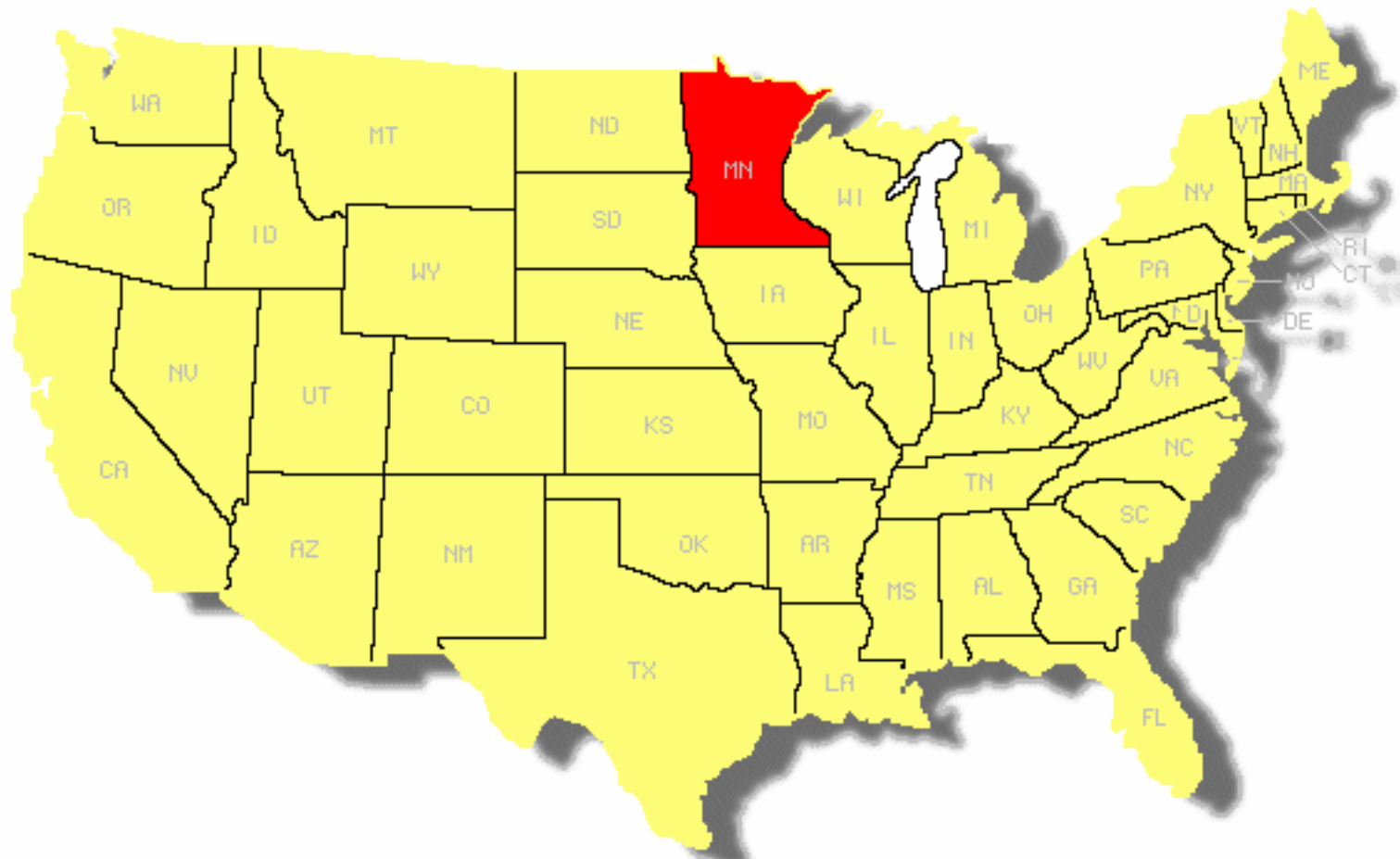


Where is Minnesota, Anyway?



Diffusion II
August 27-29, 2007

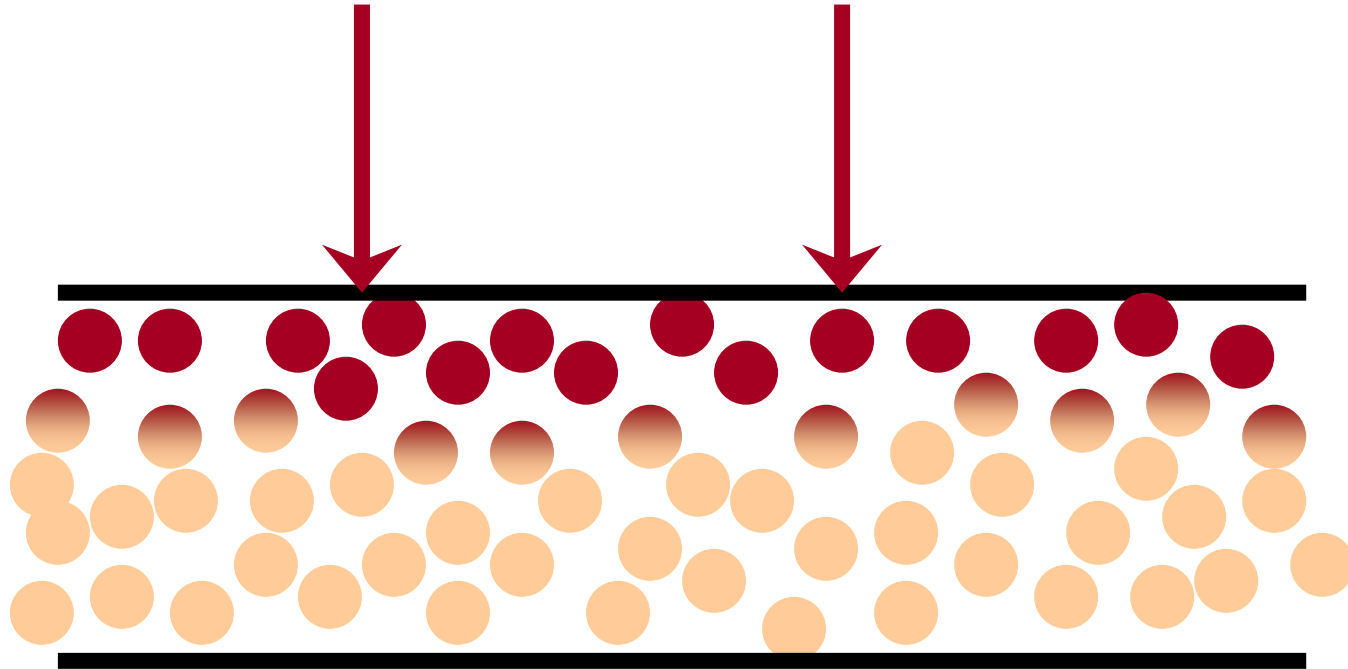
**Diffusion in Self-
Assembled Composites**

E.L. Cussler, Minnesota

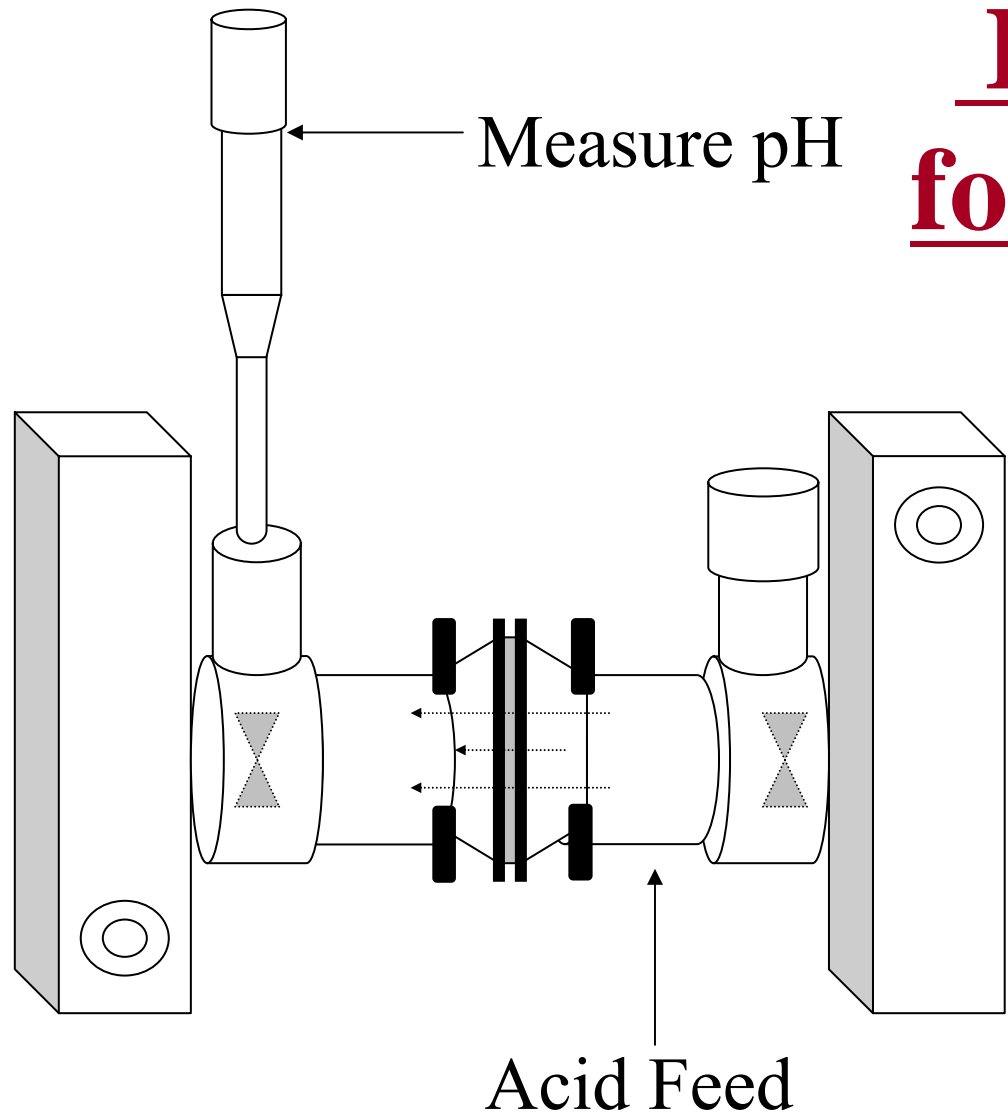
Better Barriers from:

#1: Better Polymers

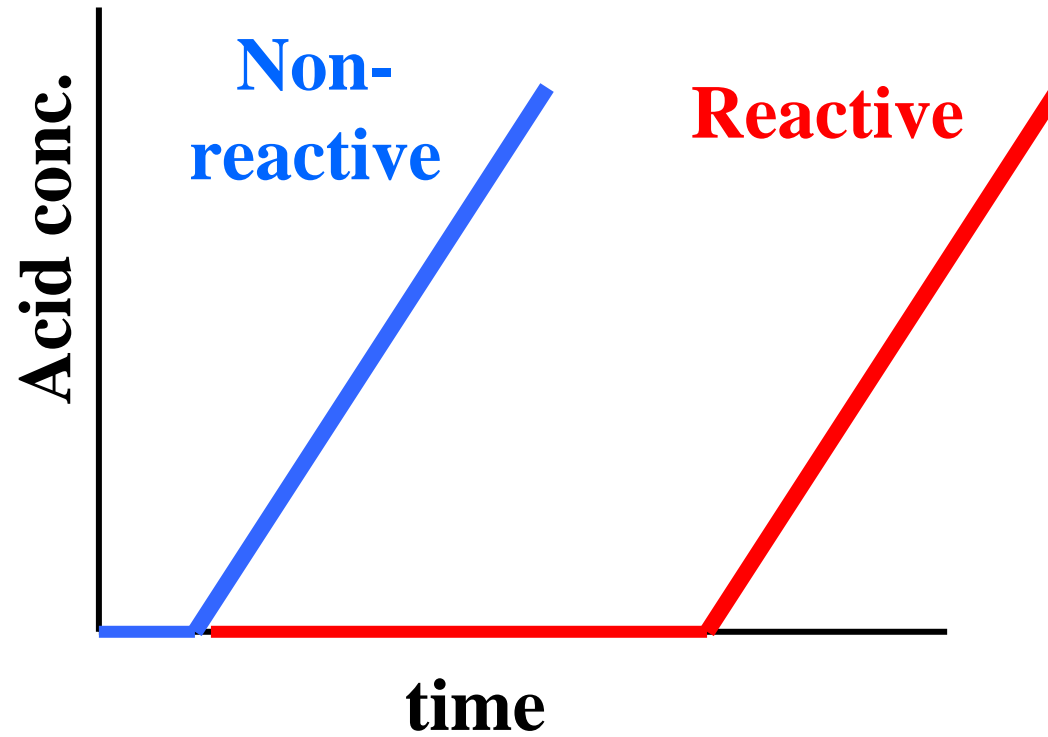
#2: Reactions



Experiment for Reactions

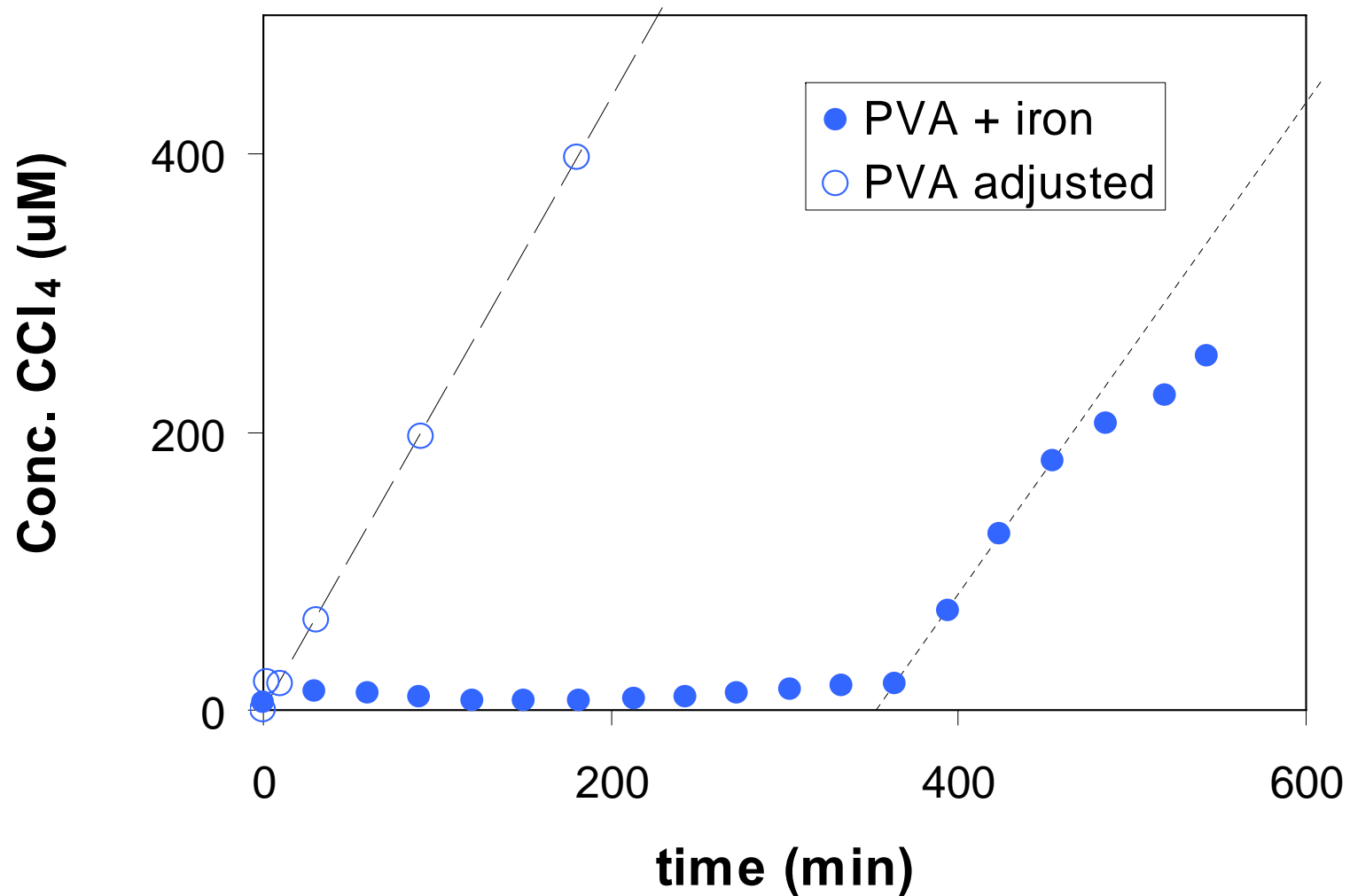


Reactions Increase Lag





Reactive Example : Landfills

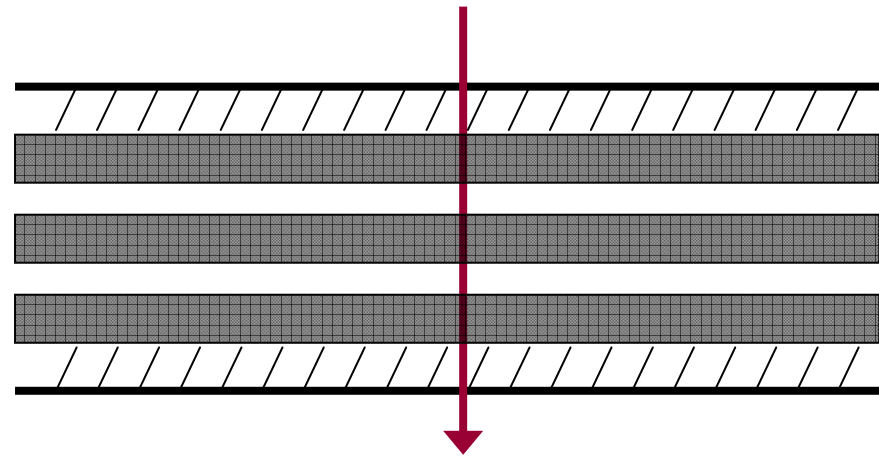
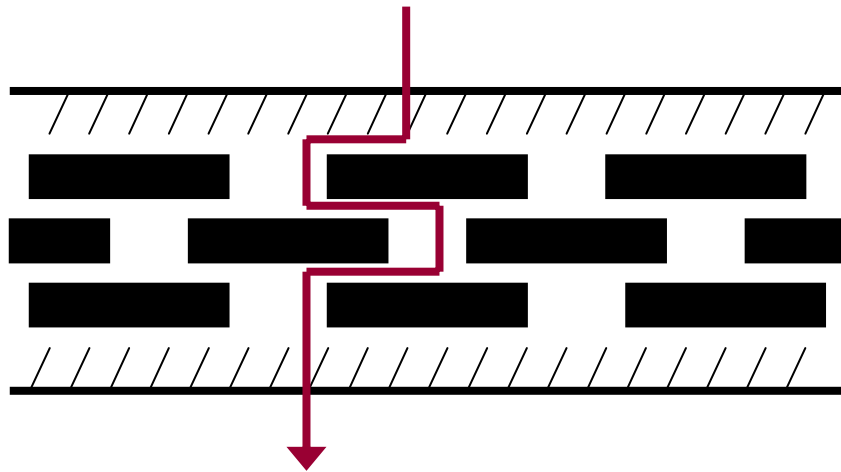


Better Barriers from:

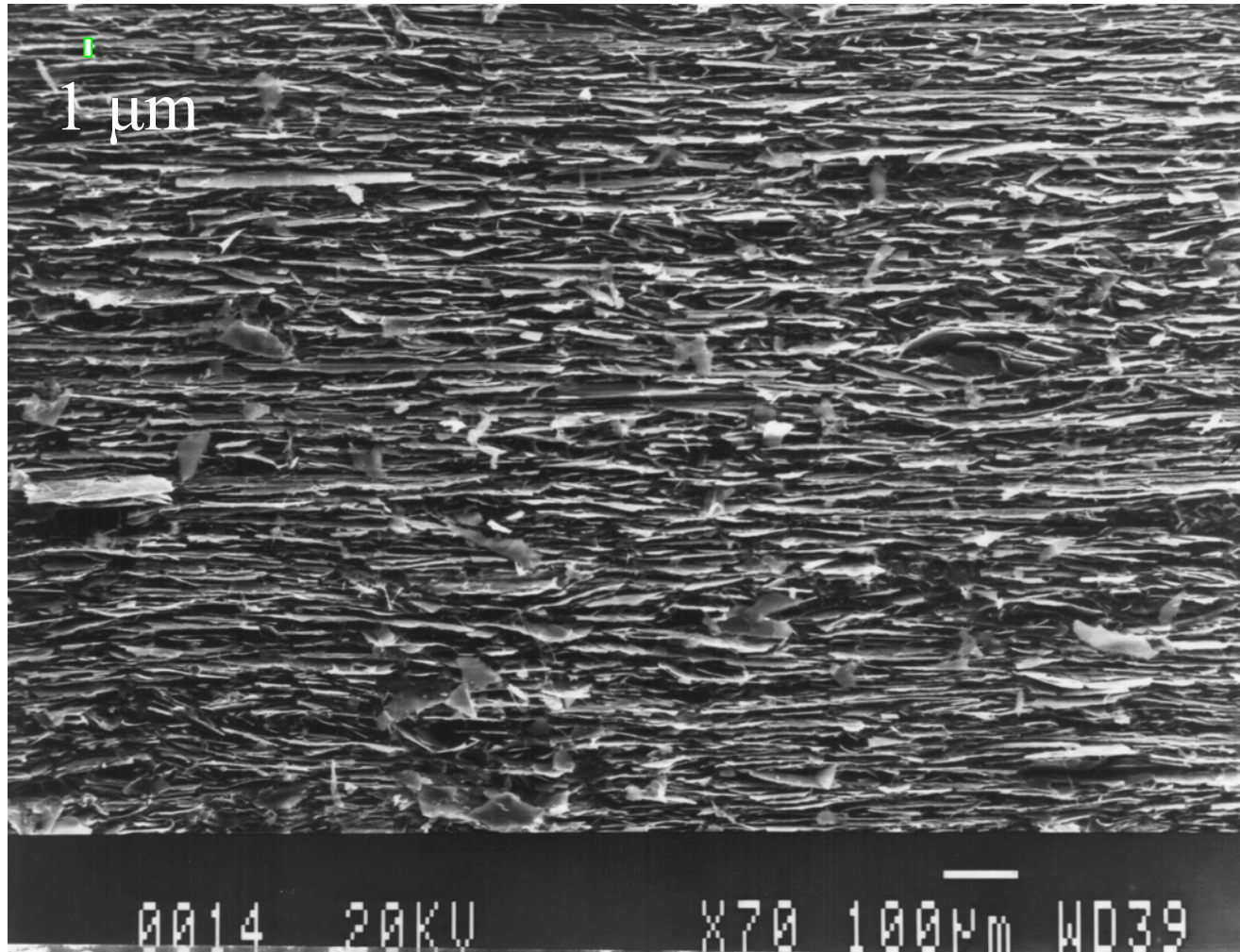
#1 Better Polymers

#2 Reactions

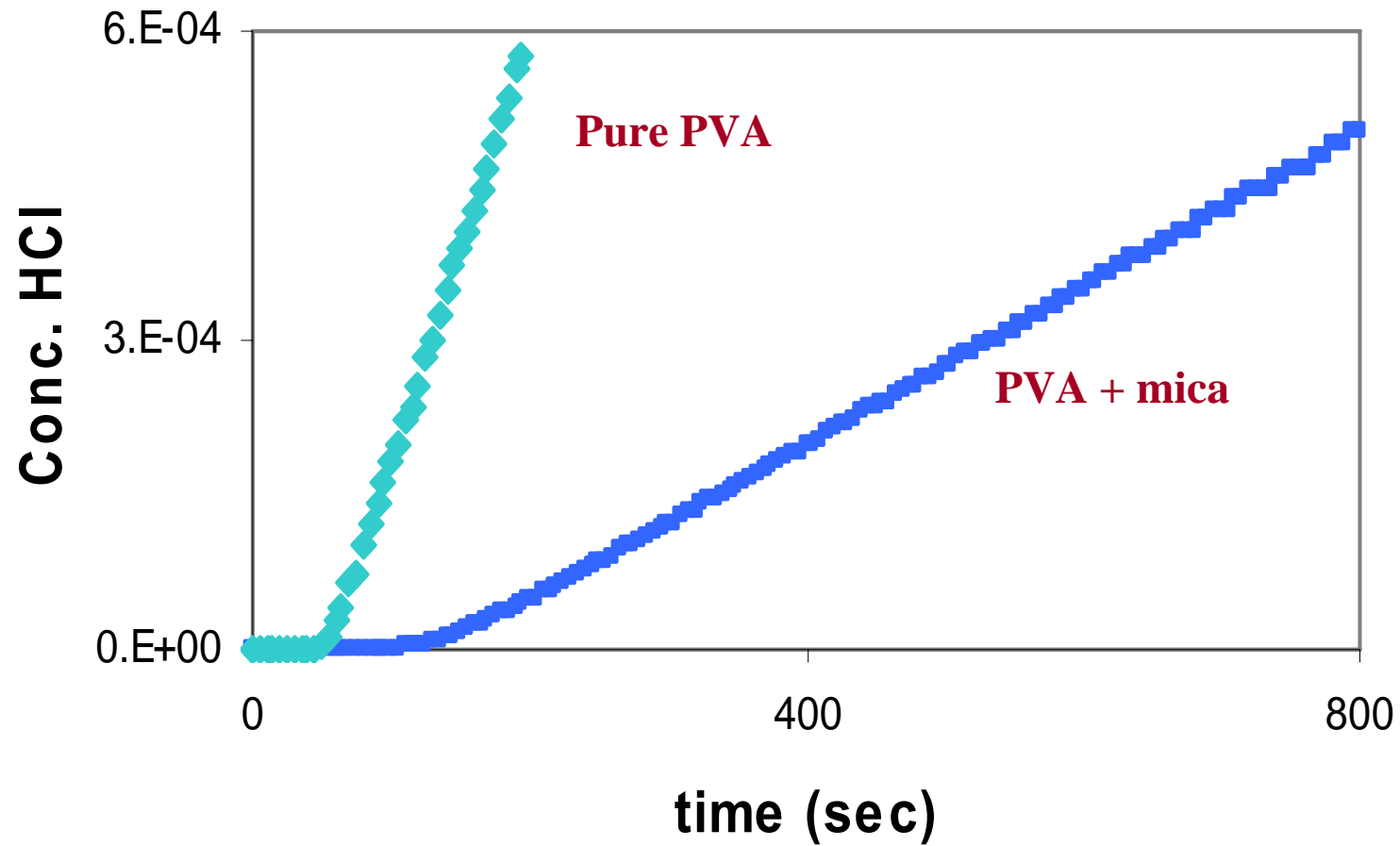
#3 Flakes



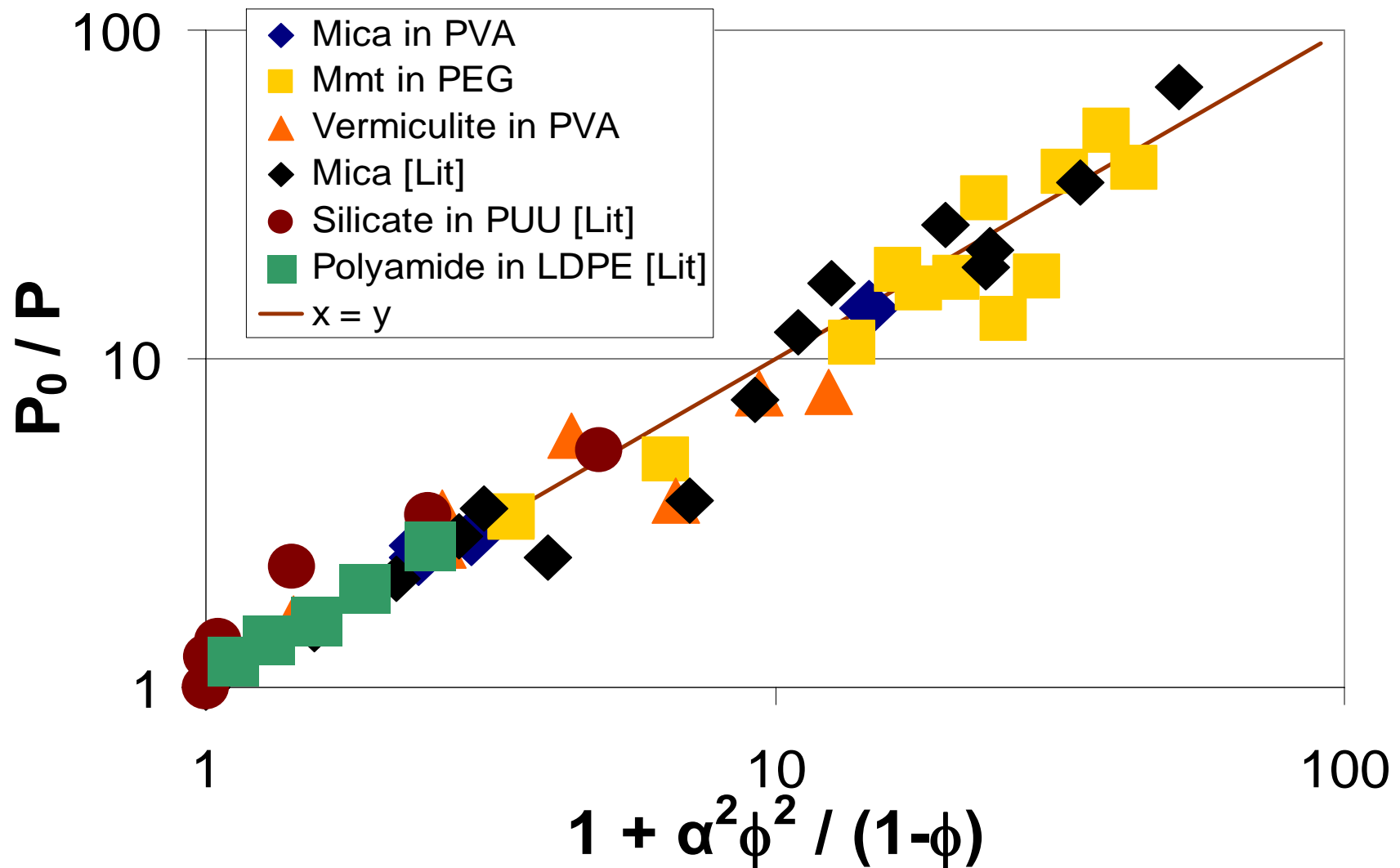
Barriers of Aligned Flakes



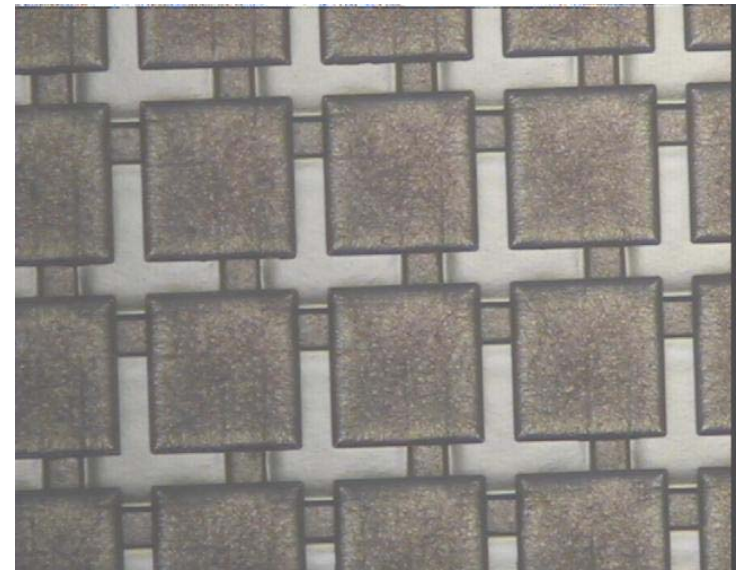
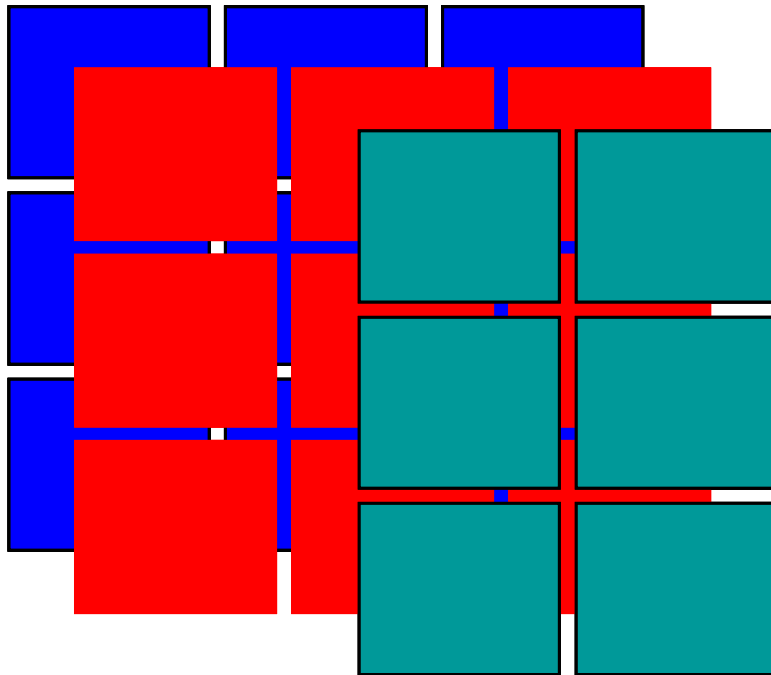
Flakes Increase Lag, Reduce Leak



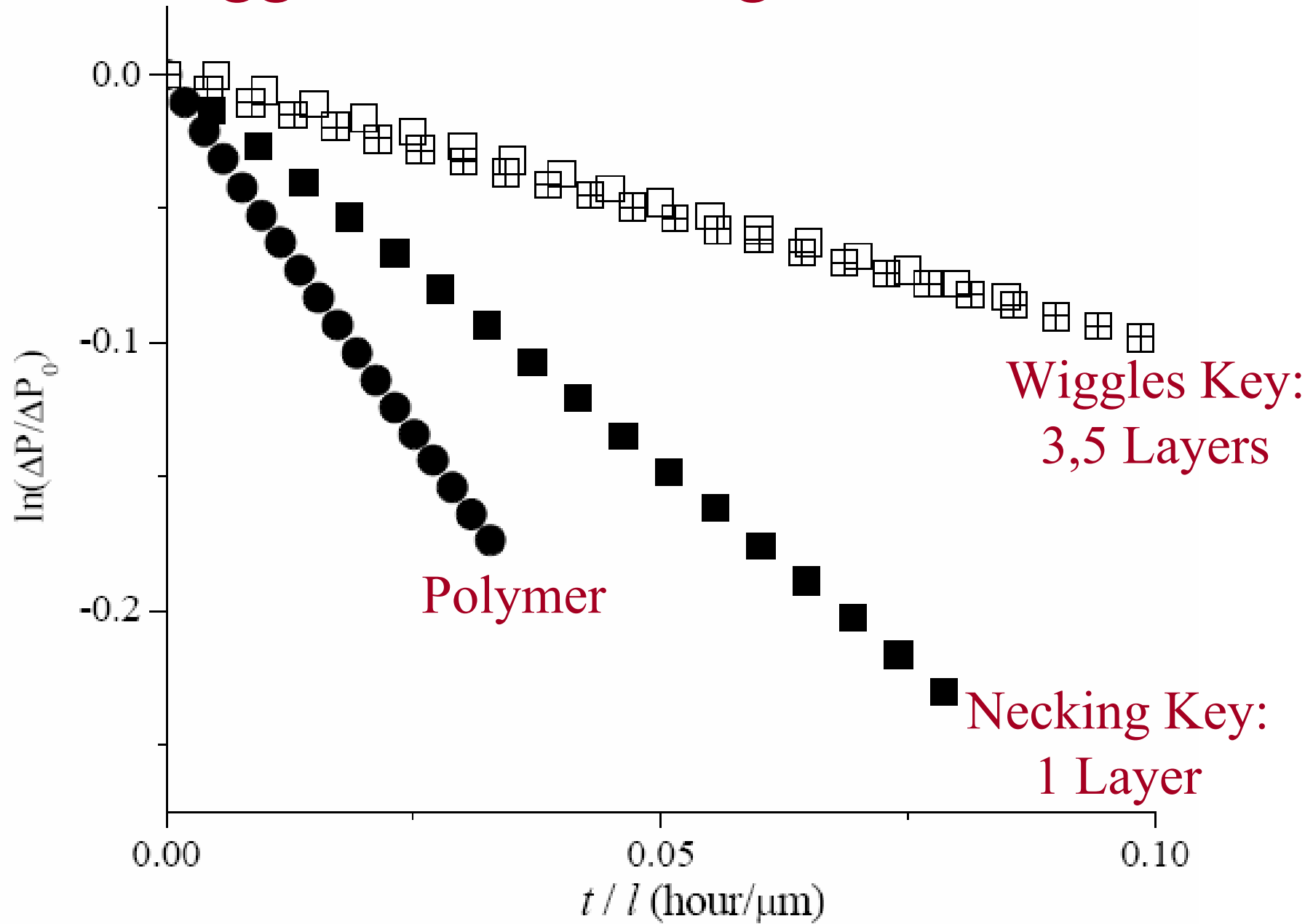
For Flakes, Wiggles Rule



Three Layers Ensure Wiggles



Wiggles vs. Necking: See B11, B16



Conclusions So Far

**1. Reactive Membranes Increase
Lag $O(1000X)$**

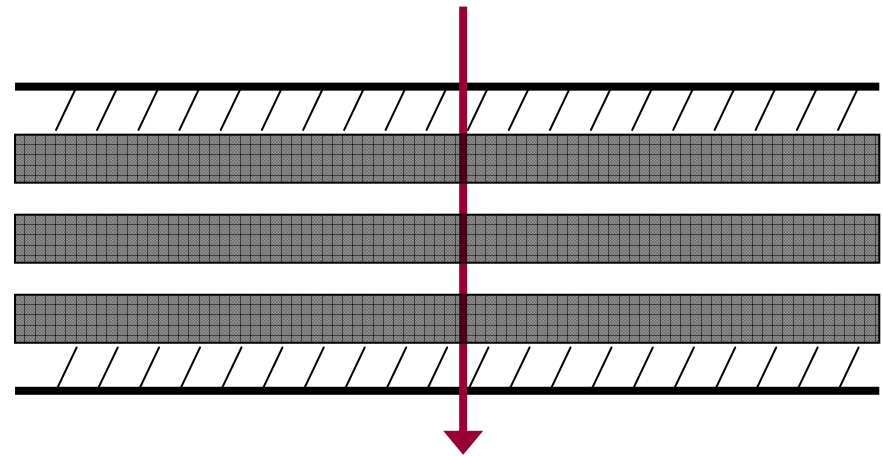
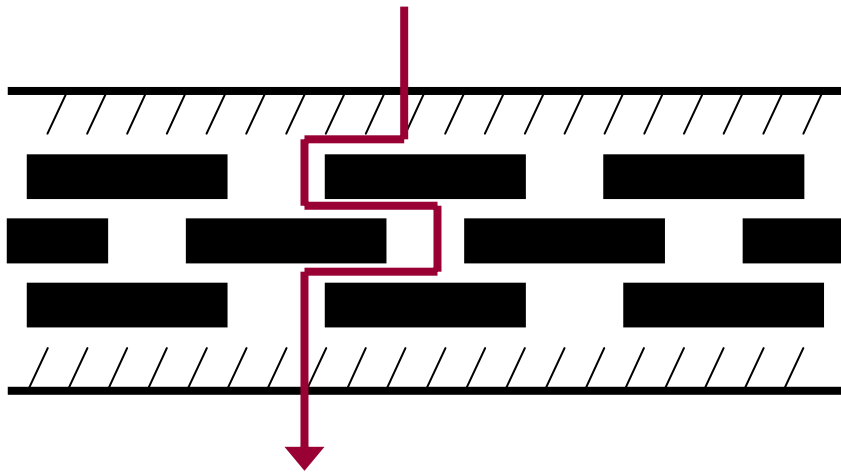
**2. Flake-filled Membranes Increase
Lag, Reduce Leak $O(50X)$**

3.

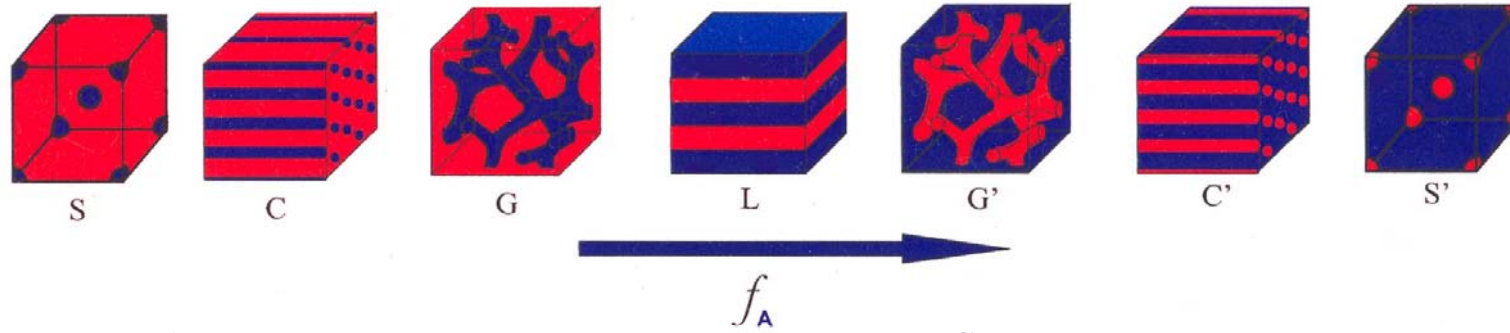
Strategy #1: Better Polymers

Strategy #2: Reactions

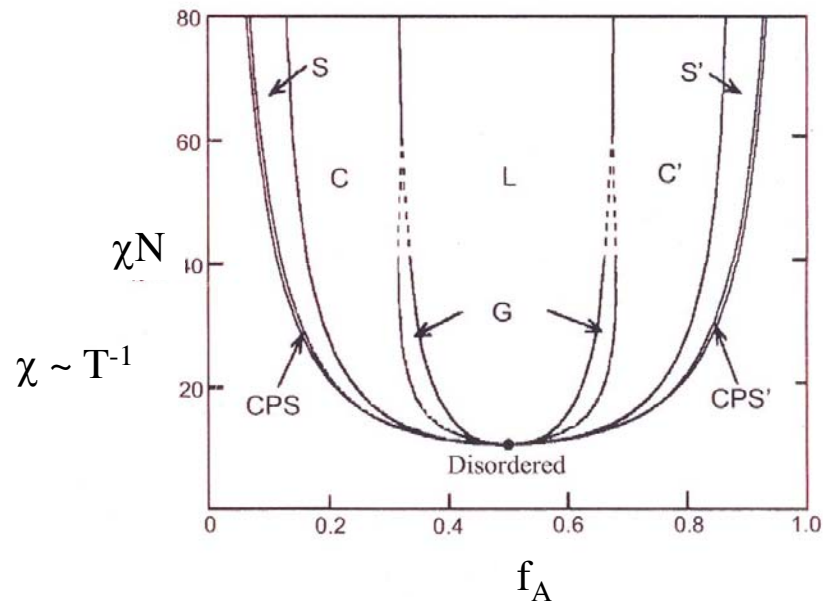
Strategy #3: Flakes (cont.)



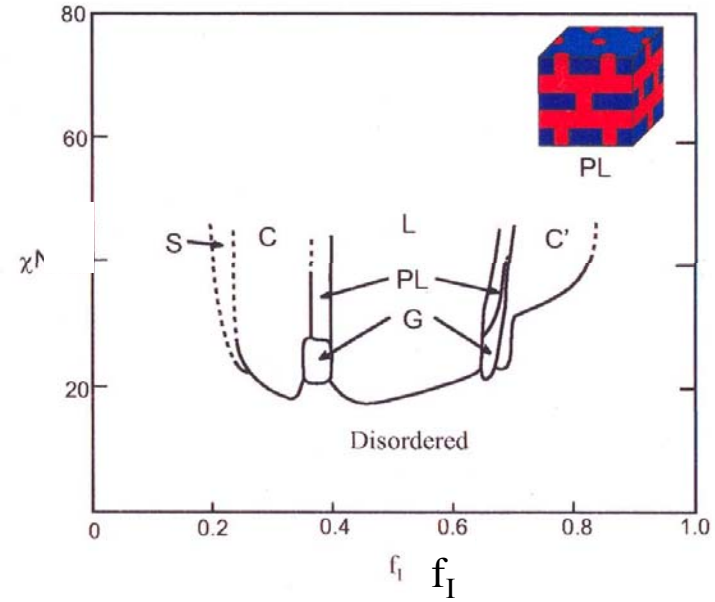
Flakes: Bottom Up Assembly



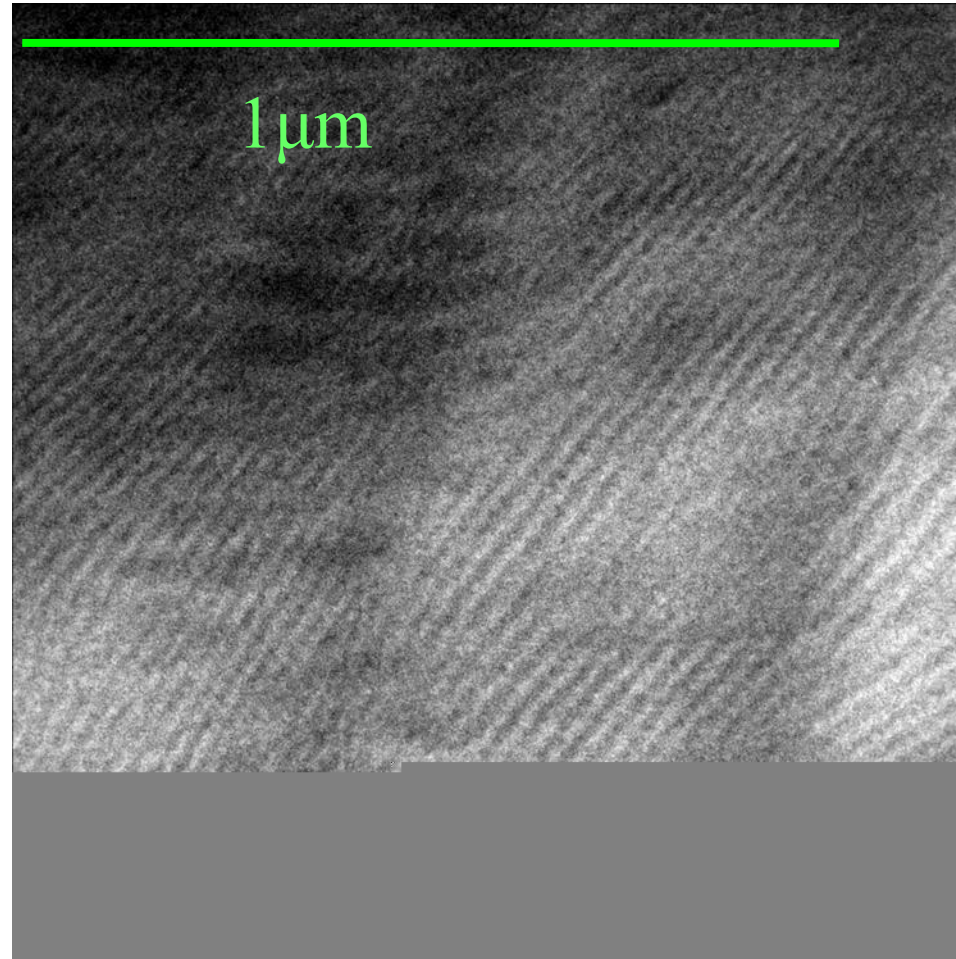
Theory



PS - PI

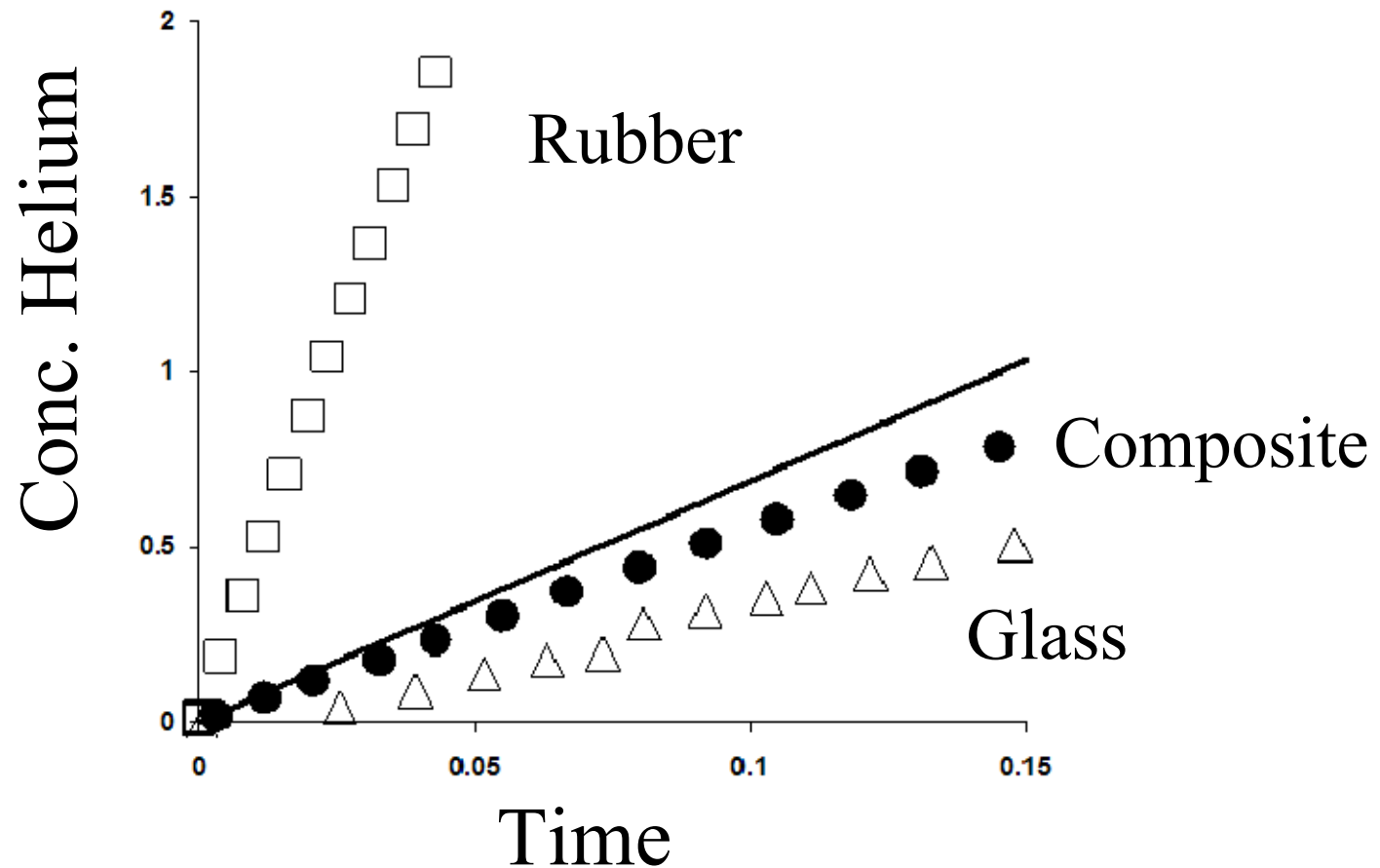


Barriers With Aligned Flakes: Bottom Up Self-Assembly

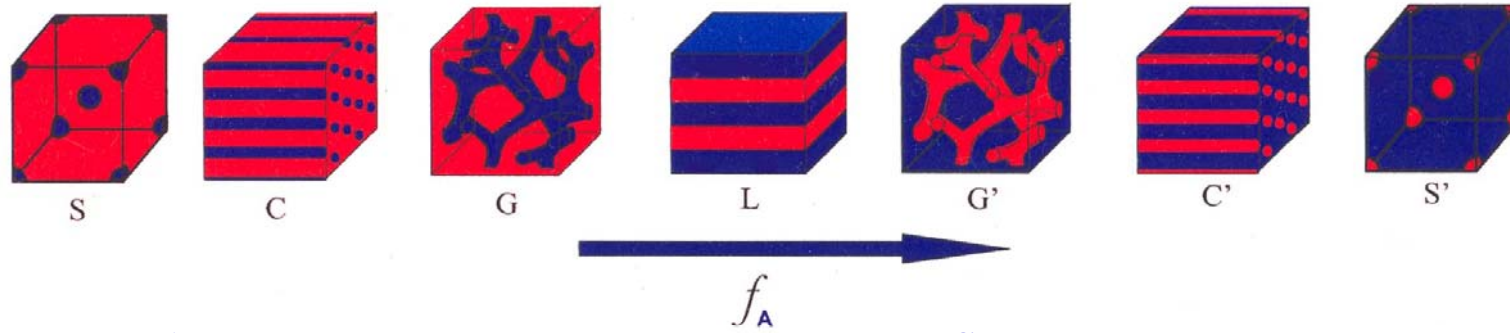


Self-Assembled Lamellae Work

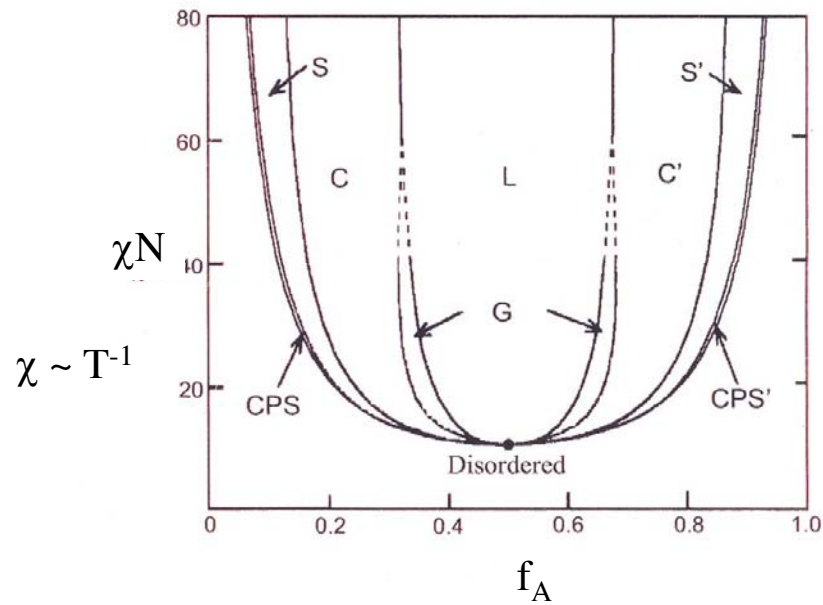
$$\frac{1}{P} = \frac{1 - \phi}{P_{Rubber}} + \frac{\phi}{P_{Glass}}$$



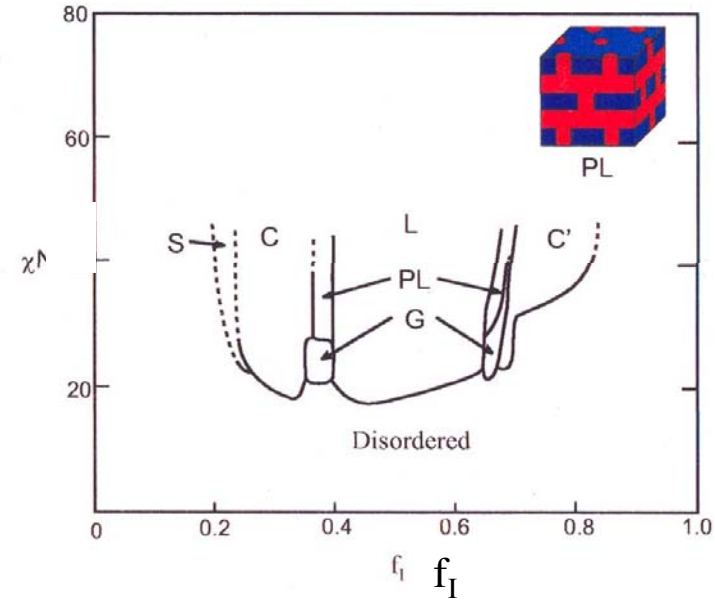
Pores: Bottom Up Assembly



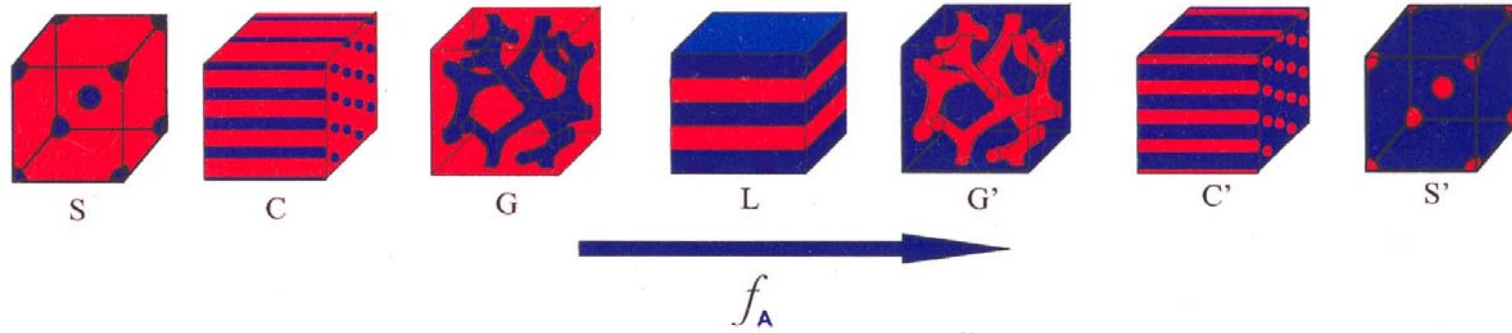
Theory



PS - PI

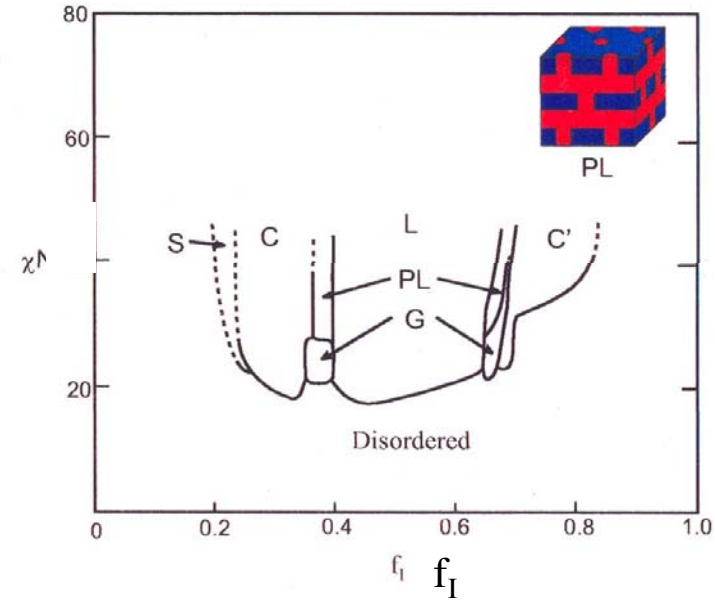
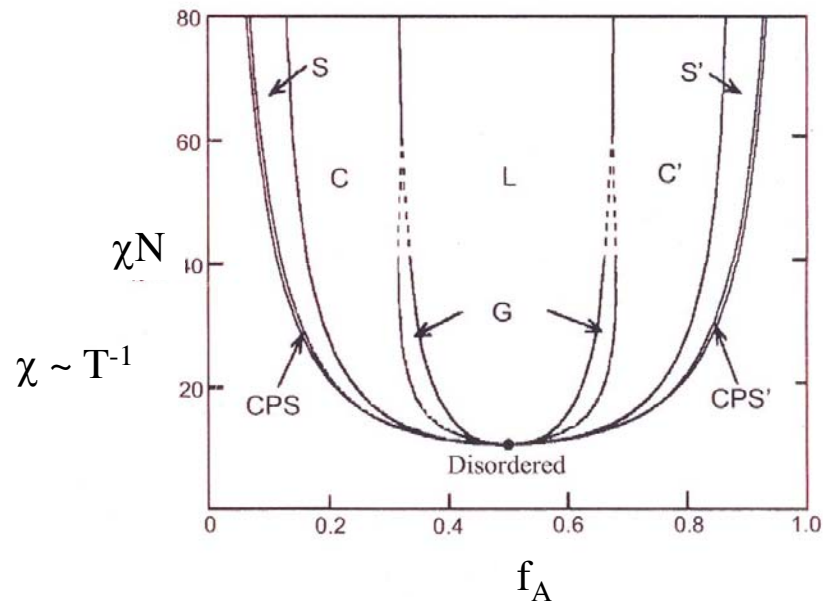


Pores: Bottom Up Assembly (C12)



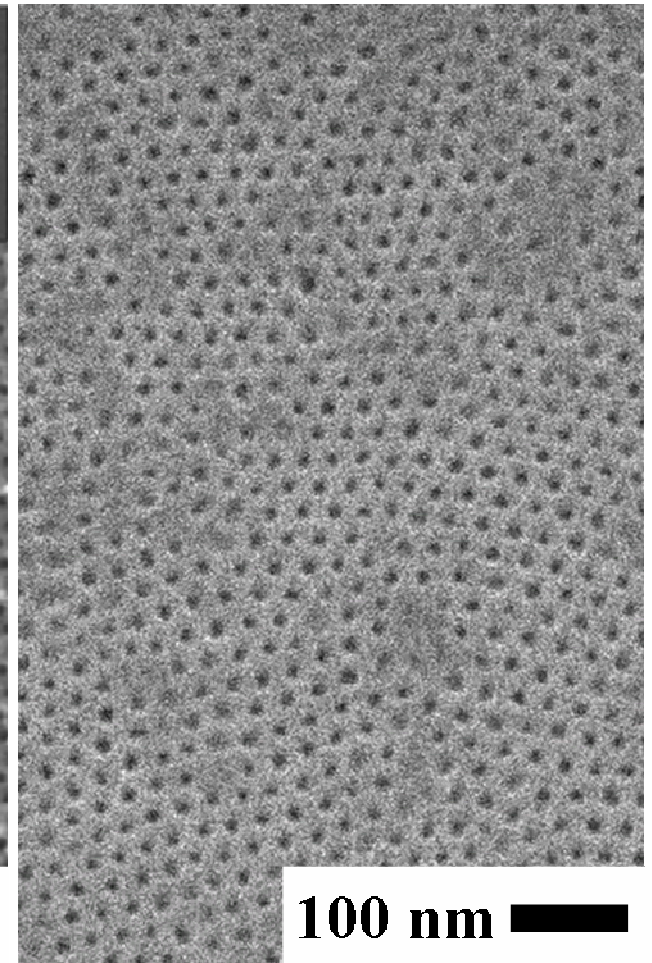
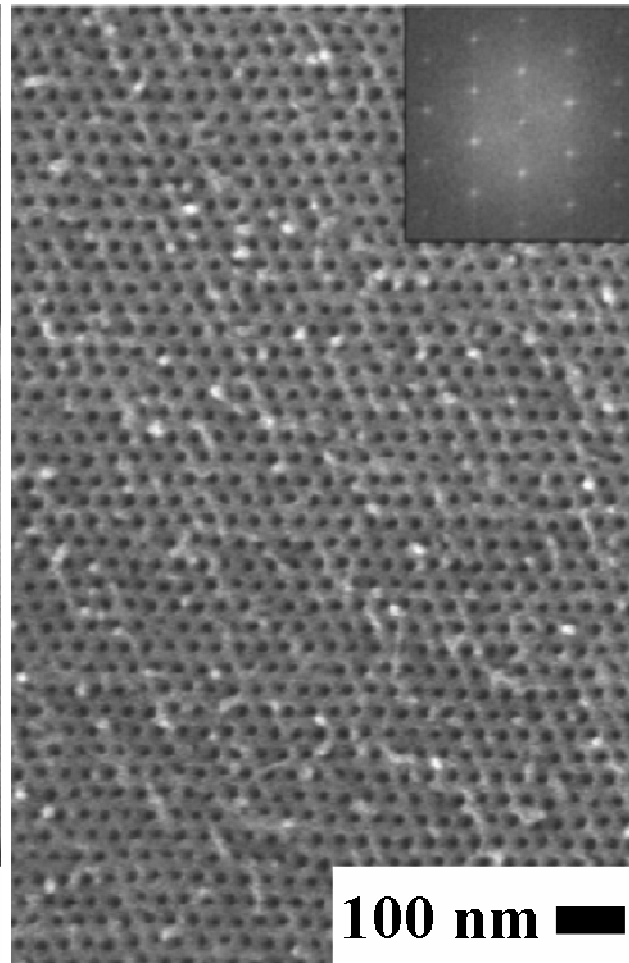
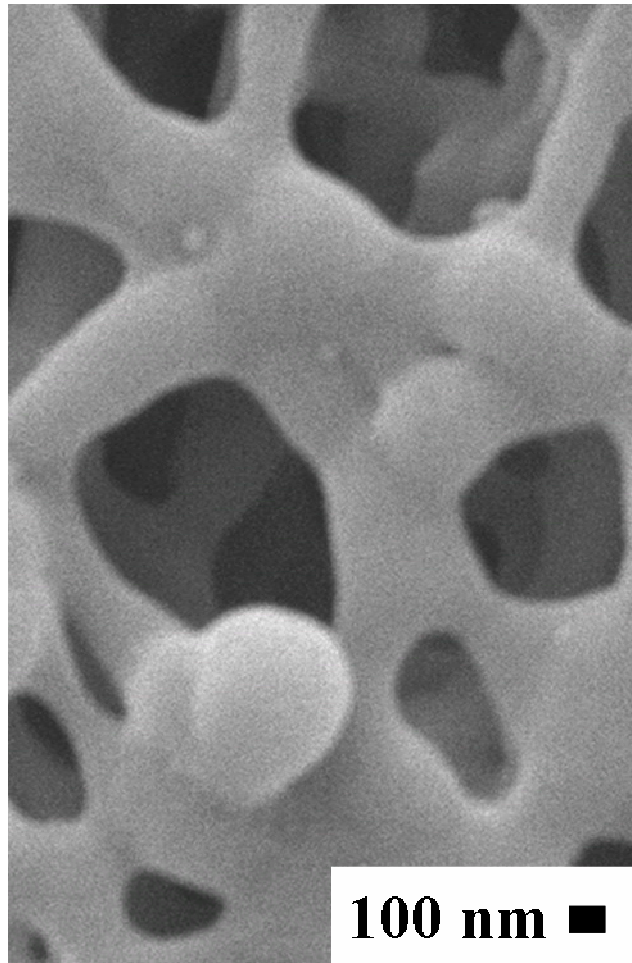
Theory

PS - PI



Three Ultrafiltration Membranes

That on the left is conventional; that in the center is shear-aligned; and that on the right is our new material.



Pores Give Faster Fluxes (C2)

Block Copolymer: Pore Diameter 13.5 nm.

Solute	Permeance (Experimental)	Permeance (Knudsen)	Permeance (Kinetic)
He	265.7	260.5	5815.7
Ar	84.2	82.2	633.9
N ₂	100.4	98.3	702.0
O ₂	89.4	92.0	713.4

Track Etched: Pore Diameter 29.5 nm.

Solute	Permeance (Experimental)	Permeance (Knudsen)	Permeance (Kinetic)
He	1.54	1.48	13.4
Ar	0.48	0.47	1.46

Conclusions

- 1. Reactive Membranes Increase Lag $O(1000X)$**
- 2. Flake-filled Membranes Increase Lag, Reduce Leak $O(50X)$**
- 3. Flakes, Pores From Self Assembly....**