Experimental report

01/03/2024

Proposal: EASY-1091 **Council:** 10/2022

Title: Pressure effects on nanoscale domain evolution and hydration in dual functional bactericidal and antifouling polymer brush mixtures

Research area: Soft condensed matter

This proposal is a new proposal

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Samples: (-C9H8O2F8-)n Poly(2,2,3,3,4,4,5,5-(octafluoro) pentyl methacrylate) (POFPMA)

Instrument	Requested days	Allocated days	From	To
D22	24	24	08/04/2023	09/04/2023

Abstract:

Poly(2,2,3,3,4,4,5,5-(octafluoro) pentyl methacrylate) (POFPMA) represents a mechanically and thermally robust low-surface energy fluorinated polymer, rendering its applicability as barrier coatings for biomaterials very powerful due to its strong antifouling efficacy. Poly (2-(dimethylamino)ethyl methacrylate) (PDMAEMA) is a stimuli-dependent (pH, temperature) polymer with LCST behavior in water, similar to the well-investigated PNIPAm, but relatively less explored especially in a grafted brush architecture. PDMAEMA allows to enhance bactericidal properties in coatings upon quaternization. However, the role of water immersion and hydrostatic pressure (P) in nanoscale reorganization in thin (<1 μm thick) films of grafted brushes from such homopolymer mixtures at ambient temperature has so far remained elusive. Using GISANS at D22 from P=1 bar to P = 1000 bar (at ambient temperature), our goal is to probe the lateral brush nanoscale morphology (including the spatial distribution of D2O) on SiOx surfaces at a single 50% surface volume fraction of: (i) mixed homopolymer PDMAEMA/POFPMA as a model system of strong segregation; (ii) mixed PDMAEMA/PMMA as a weakly segregated system.

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During EASY-1091, we have performed Grazing Incidence Small Angle Neutron Scattering (GISANS) under pressure for the morphological characterization of the nanostructure in thin (<100 nm) soft matter films. A stainless steel-based pressure cell with sapphire windows is used as sample chamber and D_2O serves the role of both, hydrostatic pressure liquid and solvent. By means of hand pump pressurization, a pressure (P) range from P = 1 bar up to P = 1 kbar is achievable. The neutron beam impinges at the solid (Si)-liquid (D_2O) interface. We demonstrate feasibility by investigating a mixture of strongly segregated PDMAEMA and POFPMA homopolymer brushes anchored on Si at T= 45 °C for two P-values, P = 1 bar (Fig. 1a) and P = 800 bar (Fig.1b). Our GISANS results reveal phase segregation and nanostructural rearrangements upon P-increase, underlining P-induced effects in tethered polymer brush layers swollen with bulk solvent.

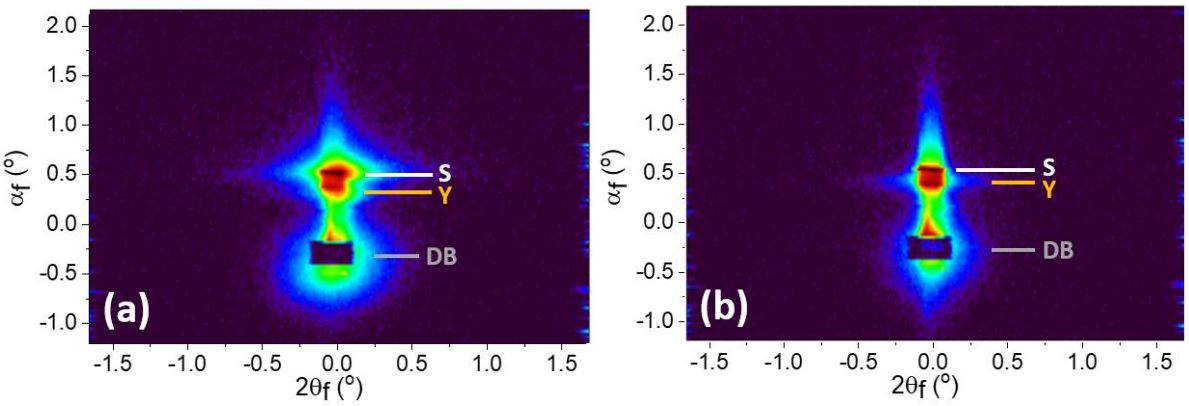

Fig. 1. 2D GISANS data, expressed as α_f vs. $2\theta_f$, at the different settings: (a) (P = 1bar, T = 45 °C) and (b) (P = 800 bar, T = 45 °C). The direct beam (DB; grey line), the Yoneda peak (Y; orange line) and the specular peak (S; grey line) are denoted as well.

We are analyzing the 1D horizontal linecuts from the 2D GISANS images to quantify the effect of pressure on the lateral nanoscale morphology. Currently, analysis of the reflectometry data (proposal Nr. 9-11-2089) is being performed to complement the information on the water distribution along the sample vs. across the sample.