

TIME-RESOLVED SMALL ANGLE SCATTERING STUDIES OF
ALIGNMENT OF BLOCK COPOLYMER SOLUTIONS INDUCED BY
ELECTRIC FIELDS

V. Urban¹, A. Böker², H. Elbs², H. Hänsel², A. Knoll², S. Ludwigs², H. Zettl², V. Abetz³, A.H.E. Müller³, and G. Krausch²

¹Chemical Sciences Division, Oak Ridge National Laboratory, P.O. Box 2008 MS 6100, Oak Ridge, TN 37831; ²Lehrstuhl für Physikalische Chemie II and ³Lehrstuhl für Makromolekulare Chemie II, Universität Bayreuth, D-95440 Bayreuth, Germany

Block copolymers are of considerable academic and nano-technological interest, as the effect of microphase separation that is driven by the incompatibility of the component blocks, provides a wide variety of attainable domain morphologies on the nanometer size scale, which can be tuned by the block copolymer architecture. However, in order to exploit fully the technical potential of these systems, it is necessary to develop methods for the controlled alignment of the nano-morphologies over macroscopic length scales. This can be achieved by applying external fields and in this context we employed time-resolved small angle x-ray scattering at the ESRF high brilliance beamline ID2 in order to study the reorientation kinetics of block copolymer solutions exposed to an electric field. Our studies reveal two distinct processes, i.e. grain boundary migration and rotation of entire grains as the two dominant microscopic mechanisms. The former dominates in weakly segregating systems, while the latter is predominant in strongly segregation systems. The orientation kinetics follows a single exponential time behavior with characteristic time constants varying from a few seconds to some minutes depending on the polymer concentration, the temperature, and the electric field strength. Optimum conditions for the preparation of highly anisotropic bulk polymer samples via solvent casting in the presence of an electric field can be deduced from the experimental results. The dependence of the kinetics upon polymer concentration, temperature, field strength, and system size will be discussed. Additionally, small angle neutron scattering studies of partially deuterated block copolymer solutions will be addressed, as these permit investigation of the polymer chain conformation and therefore can provide a more detailed understanding of the underlying mechanisms of field induced polymer orientation.

This work was funded by the ESRF, Grenoble, France and the German Science Foundation (DFG) in the framework of the Sonderforschungsbereich 481. V. Urban acknowledges financial support by the Office of Biological and Environmental Research, U.S. Department of Energy, under contract No. DE-AC05-00OR22725 with Oak Ridge National Laboratory, managed and operated by UT-Battelle, LLC.

"The submitted manuscript has been authored by a contractor of the U.S. Government under contract No. DE-AC05-00OR22725. Accordingly, the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or allow others to do so, for U.S. Government purposes."