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Current Research

Work in our group is focused on surface modification for specific applications. We chemically derivatize metal and ceramic solid surfaces so that further chemistry can be done on these surfaces. By designing and executing sequential chemical processes, we can build up complex and layered structures on surfaces. In particular we are interested in polymer brushes. A polymer brush is a layer of polymer chains, all the same length and all attached, or grafted, by one end to a surface, as shown in Figure 1. In a polymer brush,

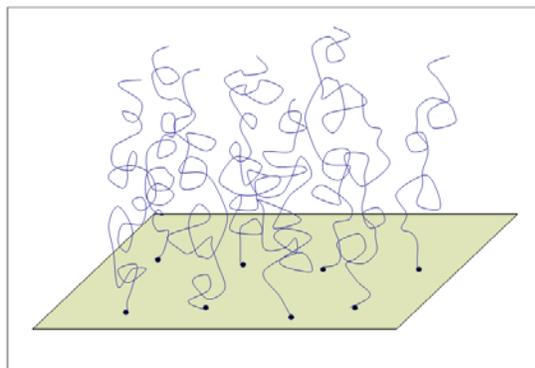


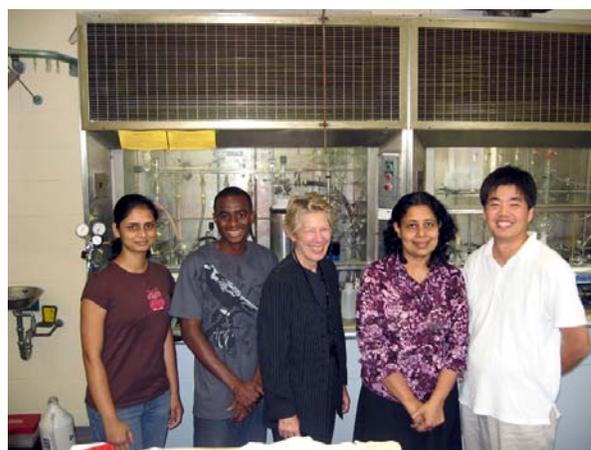
Figure 1. A single polymer brush showing stretching of end-grafted polymer chains away from solid surface to which they are grafted. The grafted chains are bathed in solvent.

the density of attachment to the surface is sufficiently high for the chains to stretch away from the surface, driven by the difference in osmotic pressure between the brush (solvent plus grafted chains) and the bulk solvent or solution exterior to the brush. This stretching is the origin of the very interesting behavior of polymer brushes.

Behavior of Polymer Brushes

We have established that the formation process of a polymer brush consists of three stages. The first stage is the rapid formation of a mushroom layer on the bare solid surface. A mushroom layer is a monolayer of non-stretched and nonoverlapping grafted chains; once complete, it is a barrier to diffusion. The second stage is a period of long duration and slow grafting. The third stage is the resumption of rapid grafting to complete the brush. The second stage can be exploited to prepare complex mixed brushes that have

The completed brush responds differently to the approach of different sized free species in solution. While all solvent molecules diffuse freely into and out of the brush, large macromolecules are either obstructed from or transported into the brush according to a size criterion. We are currently investigating this fundamental transport-selective behavior because of its potential as in drug delivery, biomedical devices and as an explanation of some biological processes. Both chemical and instrumental methods, including quartz crystal microbalance, scanning probe microscopy, high pressure liquid chromatography and dye-coupling analysis, are used for monitoring and evaluating the selective behavior of the brushes.



Recent Publications

Hyun-Su Lee and L. S. Penn, "In Situ Study of Polymer Brushes as Selective Barriers to Diffusion," *Macromolecules*, 2008, in press.

L.S. Penn and H. Huang, "Polymer Brushes are not Always Barriers to Diffusion," *Macromolecules*, 2008, 41, 2747-2748

L.S Penn, J.C. Jacobs, J. Anthony, M.M. Payne, B.D. Swiss, F.B. Mallory, K. Liu, and R.A. Miller "Ribbon-Like and Plate-Like Rigid Molecules as Reinforcements for Polymer Matrices," *J. Composite Materials*, 2008, 42, 109-123.

Heqing Huang, Arthur Cammers, and Lynn S. Penn, "Grafting of Free Chains in the Presence of Pre-existing Polymer Brushes," *Macromolecules*, 39, 7064-7070 (2006).