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Surface diffusion of polymers on carbon nanotubes

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Carbon nanotubes (CNTs) are emerging materials with a wealth of applications in different areas, ranging from molecular devices and sensors to drug delivery. However, pristine CNTs tend to bundle into strongly bound aggregates due to van der Waals interactions. This is a drawback, since many applications require individually dispersed CNTs. One possibility to overcome this problem is to use non-covalent dispersants such as surfactants or polymers, which can exfoliate and stabilize CNTs in aqueous solutions. However, non-covalent dispersion is still poorly understood at molecular level [1]. In what concerns polymers as dispersants, two main qualitative models on the polymer-CNT interaction are *wrapping* where polymers coat the CNT in a tight contact and *loose adsorption* where a weaker interaction between the polymer and the CNT takes place, so that the bound polymer remains almost like in its natural state in a good solvent, i.e. a random coil [2].

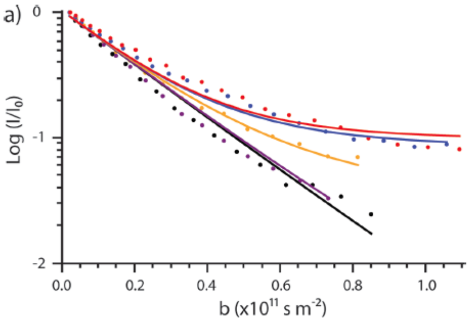

Figure 1: ^{1}H pulsed-field-gradient spin-echo decays of Pluronic® F127 recorded with different diffusion times in aqueous solutions containing single walled carbon nanotubes.

We have studied by ^{1}H NMR diffusometry the exchange and translational dynamics of triblock copolymers Pluronic® in aqueous solution containing single walled nanotubes (SWNT). The ^{1}H pulsed-field-gradient spin-echo decay (Fig. 1) was nonexponential for all investigated polymers and changed character upon changing the diffusion time Δ, which indicates a situation where there is exchange of the polymer between its free and adsorbed states and where the exchange time lies in the 100 ms range [3] set by the experimental time scale (Δ). Within the framework of the well-known Kärger model, the self-diffusion coefficient of the polymers in their CNT-adsorbed state can also be obtained. For Pluronic® F127 we found that the surface diffusion coefficient is in the order of 2.2×10^{-12} m^{2}s^{-1}, ca 30-fold smaller than that obtained for the unbound polymer in water (5.9×10^{-11} m^{2}s^{-1}). This result seems to support the “loose adsorption” model for Pluronic-CNT interaction.

References

[1] H. Wang: *Dispersing carbon nanotubes using surfactants*. Curr. Opin. Colloid Interface Sci. **14**, 364–371 (2009)

[2] M. Granite, A. Radulescu, W. Pyckhout-Hintzen, Y. Cohen: *Interactions between block copolymers and single-walled carbon nanotubes in aqueous solutions: A small-angle neutron scattering study*. Langmuir **27**, 751–759 (2011)

[3] A.E. Frise, G. Pages, M. Shtein, I. Pri Bar, O. Regev, I. Furó: *Polymer binding to carbon nanotubes in aqueous dispersions: Residence time on the nanotube surface as obtained by NMR diffusometry*. J. Phys. Chem. B **116**, 2635–2642 (2012)