Two-Dimensional Porous Membranes

D. J. Murray, D. D. Patterson, P. Payamyar, R. Bhola, W. Song, M. Lackinger, A. D. Schlüter, and B. B. T. King, Large area synthesis of a nanoporous two-dimensional polymer at the air/water interface. *J. Am. Chem. Soc.* **137**, 3450−3453 (2015).

Keywords: Hyperthin membrane, two-dimensional polymer (2DP)

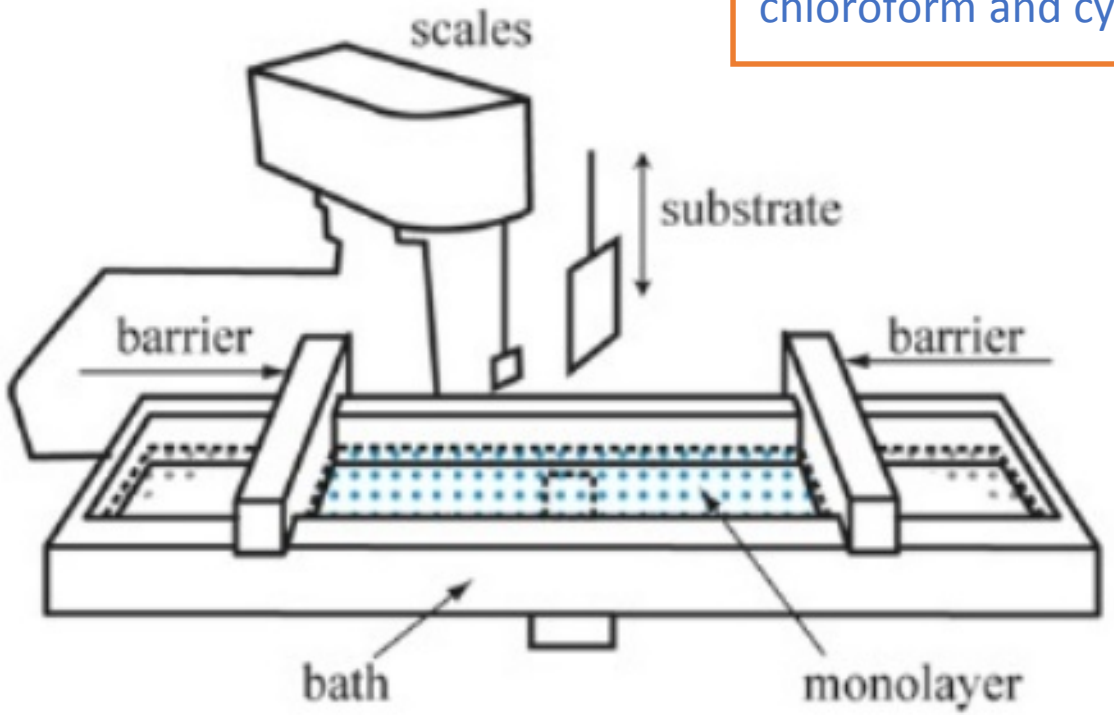
Methodology

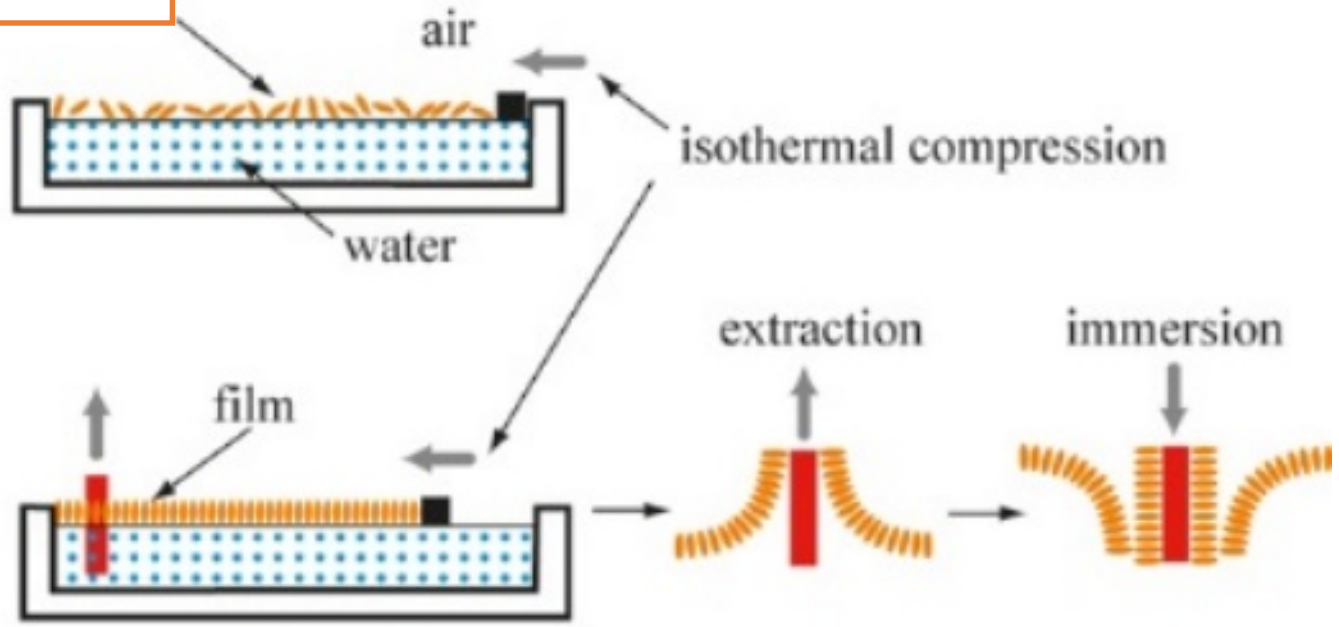
- The method is based on
  - forming a monolayer network of **amphiphilic** monomers at air-water
  - compressing to alter their density
  - photopolymerizing them at the interface to create a two-dimensional polymeric membrane
- It is possible to create a porous membrane by fine-tuning the density of monomers.
- The membrane can be transferred to a solid or porous substrate.

Langmuir-Blodgett: Synthesize a Monolayer Film

Antrip-DEG in 1:1 mixture of chloroform and cyclohexane

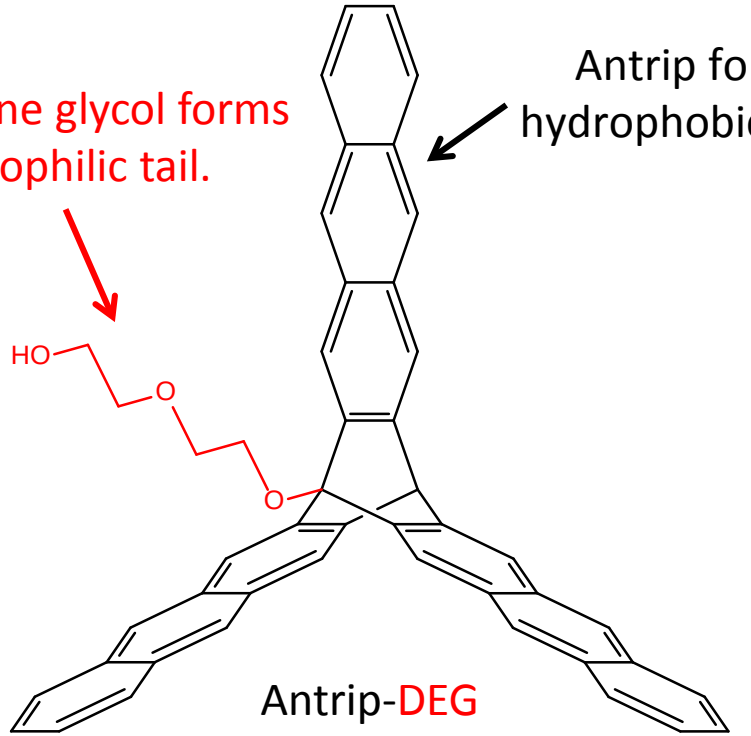
Amphiphilic monomers in volatile solvent are spread over the surface of water.



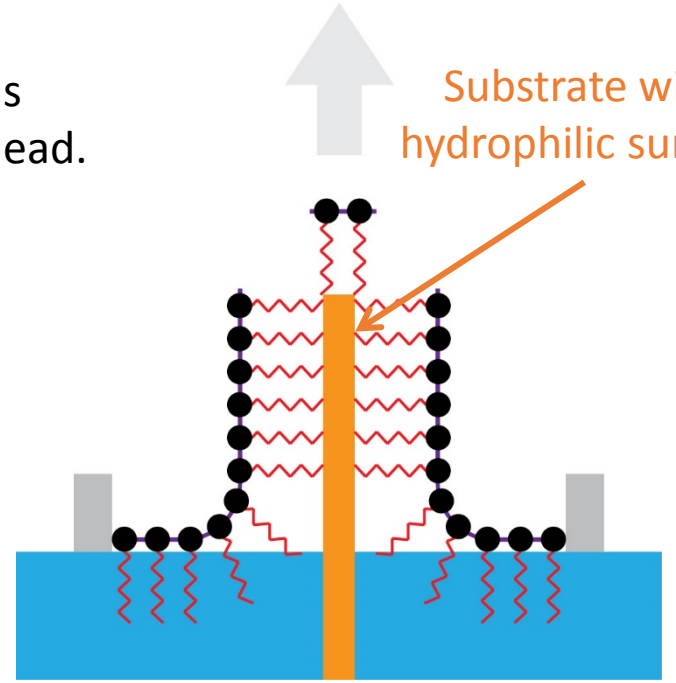


Adapted from http://eng.thesaurus.rusnano.com/wiki/article1797

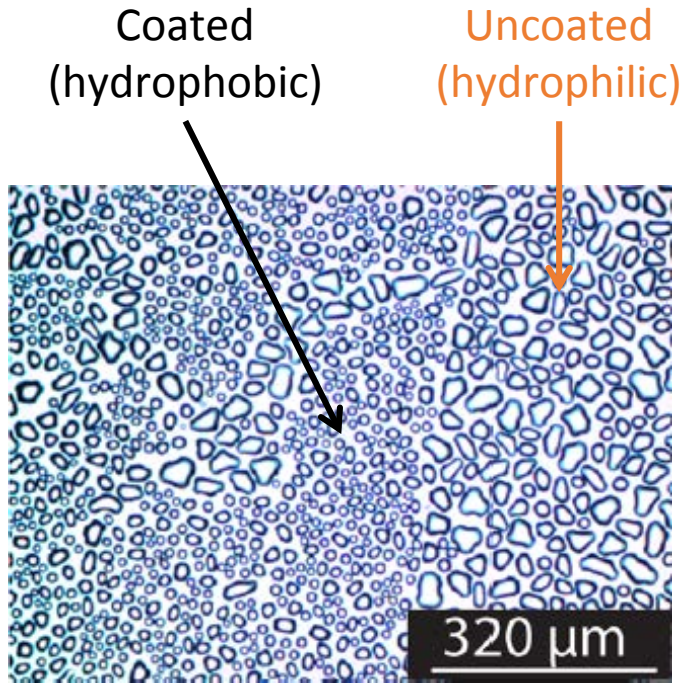
Vertical Extraction of Poly(antrip-DEG) Monolayer



Antrip-DEG monomer



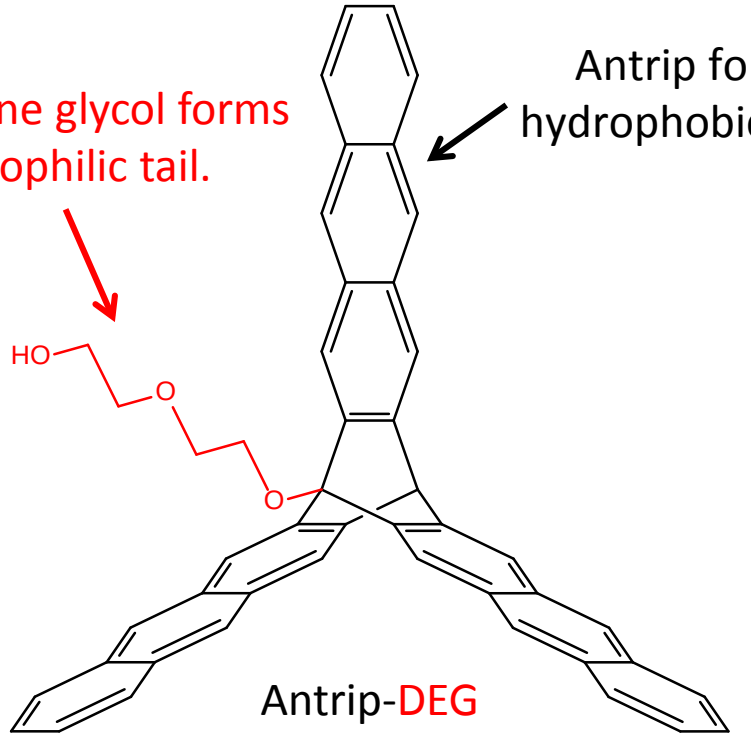
Monomers link by photo-dimerization.

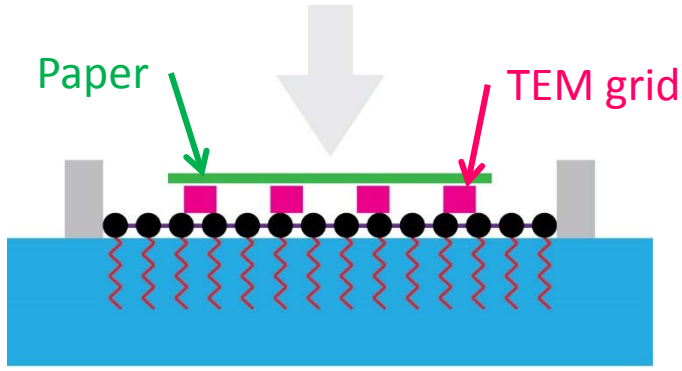


Water condensation on a SiO_2 wafer partly coated with poly(antrip-DEG).

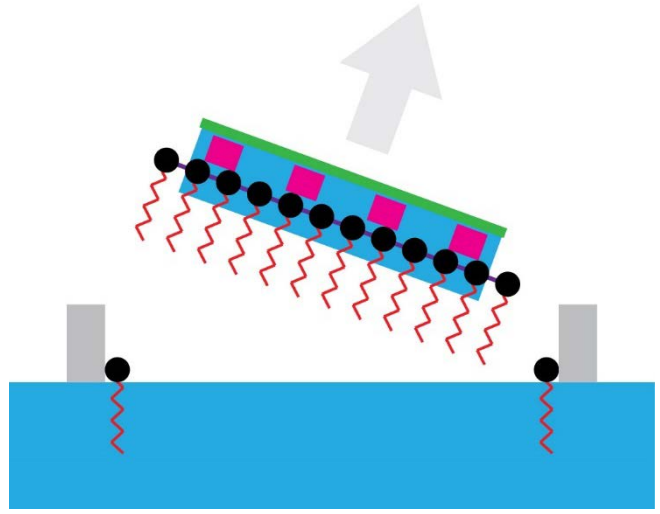
DEG = diethylene glycol

Langmuir-Schaefer: Transfer a Monolayer Film onto Substrate





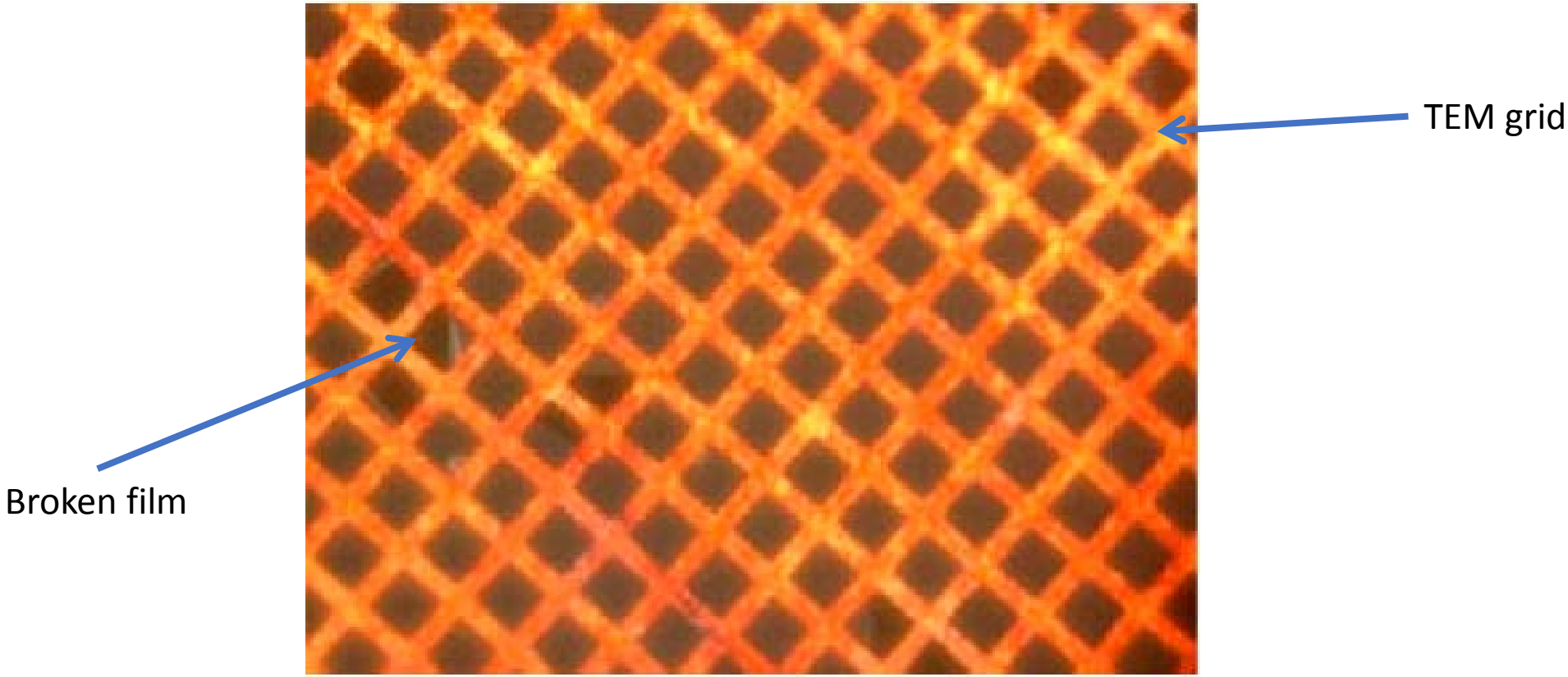
Monomers link by photo-dimerization.



Paper absorbs water along with the photopolymerized film and TEM grid.

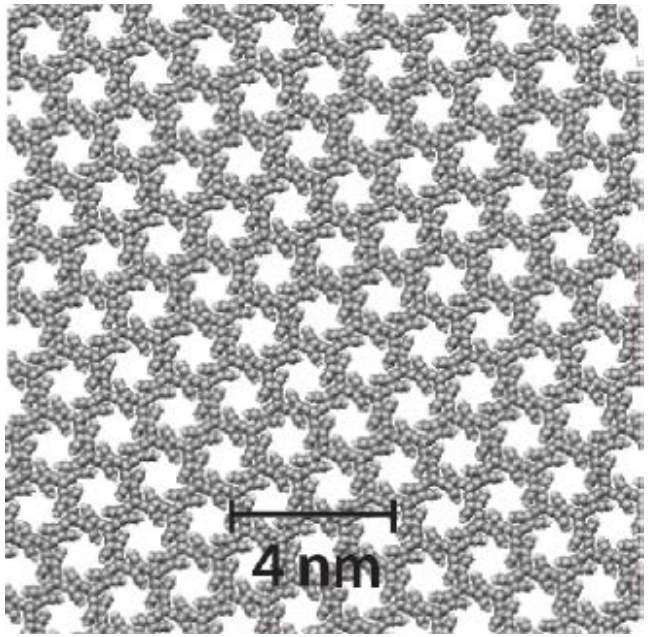
DEG = diethylene glycol

Free-standing Film Spanning 20 × 20 μm^2 Holes on a TEM Grid

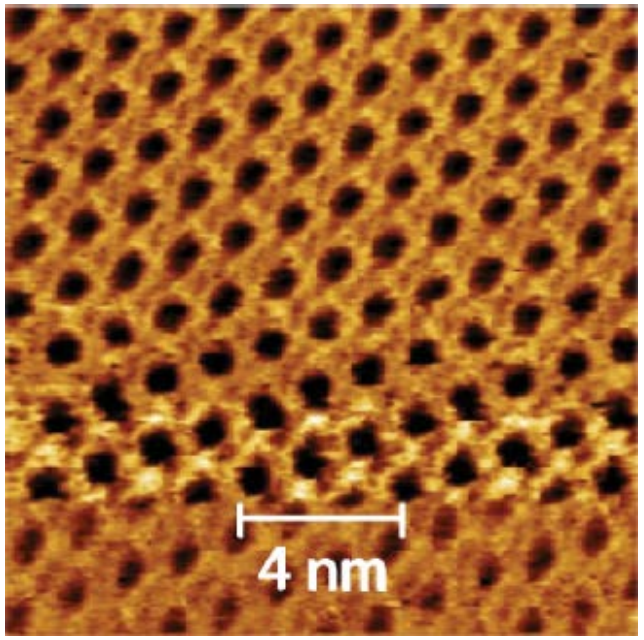


Film transferred to TEM grid by Langmuir-Schaefer method

Organized Monolayer of Poly(antrip-DEG) Membrane (1.2 nm thick)



Simulated



STM image

- Pores have a narrow size distribution (monodisperse).
- Pores are measured to be ~0.7 nm in diameter.
- Pores constitute ~30% open area.

DEG = diethylene glycol

Promise and Limitation

Promise:

- Omitting the polymerization part, the synthesis of two-dimensional organic membrane is also possible.

Limitation:

- Applicable only to amphiphilic molecules