Experimental report

17/09/2018

Proposal: 9-13-711 **Council:** 4/2017

Title: Interaction of proteins with surface functionalised crystalline carbon nanoparticles

Research area: Materials

This proposal is a new proposal

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Samples: H2O
D2O
Carbon nanotubes
bovine serum albumin (BSA)
Graphene
bovine pancreatic trypsin inhibitor (BPTI),

Instrument	Requested days	Allocated days	From	To
IN15	0	0		
D11	3	3	27/03/2018	30/03/2018
IN11	12	11	13/04/2018	24/04/2018

Abstract:

The potential of nanostructured carbon materials in biomedical applications is in its infancy. In biosensor preparations biomolecules, especially proteins, are immobilised on carbon electrodes by physicochemical methods. Adsorption of proteins on nanocarbons (graphene, nanotubes and fullerenes) is a means of chemically functionalizing the substrate for nanosensor devices. The way in which biomolecules adsorb and migrate on solid surfaces depends on the hydrophobic/hydrophilic character of the substrate, but the matter is poorly understood. Crystalline carbon nanoparticles (CCNP) offer unique chemical, thermal, optical, mechanical, electrical and structural properties with well defined surface geometry that make them ideal candidates in biomedical applications, including protein sensors. Reports on the effect of interactions of proteins with CCNPs on the protein structure and/or the cell morphology are, however, conflicting. Here we propose a combined neutron spin-echo and SANS experiment (using contrast variation) to address this question.

“Interaction of proteins with surface functionalised crystalline carbon nanoparticles”

Experimental report on 9-13-711 *experiment*

The aim of the experiment was to measure by SANS the adsorbed state of bovine serum albumin (BSA) on four different carbon nanostructures, carbon nanotubes (CNT), oxidized carbon nanotubes (CNTX), graphene oxide (GO), and reduced graphene oxide (RGO), in order to determine the BSA structure factor through contrast variation with H_2O-D_2O mixtures. In a coordinated follow-up experiment on IN11 with the same experimental number, the mobility of the BSA molecules was also measured by neutron spin echo.

Figure 1 compares the signal from the RGO sample in direct contact with BSA in D_2O with that of the individual signals from the neat suspension of RGO and that of the BSA. This figure shows that except in the neighbourhood of 0.02 $Å^{-1}$, the effect of protein adsorption on

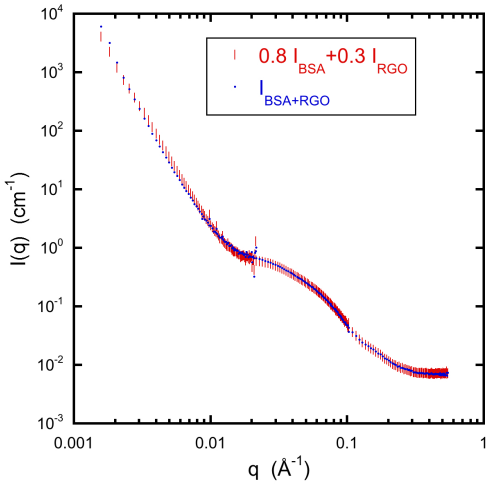

Figure 1. Signal of RGO solution in D_2O together with BSA (solid blue symbols) compared to the weighted sum of the separate signals $I_{BSA}(q)$ and $I_{RGO}(q)$ (red vertical bars).

the signal is very small. In this case, however, incomplete settling of the nanoparticle powder gave rise to a high fraction of free BSA solution in the sample cell. This masks the effect that is sought. In these measurements, delays arose partly due to obstructions in the orifice of the cylindrical sample cells, which made filling them with the nanopowder slurries substantially more time consuming than expected, and partly due to last-minute modifications of the allotted beam time, which made it impossible to complete these measurements satisfactorily. This is why we intend to request a continuation of the small angle experiment.

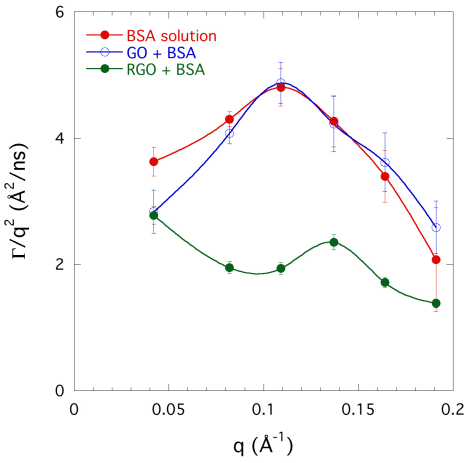

Figure 2. Reduced relaxation rate Γ/q^2 plotted as a function of q.

The NSE part of the measurements, by contrast, was more successful. Instead of banjo cells, rectangular quartz cells were used. This simplified filling and allowed full sedimentation of the slurry to occur within an acceptable time delay. Figure 2 shows how the reduced relaxation rate Γ/q^2 varies as a function of q in three different cases, the free BSA solution, BSA in the presence of GO (where adsorption is limited), and BSA with RGO, which displays a strong affinity for BSA. These results are currently being analysed.