Rheology and Small Angle Neutron Scattering of model polymer systems

Ludovica Hengeller¹, Qian Huang¹, Andriy Dorokhin², Nicolas J. Alvarez³, Jacob Judas
Kain Kirkensgaard⁴, Ole Hassager¹, Kell Mortensen⁴ and Kristoffer Almdal²

¹ Department of Chemical and Biochemical Engineering, Technical University of Denmark,
  DK-2800 Kgs. Lyngby, Denmark
² Department of Micro and Nanotechnology, Technical University of Denmark, DK-2800
  Kgs. Lyngby, Denmark
³ Department of Chemical and Biological Engineering, Drexel University, PA, USA
⁴ X-Ray and Neutron Science Section at the Niels Bohr Institute, University of Copenhagen,
  Copenhagen, Denmark

We have used anionic polymerization to synthesize well defined linear and branched
model polymers with polystyrene backbones. The linear viscoelastic properties have been
characterized in small amplitude oscillation (ARES-G2 from TA-Instruments) and in large
amplitude extensional deformations (VADER1000 from Rheofilament). We utilize the
unique features of the extensional rheometer to reach steady flow conditions and to perform
relaxation of true stress. Moreover we will show how the techniques may be used in
combination with small-angle neutron scattering (SANS) to perform single chain structural
studies after uniaxial elongation both after steady extensional flow and at several times during
true stress relaxation. Specific examples will include two entangled systems: a pure melt of
short chains and a bi-disperse melt composed of a 50/50 wt mixture of short and long chains.
By labeling the short chains we show a pronounced nematic effect of the long chains which
increases the initial short chain stretch by ~13% and delays the short chain relaxation by a
factor of ~4.