Undergraduate Thesis Proposal

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October 12, 2008

I plan to complete my undergraduate thesis with Professor Caroline Ross of the Department of Materials Science and Engineering. My topic is the morphology of thin films made of a diblock copolymer, polystyrene/poly(ferrocenylsilane) (PS/PFS). Last Spring, I received five PS/PFS samples with varying PDI, and started making and studying their properties in thin films. I continued my research over the summer, and would like to finish it this term. I would like to make these samples the subject of my thesis, and also submit a paper about the results.

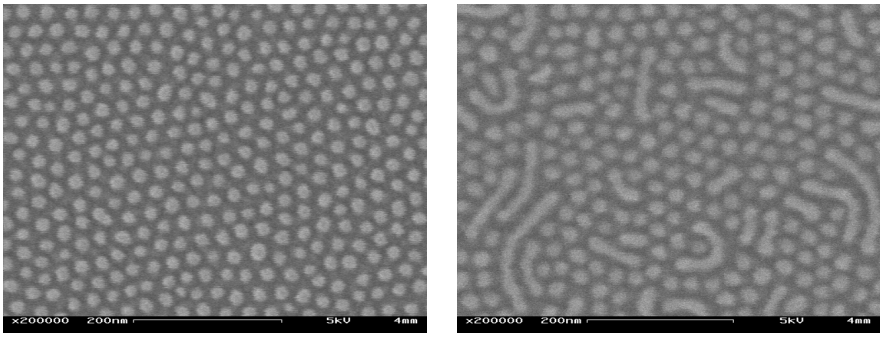
Block copolymers are notable for their ability to self-assemble into different morphologies, and are frequently studied for their use in nanoscale patterning. PFS has been studied as component of a variety of copolymers [1, 2]. The Ross group's previous work with PS/PFS [3], investigating the effects of substrate topography, served as a starting point for my research. The bulk morphology has also been researched [4]. PFS has been found to assemble into spheres and cylinders, depending on copolymer composition and annealing conditions. The effects of polydispersivity (PDI) have also been studied, but the full extent of its role in block copolymer morphology are not known [5, 6]. This research project was started in order to investigate whether the morphology of PFS features changes depending on PDI.

Five polymer samples, nominally with only their PDI varying, were received from collaborators at De Universiteit Twente in the Netherlands. Their PDIs ranged from 1.109 to 1.198. I prepared solutions of the polymers in toluene and spun films from each polymer on prime silicon. Film thicknesses ranged from 20 to 50nm. I annealed some samples in an oven, and some in toluene vapor. When annealed in the oven overnight, PFS spheres were observed (Figure 1a). However, some samples contained PFS cylinders as well (Figure 1b).

I collected data on the area of the PFS features as well as the distance between them, using image processing software. However, the data collected did not correlate with PDI (Table 1). I contacted the researchers at De Universiteit Twente who had synthesized the samples, and asked them for more information on the polymers. Their response contained information about the volume fractions of PS and PFS in each block copolymer, which correlated well with my area and distance date (Table 2).

The next steps in this project are to contact the collaborators at De Universiteit Twente once more to ask how they measured the volume fractions, PDI, and other data on the PS/PFS samples, to ensure that I understand the source of their data. I will also look at the literature to continue research into the behavior of PFS, both in bulk and in other block copolymers.

My final thesis paper will contain a significant background section on the behavior of block copolymers in general and PFS in specific, as well as the motivation for studying block copolymers. I will then discuss various experimental methods and results. The final section will be a discussion of my findings and their significance.



(a) (b)

Figure 1: SEM images of 43-44nm thin films of PS/PFS 33-10 with PDIs of 1.109 (a) and 1.123 (b).

Table 1: Calculated data for PS/PFS 33-10 samples with varying PDIs.

	Area (nm)		Distance (nm)		
PDI	Mean	Std. dev	Mean	Std. dev	Correlation length (nm)
1.109	249.8	44.9	29.5	3.1	340
1.114	222.5	47.7	26.4	2.9	240
1.123	447.1	381.2	30.3	3.2	225
1.188	290.7	104.9	29.0	3.3	360
1.198	117.8	47.3	22.7	4.5	96

Table 2: Area and distance data on PS/PFS 33-10 samples correlate well with volume fraction measurements.

PDI	Mean Area (nm)	Mean Distance (nm)	Φ PS	Φ PFS
1.109	249.8	29.5	91	9
1.114	222.5	26.4	92	8
1.123	447.1	30.3	89	11
1.188	290.7	29.0	90	10
1.198	117.8	22.7	94	6

References

[1] X. Wang et al., *J. Am. Chem. Soc.*, 129 (17), 5630 -5639, 2007.

[2] T. Chen et al., *Polymer* 46, 7585-7589, 2005.

[3] J. Cheng et al., *Adv. Mater.*, 15 (9), 1599-1602, 2003.

[4] Book here!

[5] N. Lynd et al., *Polymer*, 45, 3386-3393, 2007.

[6] A. Noro et al., *Macromolecules*, 38, 4371-4376, 2005.