Experimental report

19/12/2017

Proposal: 9-11-1773 **Council:** 4/2016

Title: Exploring the effect of tube dilation in bidisperse blends of long and short PEO chains using ring polymers as probes

Research area: Soft condensed matter

This proposal is a new proposal

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Experimental team: Barbara GOLD
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Samples: C2H4O

Instrument	Requested days	Allocated days	From	To
IN15	14	6	06/12/2016	12/12/2016

Abstract:

Objective of this proposal:

This proposal aims at the investigation of the unrelaxed diluted tube diameter of entangled chains (dPEO, 200.000 g/mol) in dependence of its dilution with short chains (dPEO, 1.000 g/mol) from the dynamic structure factor via neutron spin echo spectroscopy using ring polymers (hPEO, cyclic, 20.000 g/mol) as probes (see scientific background).

The underlying static structure factors of the sample and the reference systems will be investigated by small angle neutron scattering (scheduled at KWS-2, MLZ, Garching, Germany, in May 2016).

experimental report for experiment 9-11-1773

EXPLORING THE EFFECT OF TUBE DILATION IN BIDISPERSE BLENDS OF LONG AND SHORT PEO CHAINS USING RING POLYMERS AS PROBE

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Instrument: IN 15

Aim of experiment: This proposal aims at the investigation of the unrelaxed diluted tube diameter of entangled chains (dPEO, 200.000 g/mol) in dependence of its dilution with short chains (dPEO, 1.000 g/mol) from the dynamic structure factor via neutron spin echo spectroscopy using ring polymers (hPEO, cyclic, 20.000 g/mol) as probes (see scientific background).

Scientific background: Latest results showed that the segmental dynamics of ring polymers embedded in low concentrations ($c < c^*_{ring}$) in a matrix of well entangled linear chains is fully controlled by the surrounding host. Via the state-of-the-art method using labelled linear chains, where the detected dynamics of the model chain is always an overlay of the entangled matrix and the intrinsic local reptation of the model chain itself, the "relaxed" tube diameter (reflected by GN in rheological measurements) is detected. As cyclic polymers cannot relax by local reptation a ring probe gives access to the "unrelaxed" tube diameter (reflected by Ge in rheological measurements), a fundamental parameter for all tube theories, which was accessed experimentally for the very first time by our group via neutron spin echo spectroscopy (IN15) last year [S. Gooßen et al., PRL 115, 148302 (2015)].

After this proof-of-principle in the current proposal we will use ring polymers in low concentrations as probes to explore the effect of tube dilation which can be quantitatively controlled by the concentration of short PEO chains in a well-defined entangled matrix of long PEO chains.

Sample system: The effect of tube dilation was explored by 4 different total fractions of short chains using 10 w % protonated ring polymers (c^*_{ring} = 17 w% in theta solvent) as probes. To compare the "unrelaxed" and "relaxed" tubes, we plan to measure for each dilution also a purely linear reference system, where 10 w% of the long linear chains are protonated.

Dilution (≙ total weight fraction of short chains) 0 w%:
0-cyclic (S1): 10 w% (hPEO-cyclic) / 90 w% (dPEO-lin 200K) / 0 w% (dPEO-lin 1K)
0-linear (S2): 10 w% (hPEO-lin 200K) / 90 w% (dPEO-lin 200K) / 0 w% (dPEO-lin 1K)

Dilution (≙ total weight fraction of short chains) 12.5 w%:
12.5-cyclic (S3): 10 w% (hPEO-cyclic) / 78.75 w% (dPEO-lin 200K) / 11.25 w% (dPEO-lin 1K)
12.5-linear (S4): 10 w% (hPEO-lin 200K) / 78.5 w% (dPEO-lin 200K) / 12.5 w% (dPEO-lin 1K)

Dilution (≙ total weight fraction of short chains) 25 w%:
25-cyclic (S5): 10 w% (hPEO-cyclic) / 67.5 w% (dPEO-lin 200K) / 22.5 w% (dPEO-lin 1K)
25-linear (S6): 10 w% (hPEO-lin 200K) / 65 w% (dPEO-lin 200K) / 25 w% (dPEO-lin 1K)

Dilution (≙ total weight fraction of short chains) 50 w%:
50-cyclic (S7): 10 w% (hPEO-cyclic) / 45 w% (dPEO-lin 200K) / 45 w% (dPEO-lin 1K)
50-linear (S8): 10 w% (hPEO-lin 200K) / 40 w% (dPEO-lin 200K) / 50 w% (dPEO-lin 1K)

Temperature: 413 K

Q-values: 0.05, 0.08, 0.10, 0.13, 0.2 Å^{-1}

Preliminary results: In the plateau regime, the dilution with short chains leads to a decreasing confinement which results in a drop down of the plateau. The figures below show the NSE data obtained for the model system at T = 413 K of the h-ring-system (S1, S3, S5, S7, figure 1 a and b) and h-linear-system (S2, S4, S6, S8, figure 2 a and b).

As can be seen, the predicted trend is clearly visible in the relaxation spectra. A quantitative description by modelling the data in terms of a dynamic random phase approximation is currently underway.