Experimental report

08/02/2018

Proposal: 9-12-482 **Council:** 10/2016

Title: Exploring complex internal dynamics in thermoresponsive nanocompositegels

Research area: Soft condensed matter

This proposal is a continuation of INTER-329

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Samples: graphene oxide (C2O)n
carbon nanotube C92O8
heavy water, D2O
poly(N-isopropyl acrylamide) (C6H11NO)

Instrument	Requested days	Allocated days	From	To
IN11	16	14	17/02/2017	03/03/2017
IN15	5	0		

Abstract:

"Smart", responsive hydrogels are promising candidates for actuators, sensors and biomedical applications such as pressure sensing or artificial cartilage. However, their application is often restricted by physical limitations. Composite systems offer a means to overcome these problems. This proposal aims to study the internal dynamics of carbon nanoparticle (CNP) filled responsive hydrogel systems based on poly-N-isopropyl-acrylamide (PNIPA) above the volume phase transition (VPT) temperature. Our proposed experiment will further deepen our knowledge of the diffusive properties of the nanocomposite systems above the VPT, and provide a better perception of the effect of the different CNPs on the dynamics of these gels on the microscale.

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Experiment dates:17/02/2017-03/03/2017

Experiment team: Barbara Berke, Orsolya Czakkel

Local contact: Orsolya Czakkel

INTRODUCTION

The aim of the experiment was to study the internal dynamics of carbon nanoparticle (CNP) filled soft gel systems based on poly(N-isopropyl acrylamide) (PNIPAM). Such polymer gels exhibit a thermoresponsive behavior in which the matrix swells or deswells according to external stimuli. Our previous results showed that while the nature of the volume phase transition (VPT) is conserved the temperature response of the systems is strongly affected by incorporating CNPs.

EXPERIMENT

We investigated the dynamical behaviour of the nanocomposites above their VPT (~34 ˚C) at two temperatures: 40 and 50 °C. We used the IN11A configuration with the small-angle sample environment, with 8 Å wavelength incident neutron. A Lauda thermostat bath was used for precise temperature control of the samples.

Measurements were made at 4 different Q values in the range of 0.04-0.137 $Å^{-1}$.

We have continued the measurements at 40 ˚C with 5 mg/g NIPAM graphene oxide (GO) and a carbon nanotube (CNT) containing samples, and pure PNIPA, 5 and 20 mg/g NIPA GO and a CNT containing samples at 50 °C.

RESULTS

Similarly to the measurements at 40 °C (see experimental report of INTER 352), the dynamics slowed down at 50 °C as well in comparison to the curves measured below VPTT (Figure 1).

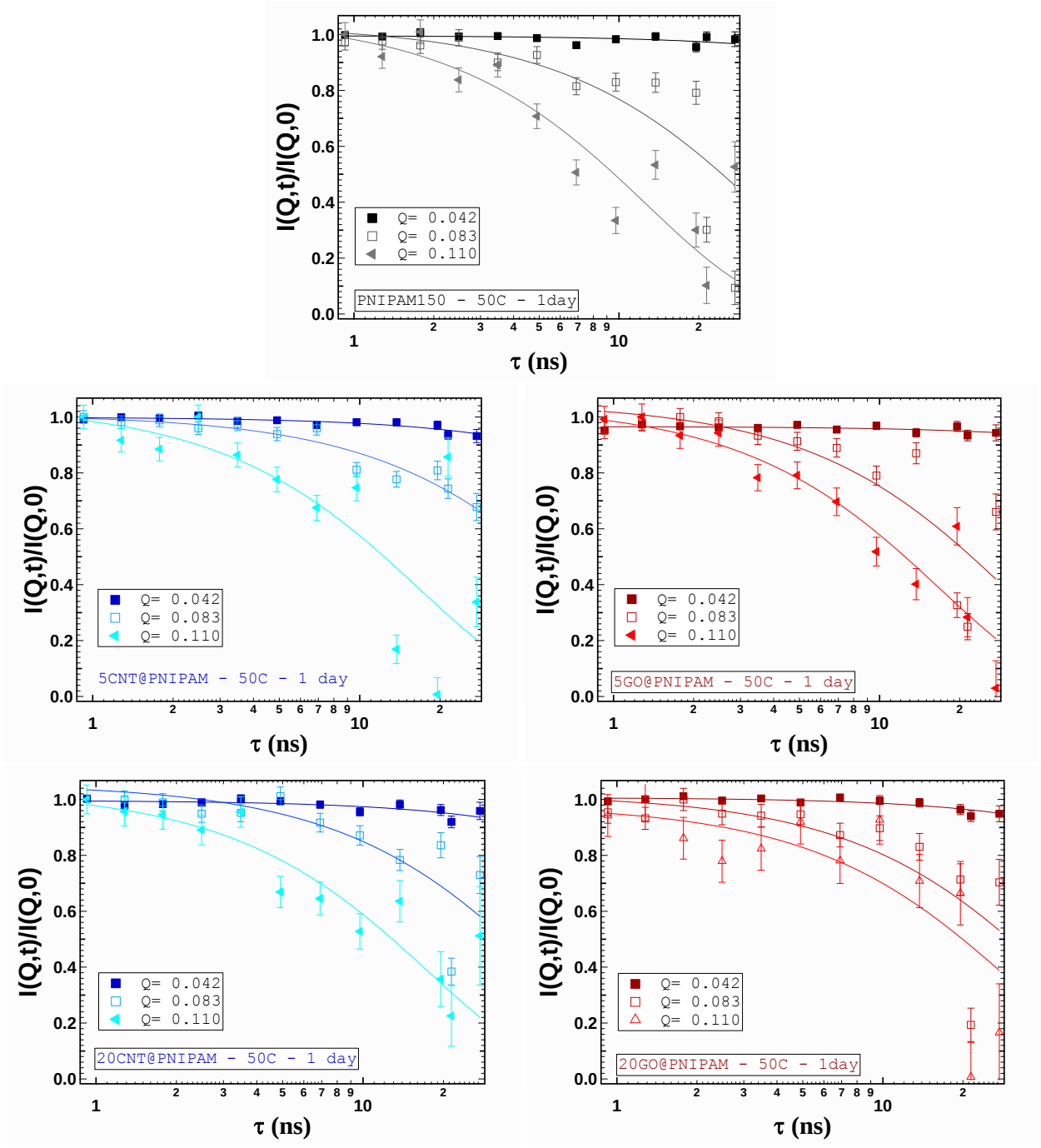

Figure 1. Measured intermediate scattering functions of a) PNIPAM150, b) 5CNT@PNIPAM, c) 5GO@PNIPAM, d), 20CNT@PNIPAM, e) 20GO@PNIPAM at 50 ˚C after 1 day

Based on the preliminary fits, using the Einstein-Stokes equation dynamic correlation length values (ξ_H) were determined (Figure 2). As expected, the increasing temperature resulted in a

larger dynamic correlation length. The polymer chains stuck together, but after 1 day they were still able to move. In case of the GO@PNIPAM systems the ξ_H increased with the increasing concentration at 40 and 50 °C as well. 20GO@PNIPAM shrunk more at both temperatures than 5GO@PNIPAM, which can explain the larger values.

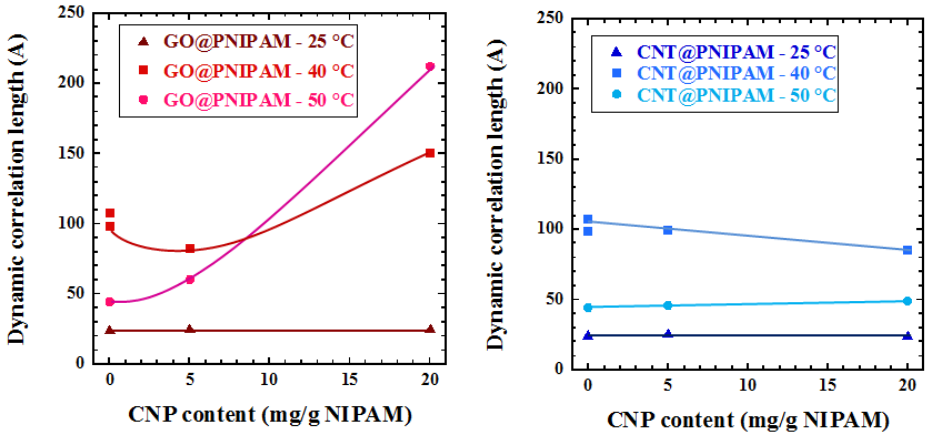

Figure 2. Calculated dynamic correlation length values for GO@PNIPAM and CNT@PNIPAM systems at 25, 40 and 50 ˚C after 1 day. The solid lines are guides to the eye.

CNT@PNIPAM systems shrunk rapidly at 50 °C, therefore the ξ_H values at 50 °C are smaller than those at 40 °C in all cases.