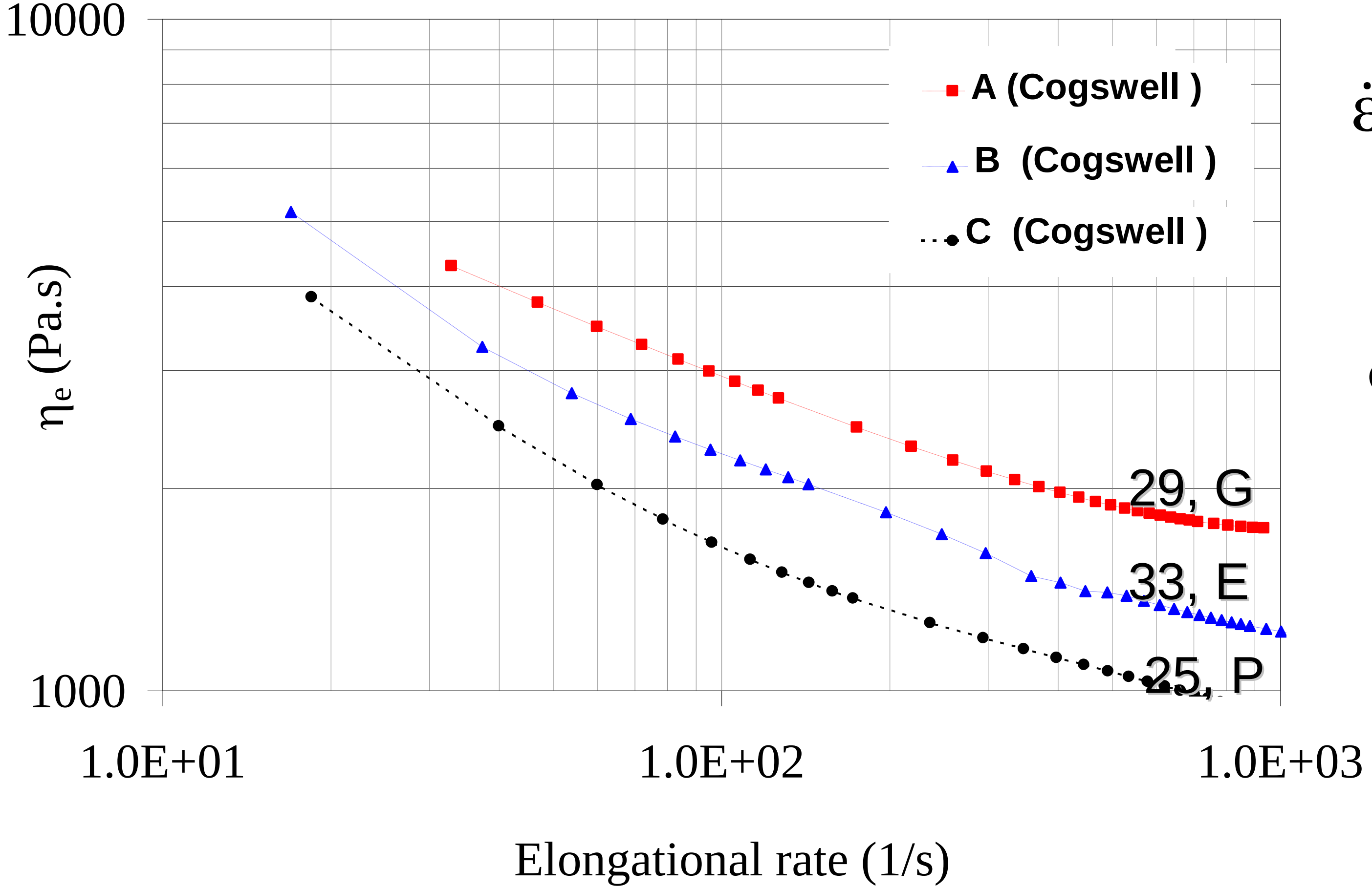
MEASUREMENT AND PREDICTION OF COGSWELL ELONGATIONAL VISCOSITY OF PEROXIDE DEGRADED POLYPROPYLENE RESINS USING THE WAGNER MODEL

Cogswell analysis. Results

Three different PP resins



$$\dot{\varepsilon}_A = \frac{4\dot{\gamma}_A^2 \eta_A}{3(n+1)\Delta P_{ent}}$$

$$\sigma_e = \frac{3(n+1)\Delta P_{ent}}{8}$$

$$\eta_e = \frac{\sigma_e}{\varepsilon_A}$$

OBJECTIVES

- To predict elongational viscosity using the Wagner model and a published damping function which was obtained from direct elongational measurements.

HIGHLIGHTS

- We will use reported damping function (Verney et al. 1993).
- The Wagner model has been validated with LDPE and PP resins

Damping function

Wagner

$$h(t,t')=f_1\exp\{-n_1[\exp(2\dot{\varepsilon}(t-t')-\exp(-\dot{\varepsilon}(t-t'))]\}+$$
$$(1-f_1)\exp\{-n2[\exp(2\dot{\varepsilon}(t-t')-\exp(-\dot{\varepsilon}(t-t'))]\}$$

Papanastasiou:

$$h(t,t')=\Big\{\,1-a\,\{\;\beta\,[\exp(2\dot{\varepsilon}s)+\exp(-\dot{\varepsilon}s)]\;+$$
$$(1-\beta)\,[\exp(-2\dot{\varepsilon}s)+\exp(\dot{\varepsilon}s)]\;-\;3\}^{c}\;\Big\}^{-1}$$

With Verney's (1993) constants:

PP constants: **a=0.056** **c=1.43** β **=0.02**

" β might be material dependent as shear rate increases"

Finger strain tensor for uniaxial elongation

$$C_t^{-1}(t') = \left| \begin{array}{ccc} \exp[2\dot{\varepsilon}s] & 0 & 0 \\ 0 & \exp[-\dot{\varepsilon}s] & 0 \\ 0 & 0 & \exp[-\dot{\varepsilon}s] \end{array} \right|$$

where $s = (t - t')$

Wagner Model: calculation of elongational viscosity

$$\sigma_{11} - \sigma_{22} = \int_{-\infty}^{0} \mu\,(\mathbf{s})\; h(I_1,I_2)\; s\,\{\exp(2\dot{\varepsilon}s)-\exp(-\dot{\varepsilon}s)\}\,dt' \;+$$

$$h(I_1,I_2)\; t\,\{\exp(2\dot{\varepsilon}t)-\exp(-\dot{\varepsilon}t)\} \int_{-\infty}^{0} \mu\,(\mathbf{t})\, dt' = \sigma_e$$

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where : $s = (t - t')$,

$$\sigma_e(t) = \sigma_{11}(t)-\sigma_{22}(t) = \sigma_{11}(t)-\sigma_{33}(t)$$

$$\gamma_e(t,t') = C_{11}^{-1} - C_{22}^{-1} =$$

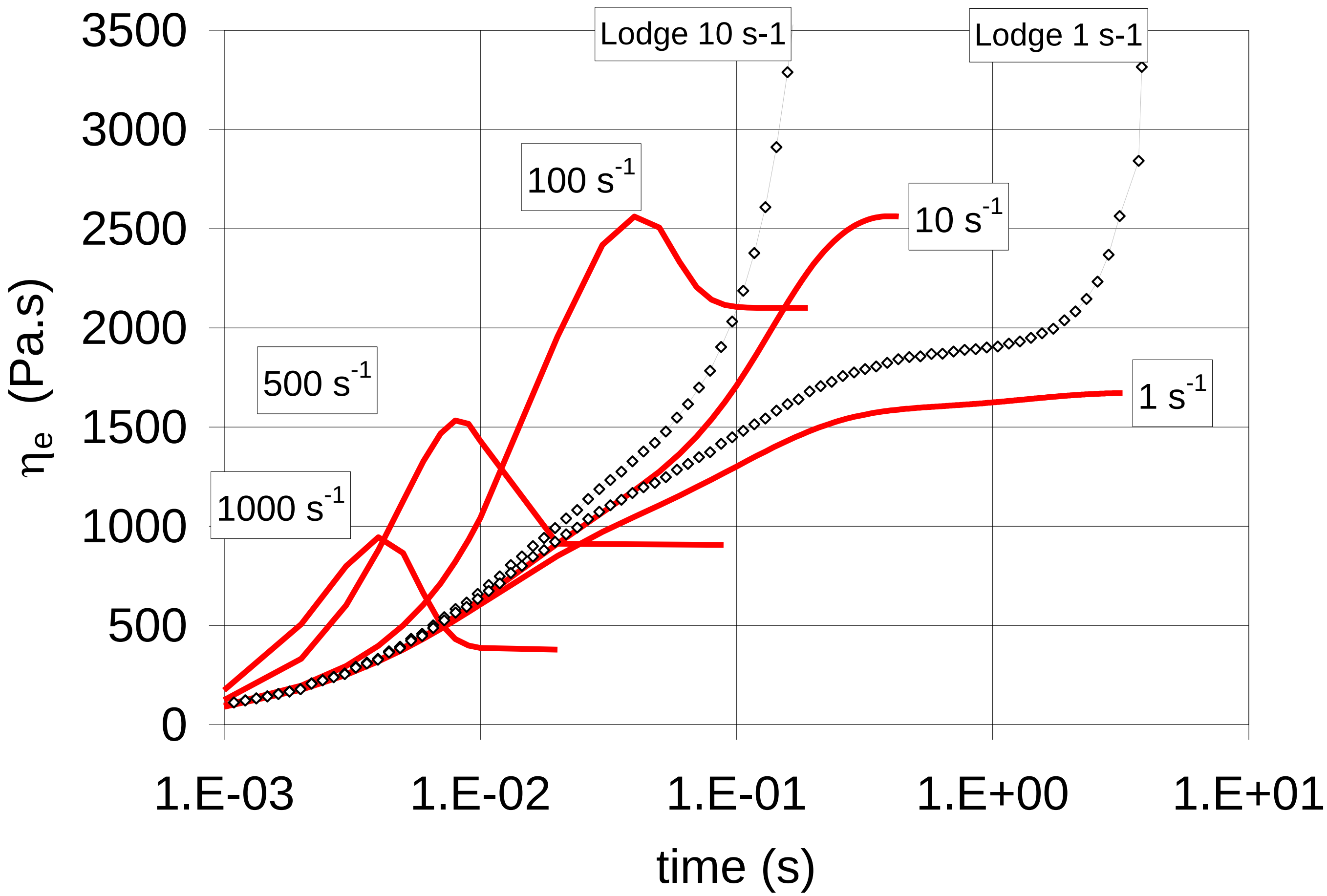
$$= \{\exp(2\dot{\varepsilon}s)-\exp(-\dot{\varepsilon}s)\}$$

$$G(t) = \int_{-\infty}^{0} \mu\,(\mathbf{t})\, dt'$$

$\dot{\varepsilon}$ = elongational rate

$$\eta_e = \sigma_e / \dot{\varepsilon}$$

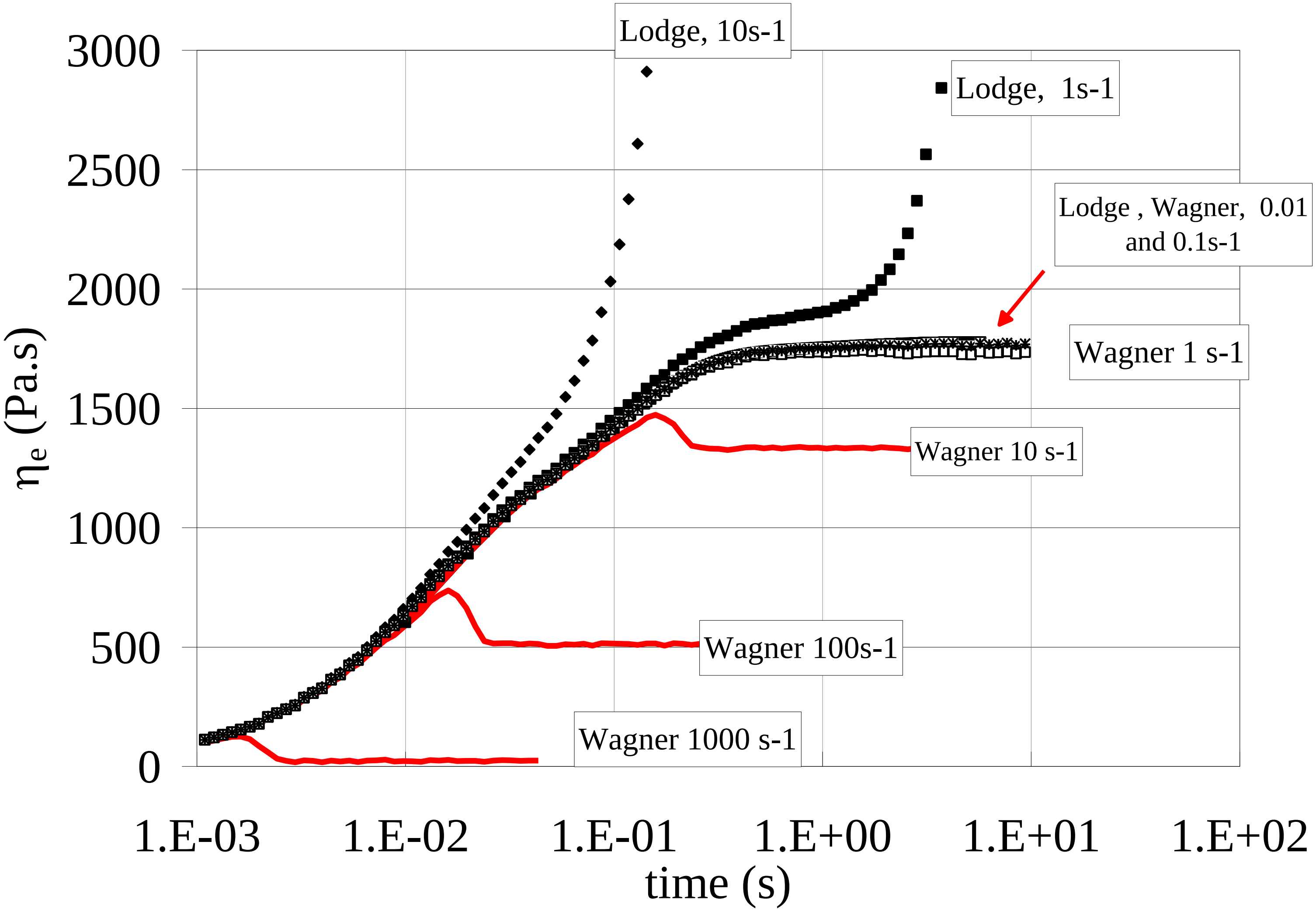
Predicted elongational viscosity versus time



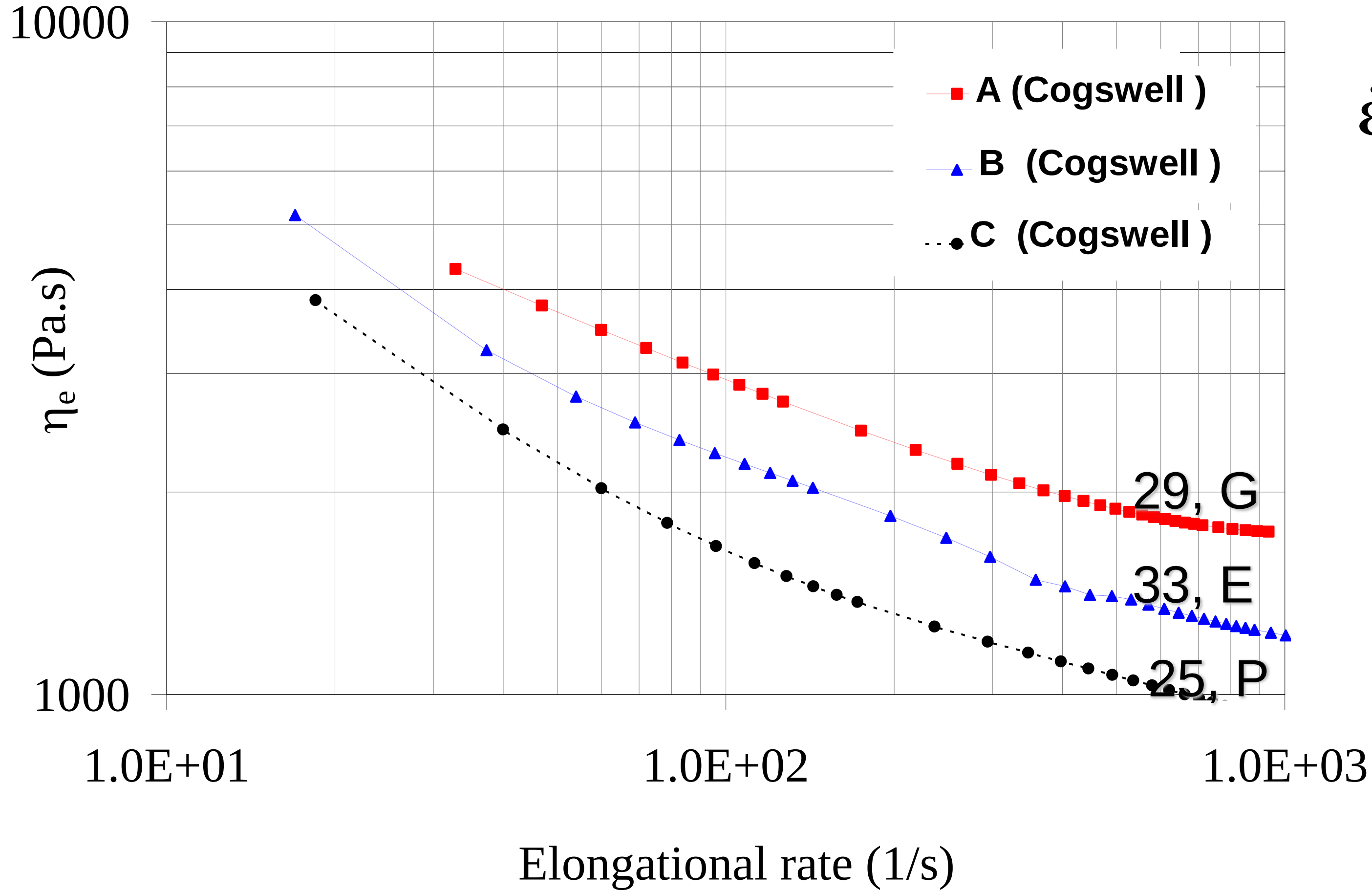
Prediction using Papanastasiou damping function, and Verney's constants for PP resins. Diamonds represent the case were $h(\gamma) = 1$

Predicted elongational viscosity versus time. Lodge and Wagner Models

Lodge model uses h(γ)=1, Wagner model uses a damping function proposed by Wagner



Cogswell analysis. Results



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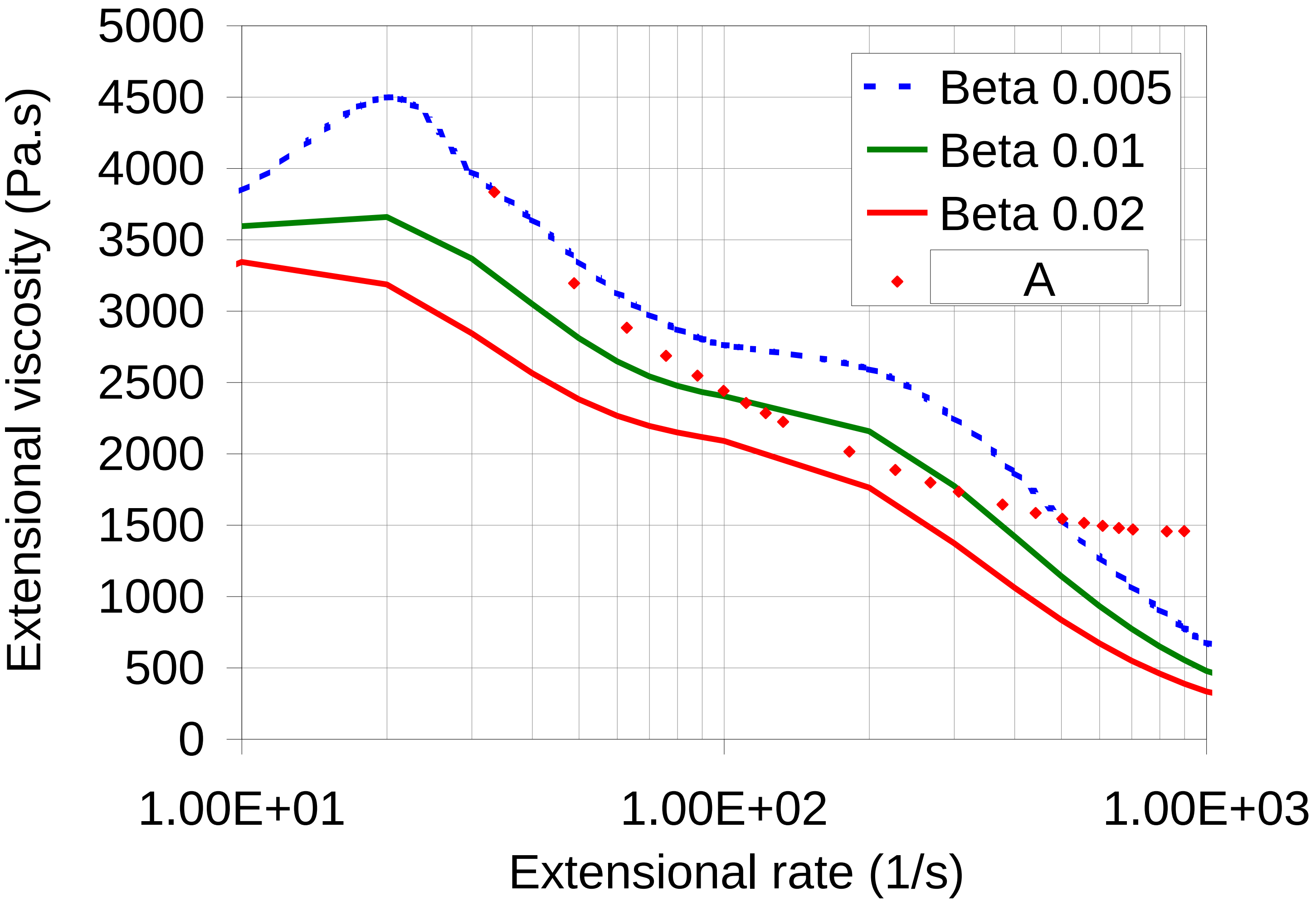
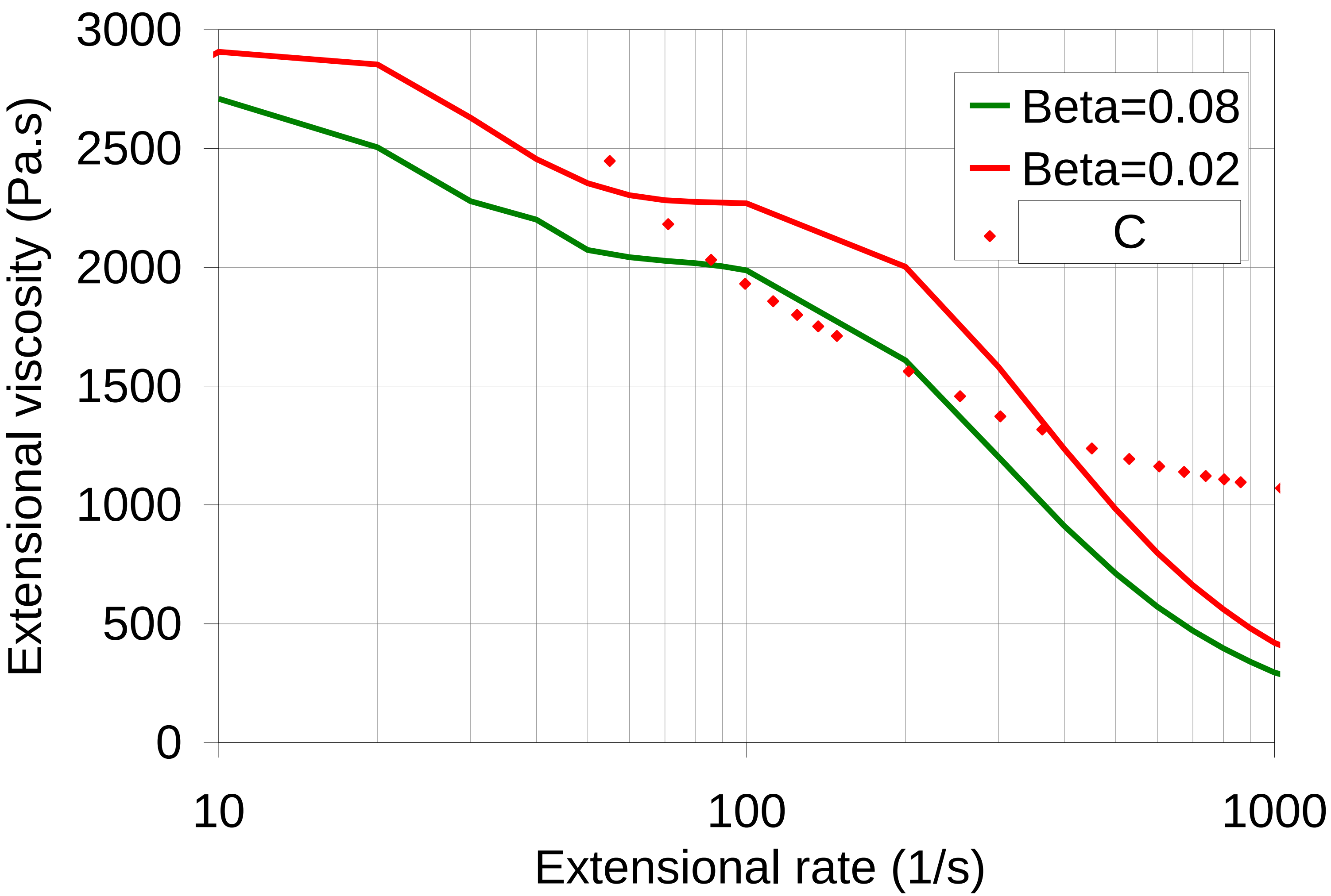
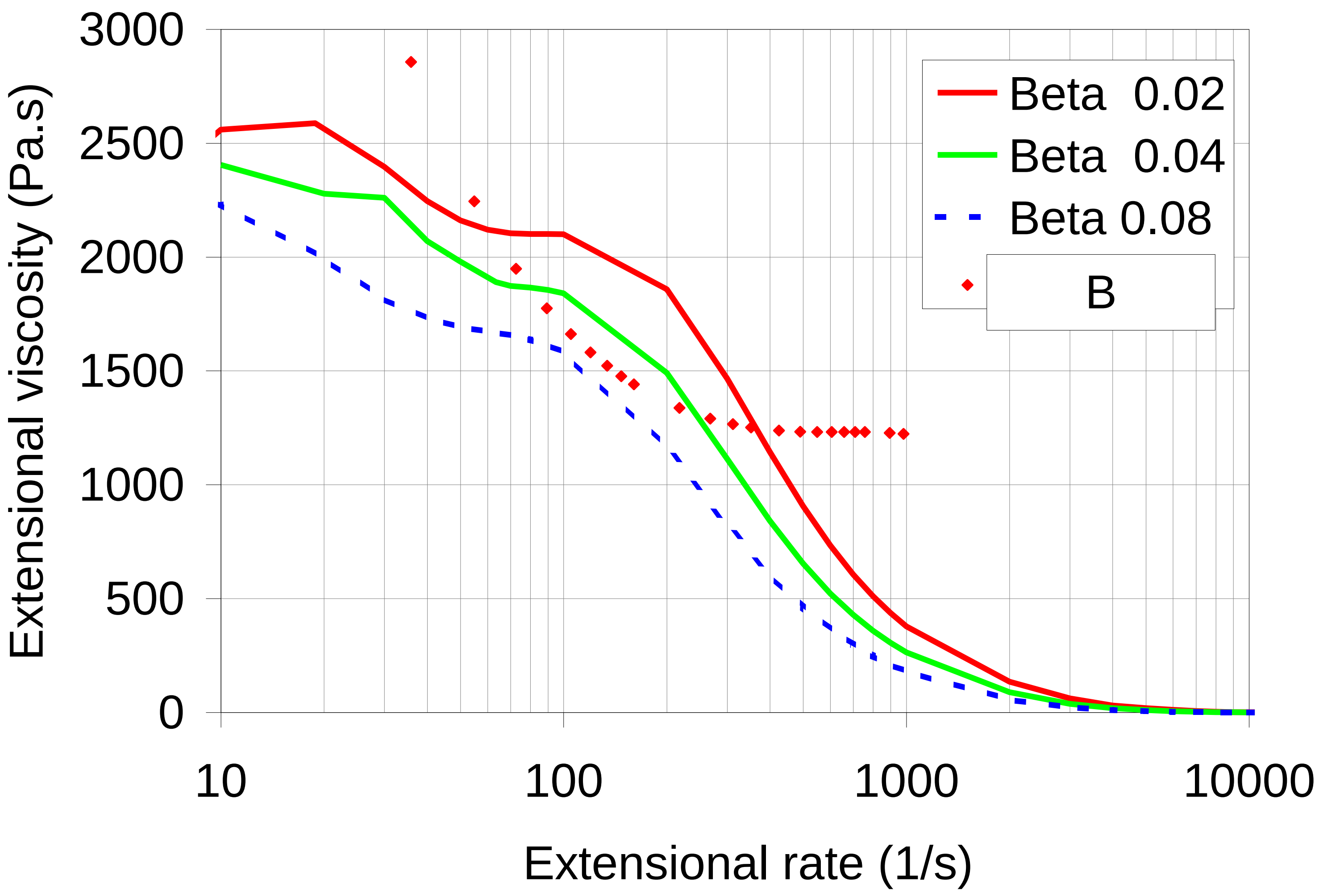
Effect of Beta



Effect of Beta



Effect of Beta



CONCLUSIONS

- Resins with similar MWD moments and MFI have different Cogswell elongational viscosity (η_{ec}).

- Predictions of shear data using constitutive Wagner model were within the range of the Cogswell elongational viscosity, but while η_{ec} seems to converge to a plateau value, the Wagner elongational viscosity decreases sharply after $200 s^{-1}$.

- β is a material dependent parameter.