Structural and Mechanical Properties of Dendrimer-mediated Thin Films

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Objective

- To make 1 monolayer (1 ML) thick dendrimer nanopatterns as templates for the study of metal dendrimer interactions.
- Competition between short range interphase boundary energy (attractive) and long range electrostatic interaction (repulsive) establishes the scale of the patterns.
- To deposit the metal films on the dendrimer domain structures (PVD deposition)
- To study the metal penetration into dendrimer by AFM, LFM, and FMM in a single sample which has both dendrimer monolayer regions and clean substrate regions as a function of metal thickness.

Samples

- The G4-25%C12 Dendrimer used has a hydrodynamic diameter of ~10.7 nm by dynamic light scattering, its monolayer (ML) adsorbed on a substrate would be expected to have a height of 4 – 5 nm because it 'collapses' when adsorbed onto substrate surface.
- Mica as substrate and Au for the metal films

Fabricating the 1 ML thick dendrimer domain patterns

(formation governed by competing interaction theory)

AFM topography of dendrimer domains (10×10 (µm)) as a function of coverage f. f = (a) 0.13, (b) 0.16, (c) 0.23, (d) 0.33, (e) 0.39, (f) 0.45, (g) 0.52, (h) 0.64, (i) 0.73. The thickness of the dendrimer molecule is ~ 4.7 nm, corresponding to 1 ML of Ci2G4 dendrimer. The dark contrast in the images is the mica substrate. The evolution of domain patterns as a function of area fraction follows the sequence: circular islands of A in a matrix of B (the droplet phase), alternating elongated domains of A and B (the striped phase), and circular islands of B in a matrix of A (the inverted droplet phase) which is in agreement with the competing interaction theory.

Conclusions

A simple aerosol spray method is used to make self-assembled dendrimer monolayer patterns. These 2D structures were used as substrates for growth of sputtered Au films to form Au/mica and Au/dendrimer/mica films on single samples. The intermixing between Au and the dendrimer monolayer was directly observed to be 1.7 nm by AFM. LFM results indicate that the friction between the tip and dendrimer molecules is larger than that between the tip and the mica substrate. LFM, FMM, and step height measurements were also used to conclude that Au is absorbed by the dendrimer layer up to an equivalent thickness of Au of 1.7 nm and beyond this Au film grows on top of both the dendrimer-mediated and bare mica surface.

Schematic of competing interaction system: 25%

C12 - PAMAM G4 / Pentanol on Mica.