Polymers Additives for "Flow Assurance" of Crude Oils

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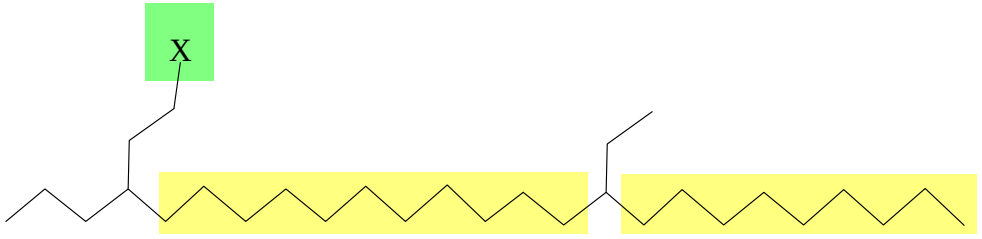
Poly(ethylenebutylene) polymers (PEB)

Control crystallinity

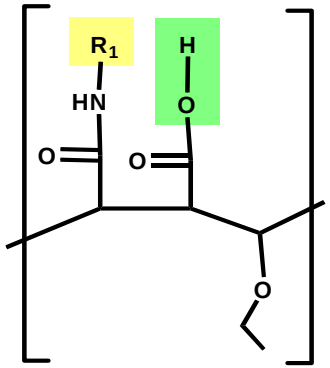


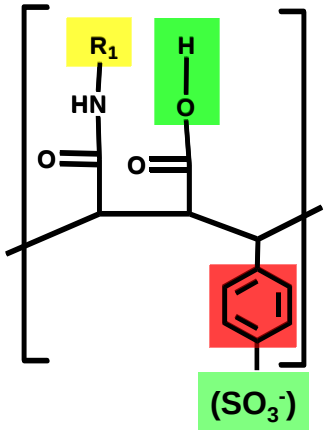
Control crystallinity and polarity/acidity

X = -OH, -NH2, -COOH, -SOOOH

Maleic Anhydride Copolymers

Copolymerization with crystalline and/or polar monomers





crystallinity

polarity/acidity

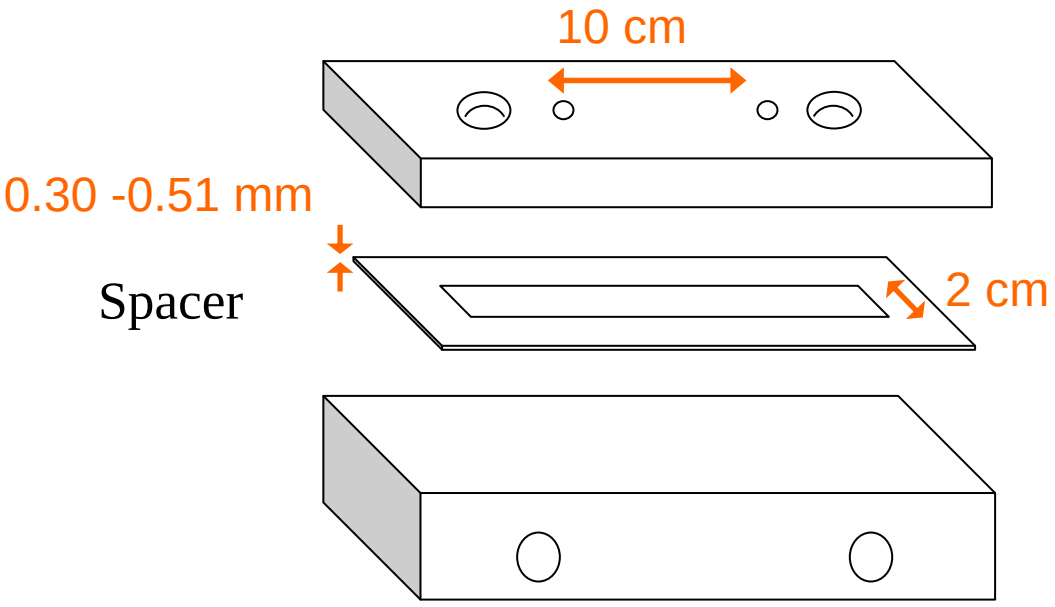
aromaticity

- $R_1 = C_6, C_{12}, C_{22}$
- Effort to obtain equal M_w

Deposition Apparatus

Internals of Parallel Plate

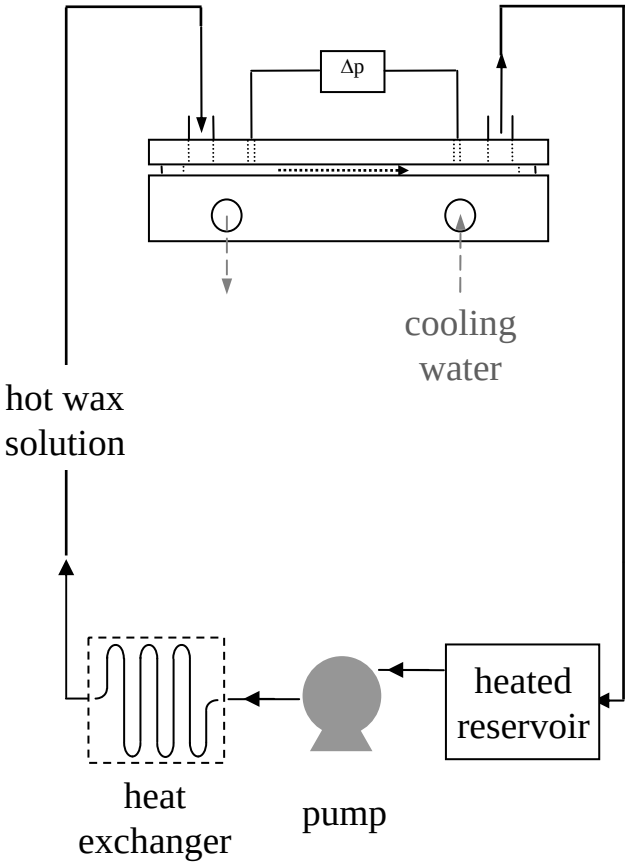
Plexiglas plate:
uncooled



Spacer

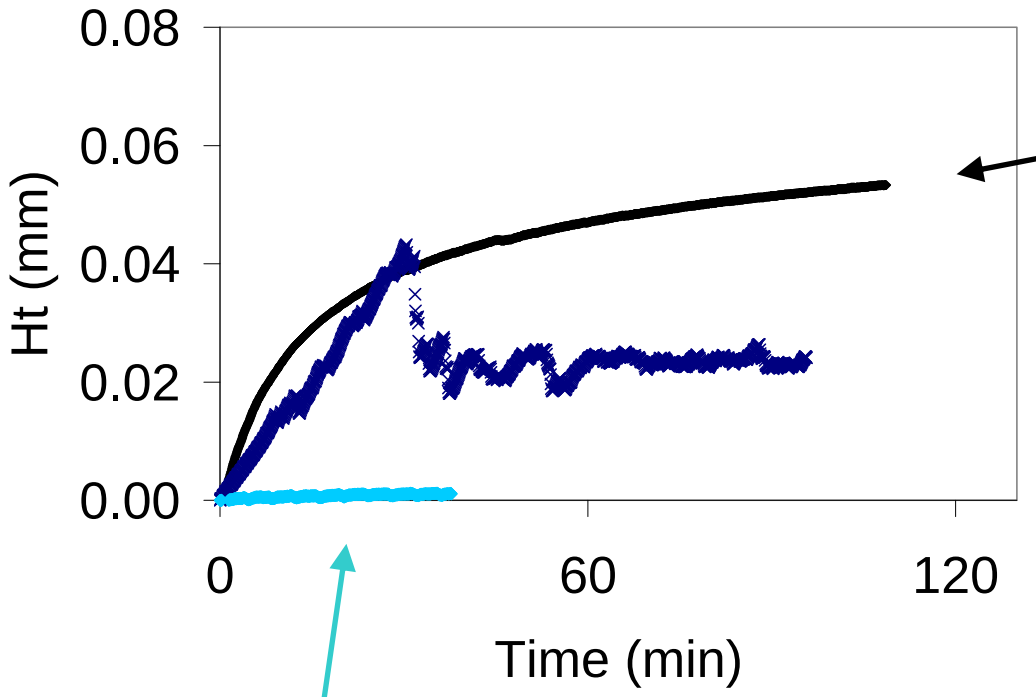
Copper plate:
cooled test surface

External Loop



Deposition with Polymers

- High wall shear stress, T_{plate} = 19.5°C

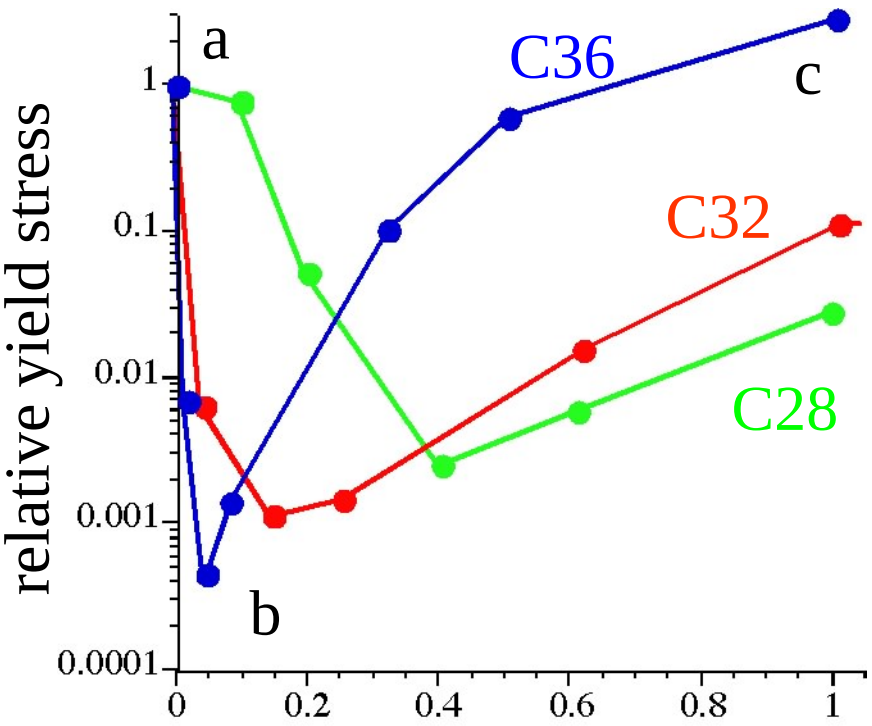


Effect of PEPEP on 4wt% Wax Yield Stress

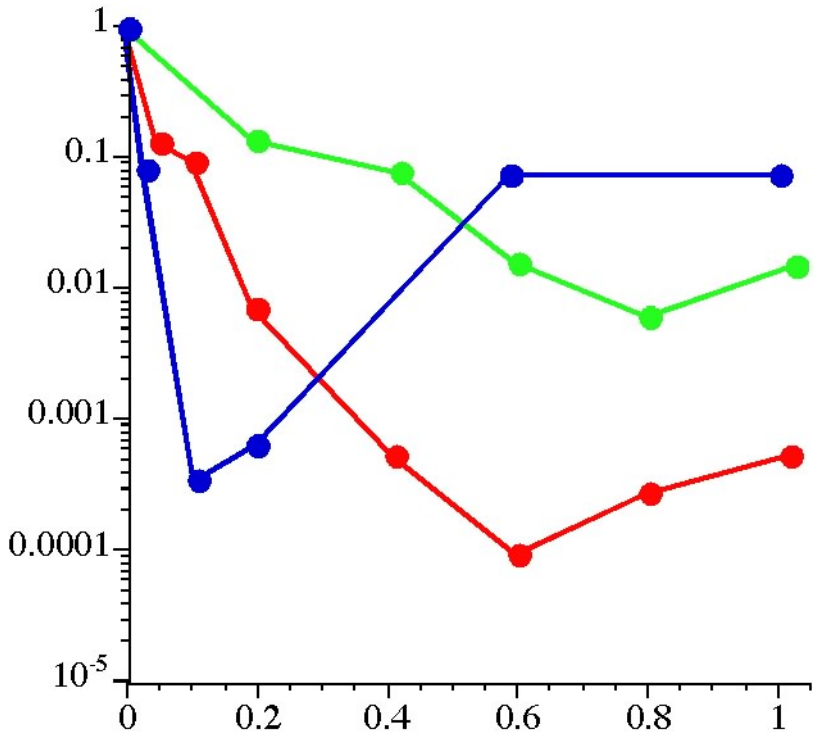
a) pure wax gel

b) stable wax dispersion

c) re-gelation



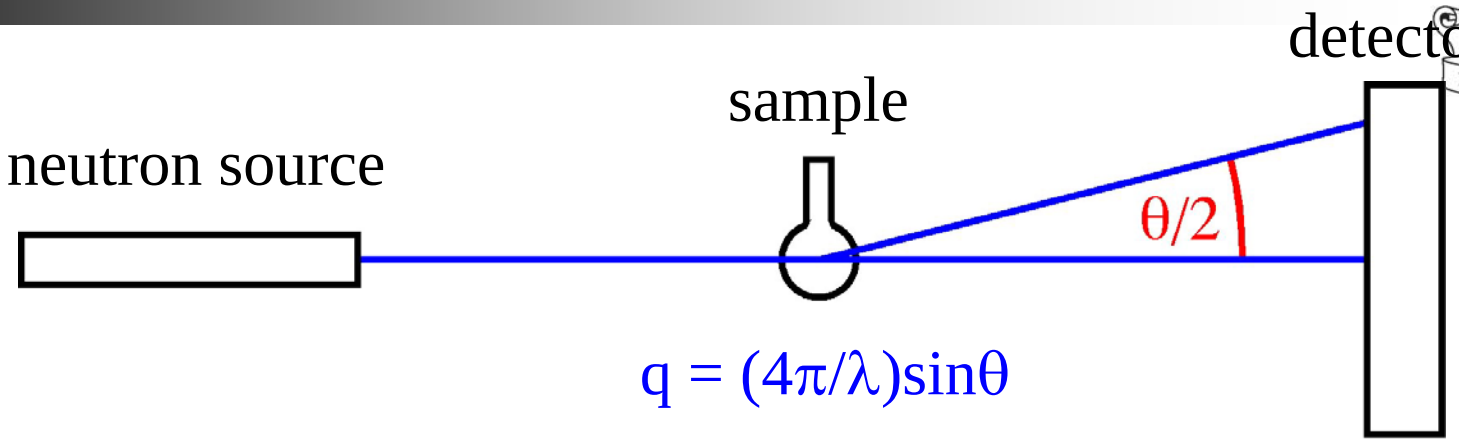
PEPEP 1.5k/5k (wt%)



PEPEP 1.7k/11k (wt%)

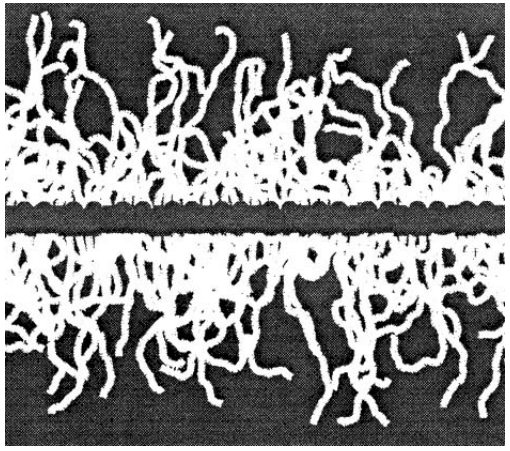
* At $3/pound it costs $0.21/barrel to treat at 200ppm

Neutron Scattering

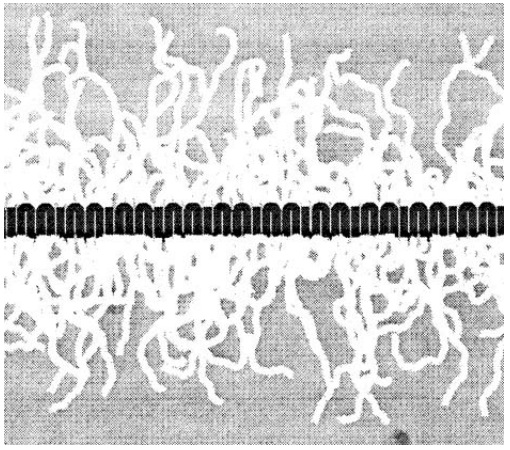


$q = (4\pi/\lambda)\sin\theta$

Scattering contrast: light - index of refraction
x-ray - electron density
neutron - Hydrogen and Deuterium nuclei



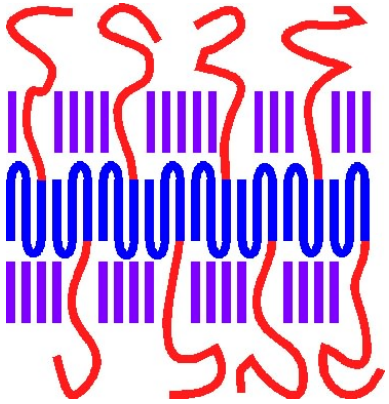
PEI-PI brush



zero average contrast

Scattering Results

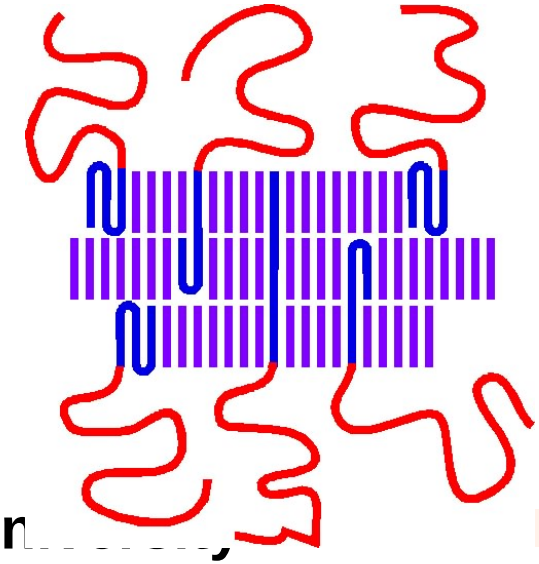
- Wax nucleates within the brush layer



$T_{agg} > T_{solubility}$

Potential to overwhelm brush layer with excess wax

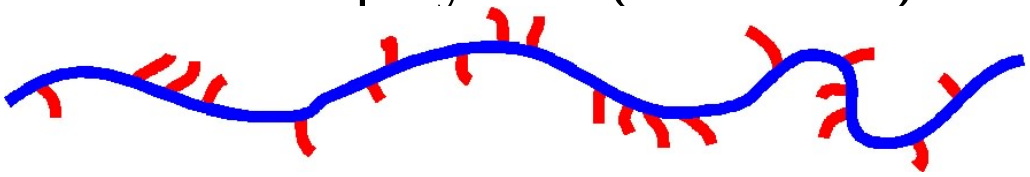
- Polymer and wax co-crystallize - Optimum



$T_{agg} \sim T_{solubility}$

Polymer Structures

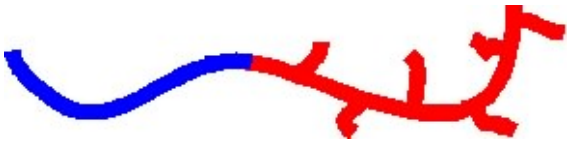
- Random copolymers (traditional)



Ethylene vinyl acetate (EVA)

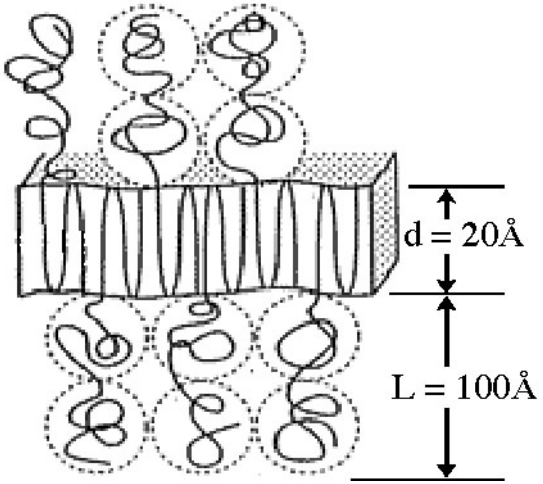
M_w = 60 to 100$^+$ k

- Block copolymers
  (Exxon patent #WO9628523A1)

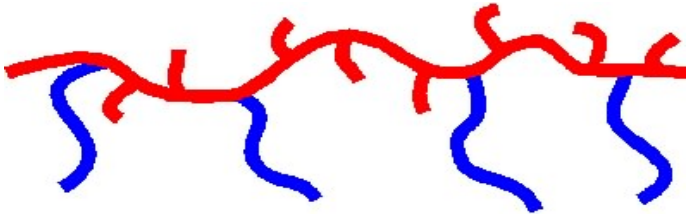


PEPEP

M_w = 6 to 20k



- Comb copolymers (Rohm Inc - expensive)



Requirements: • "wax-like" crystallizable domain

• oil soluble steric stabilizing domain