

Floc, EPS and Membrane Fouling

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The background is a 3D-rendered scene with a monochromatic blue color palette. In the foreground, a checkered floor recedes into the distance. To the left, there are several large, spherical objects of varying sizes, some appearing to be part of a mechanical or scientific apparatus. A bright, glowing light source is visible in the upper right corner, casting a strong light across the scene. The overall atmosphere is futuristic and mysterious.

Disclaimer

Process Integration, backwashing sequence, risk assessment, etc



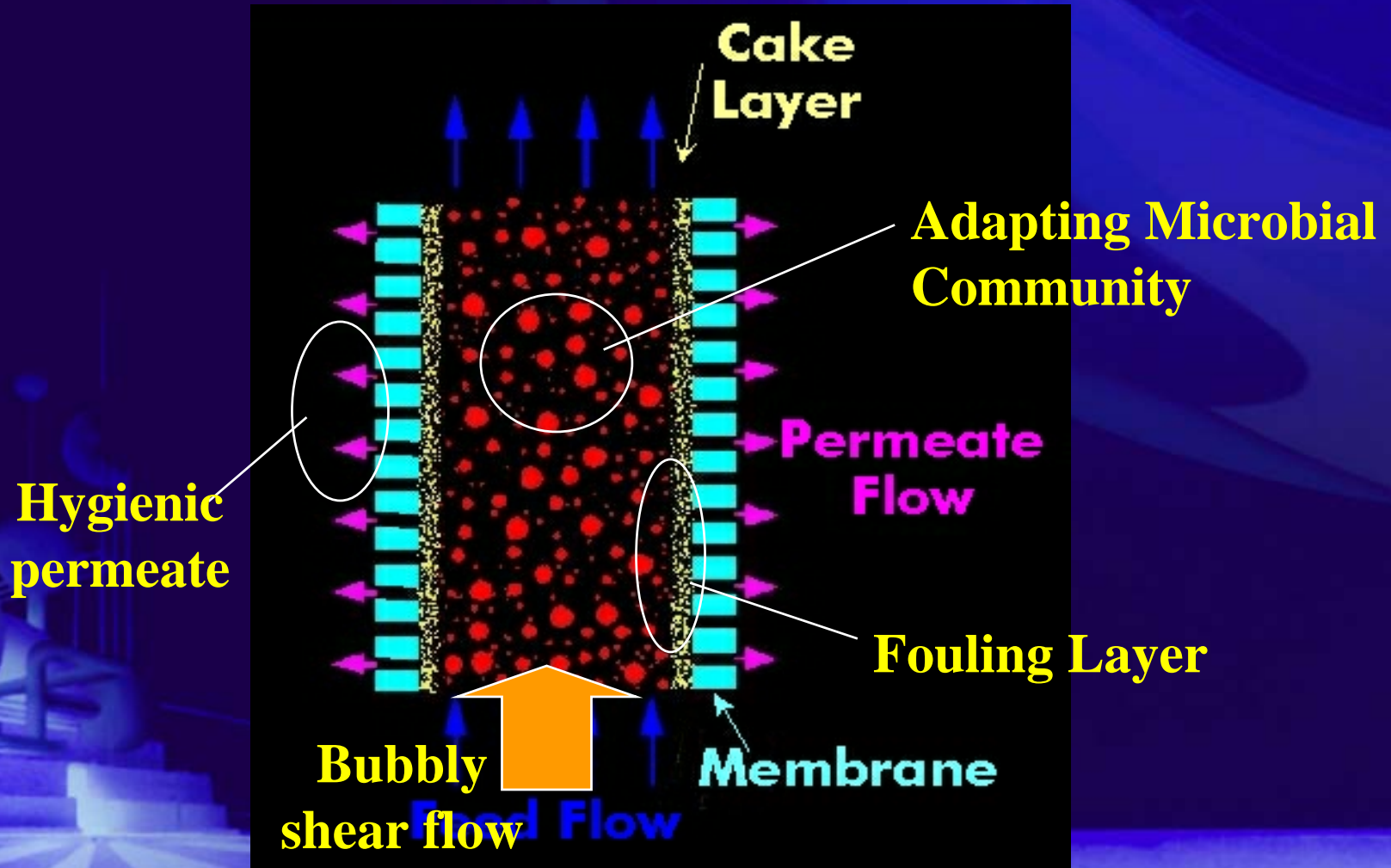
Pre-coagulation
Extraction
Prevaporation
Phase transfer
etc

Two-phase flow
O₂ transfer
Adapting MOs
Monitoring
etc

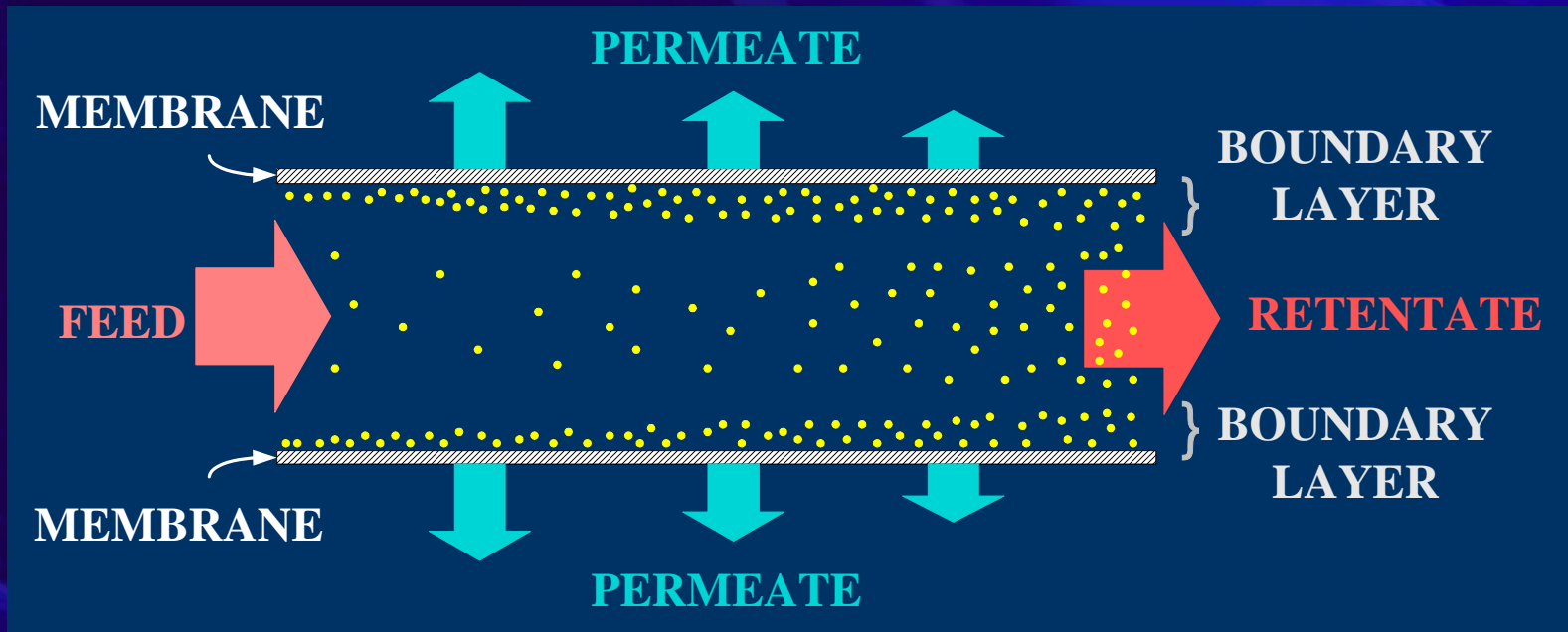
Fouling control
New membrane
Monitoring
etc

Monitoring
Gene Chip
etc

What occurs in MBR

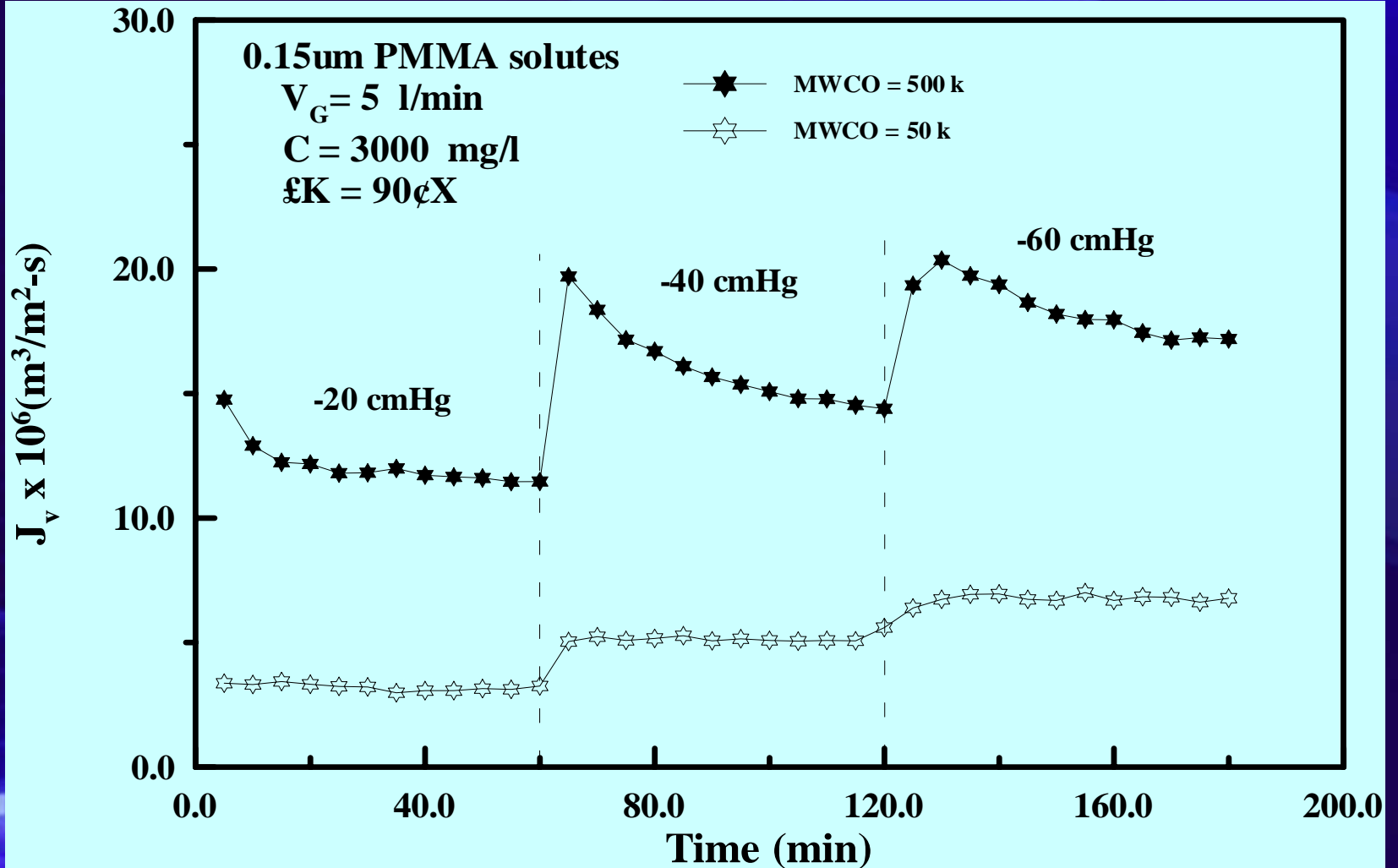


□ Membrane Ultrafiltration

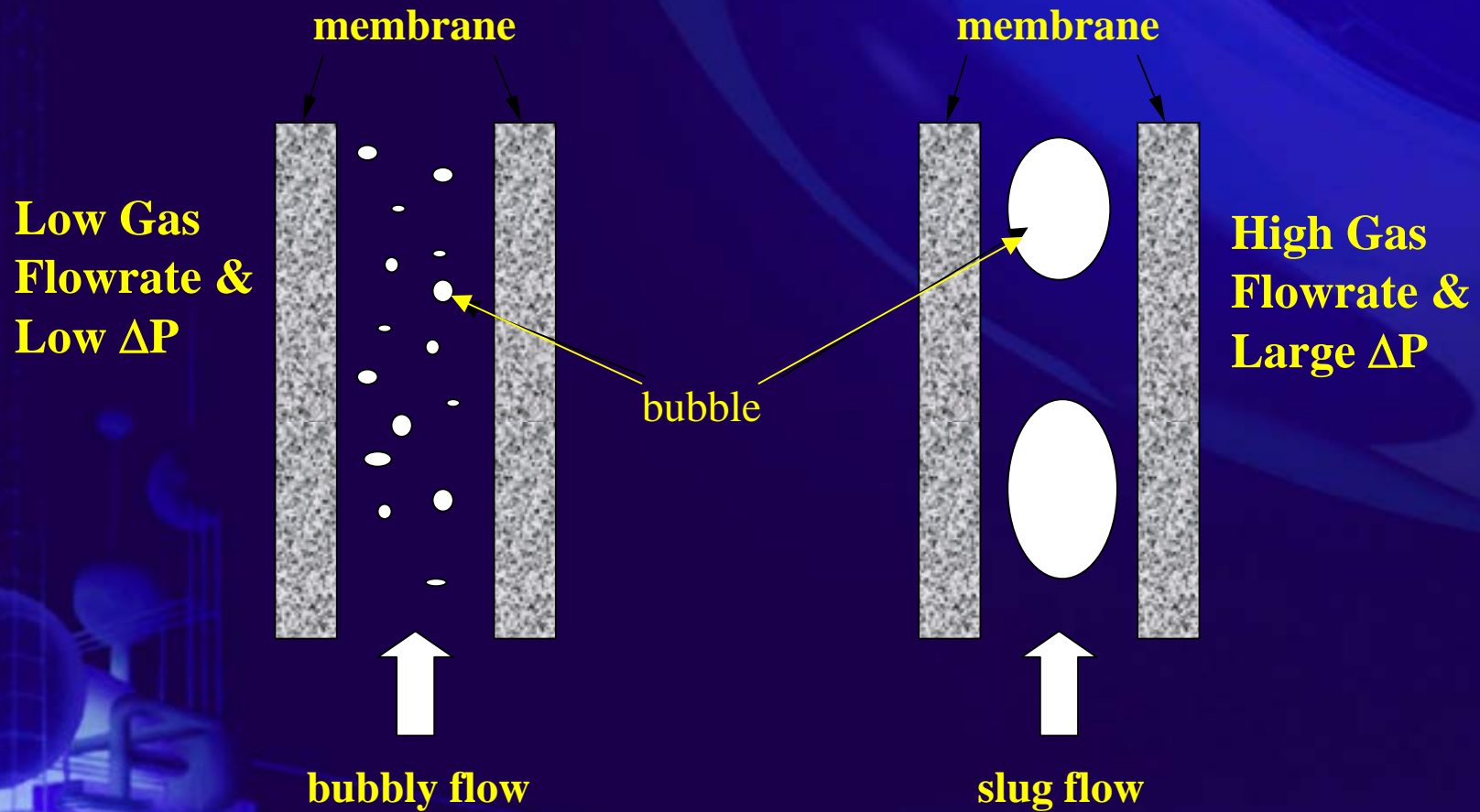


□ To reduce fouling:

- 1. Pretreatments of feed solution**
- 2. Modifying membrane properties**
- 3. Cleaning**
- 4. Positive control**
 - Assisted field (electric, vibrating, etc)
 - Flow manipulation
 - 1. Turbulence promoters**
 - 2. Secondary flow**
 - 3. Pulsating flow**
 - 4. Gas-liquid two-phase flow**

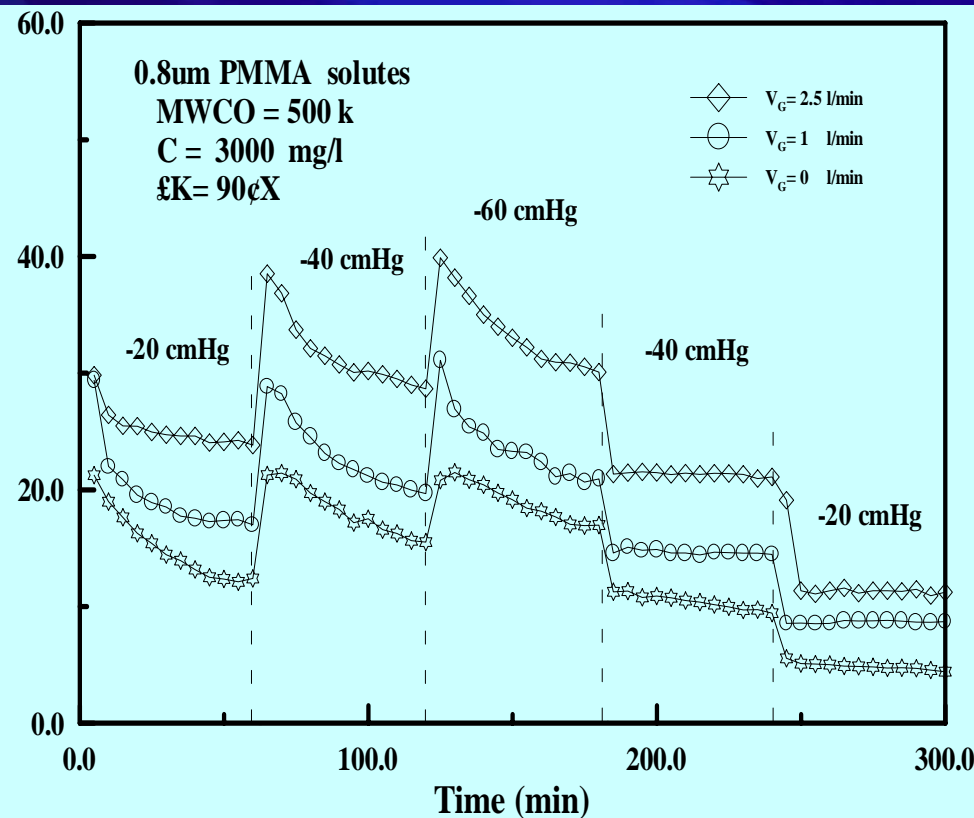
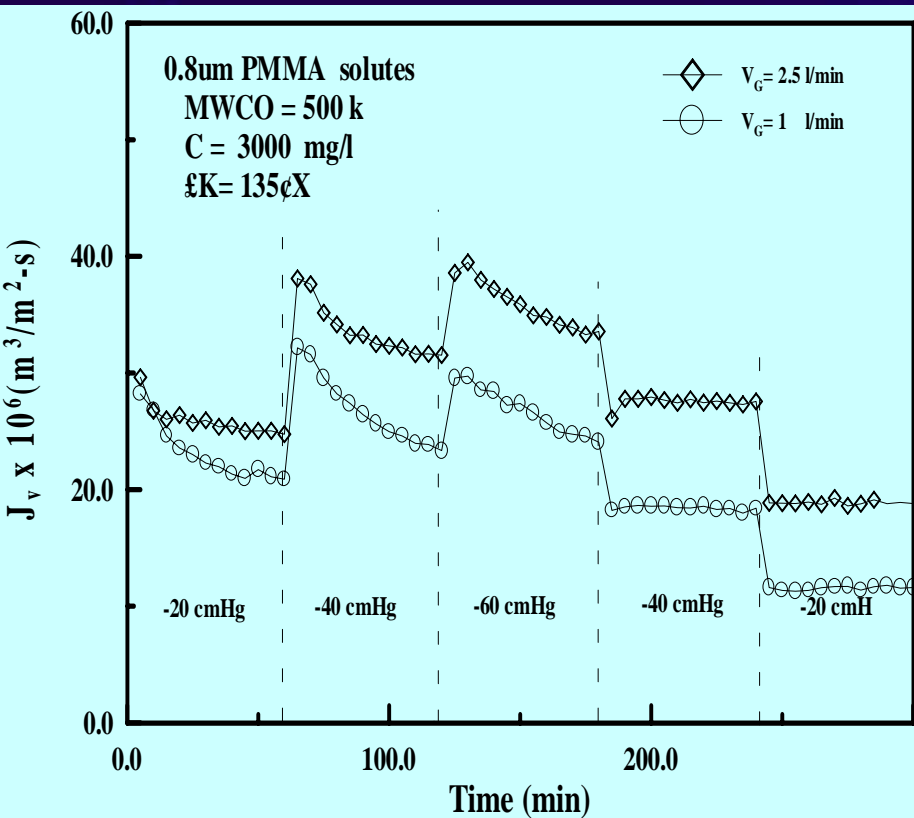


Flow Patterns in MBR



Affects Floc Deposition & Detachment

Effect of ΔP and attack angle (90° or 135°)



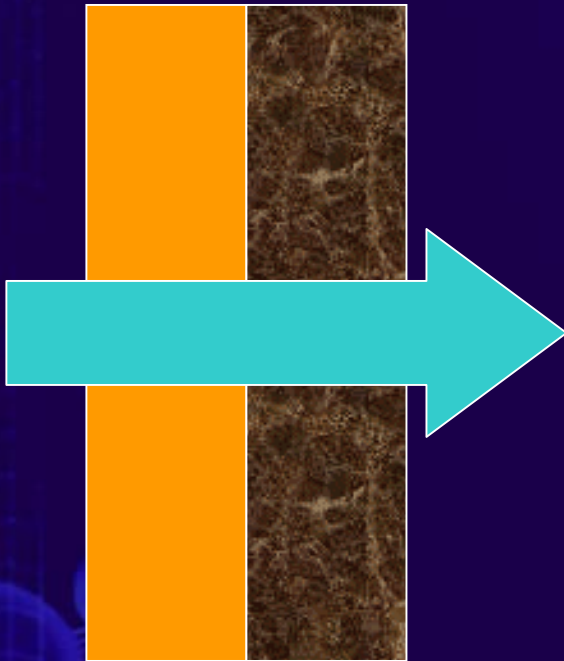
Membrane fouls ...

**Interactions between
microorganisms
and the membrane**

Medium fouling:

Neutral polysaccharides: Kimura, Hane, Watanabe, 2003/Nov

Not carbohydrates or protein: Watanabe, 2004/Feb



Filtration resistance = Cake + medium + others

Cake layer:

Polysaccharides & protein: CH Lee, 2004/Feb

Permeate resistance and screener of fines

Goal:

Fast rate & quality effluent

Less irreversible clogging

Good cake → slow rate & good screener??

Very confused term

Choi/Fane (2002) EPS contributed most to membrane fouling

Lee/Hang/Shin (2003) Floccs 70%, others 30%.
No role of EPS.

Choi et al. (2002) hydrophobic membrane fouls more severely than hydrophilic ones.

Ognier et al. (2002) Fouling is reversible if the TMP-flux curve shows no hysteresis.

Defrane/Jaffrin (1999) if TMP does not increase the fouling is reversible.

Many others....

EPS: Glue together the floc

Extracellular polymeric substances was produced by microorganisms to bind water and chemicals to form protective layer and storage room.

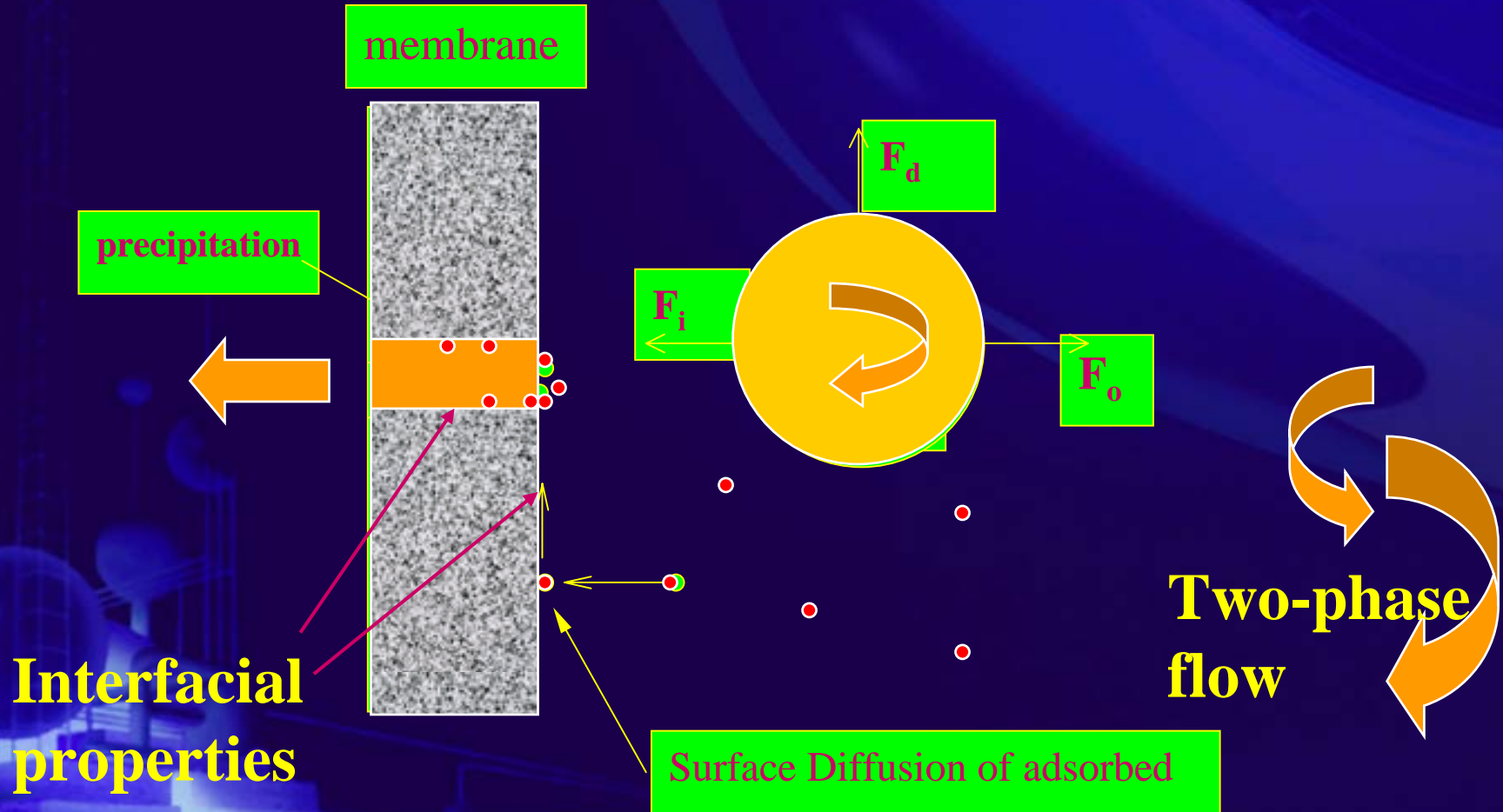
EPS is easily formed from soluble BOD by MO when N- or P- is deficient. Suspended EPS increases with F/M ratio and shearing velocity

Proposed to correspond to 5-90% fouling

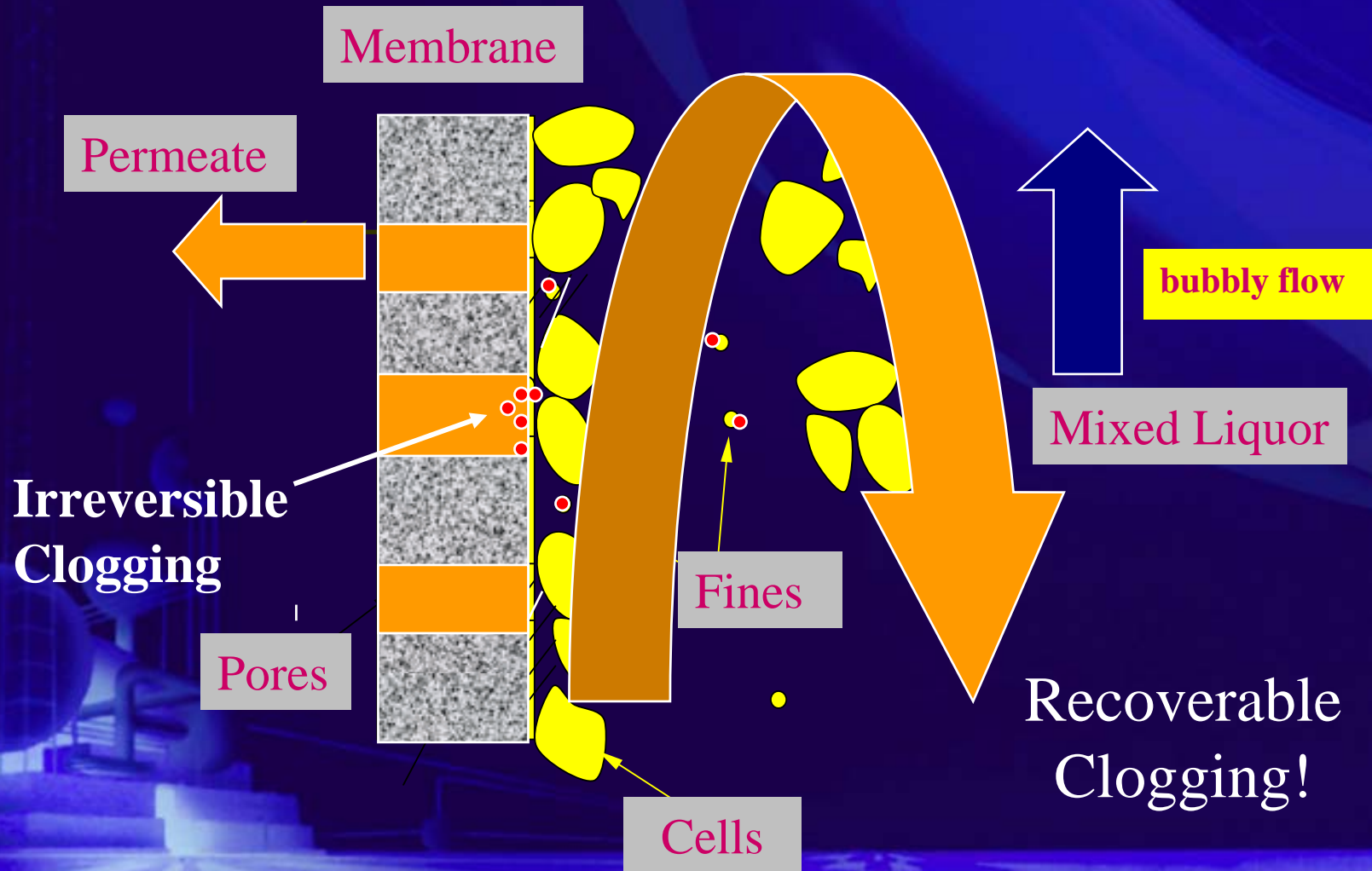
Mainly comprised of carbohydrate and protein

Role of EPS/soluble matters/colloidal particles normally studied under subcritical condition

Near-Membrane Dynamics



Fouling schematics



Irreversible clogging

❏ Mechanism I:

- ❏ The fines pass through and precipitate inside the membrane pores.

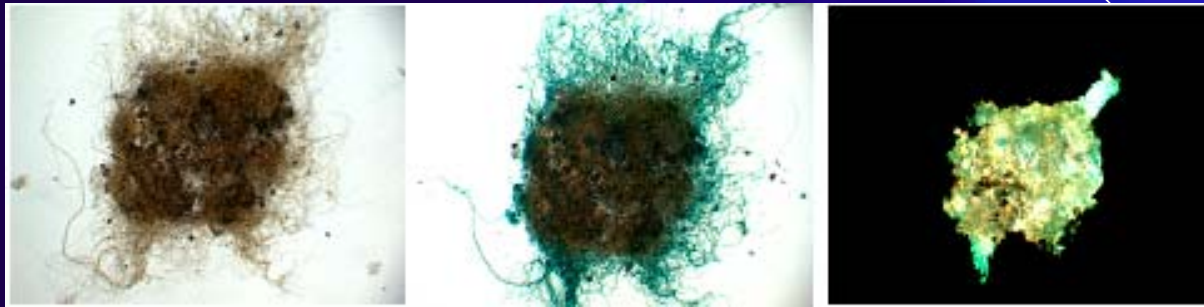
❏ Mechanism II:

- ❏ Cell deposits at the membrane surface first, and then yields ECPs to clog the pores.

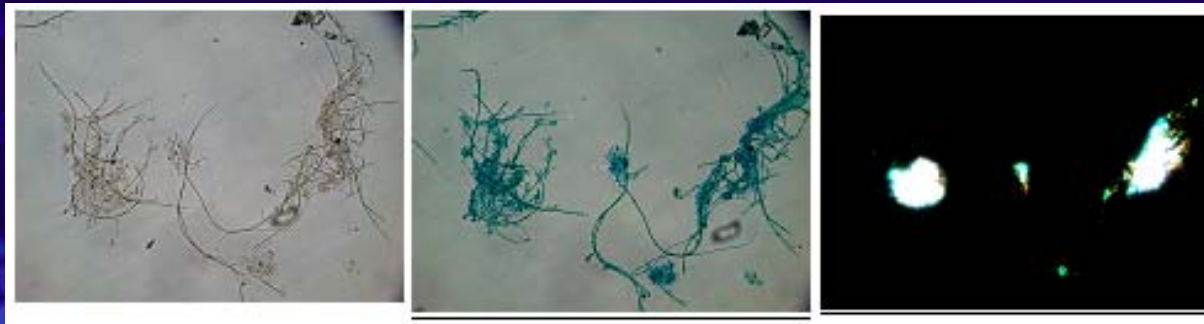
Ways to block out Mech. I or II are different!!

EPS: abundant in floc, rarely in solution

(40X)

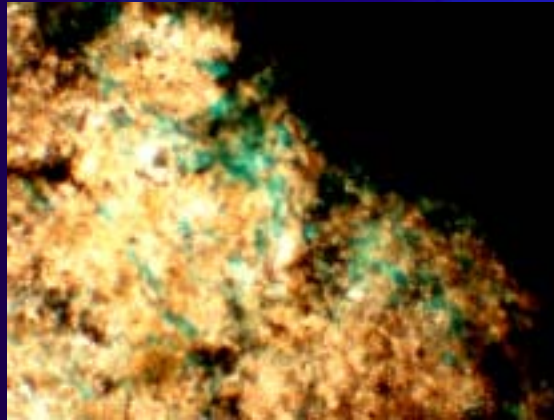


(100X)

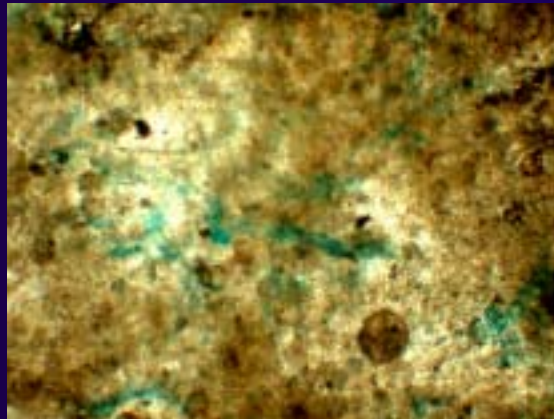


Alcian Blue & indian ink staining

Perimeter



Centre



(40X)

(1000X)

EPS: not in a uniform state (Li XY, 2004): LB (exchangeable) & TB EPS



Centri. 6,000 g, 10 min
Sonicated 2 mins in
0.85% NaCl solu
Shaken 10 mins, sonicated 2 mins,
centri. 8,000 g 10 min

Liquid

LB EPS

Sonicated 2 mins
in 0.85% NaCl solu
Heated at 80oC for 10-45 mins
centri. 12,000 g 30 min

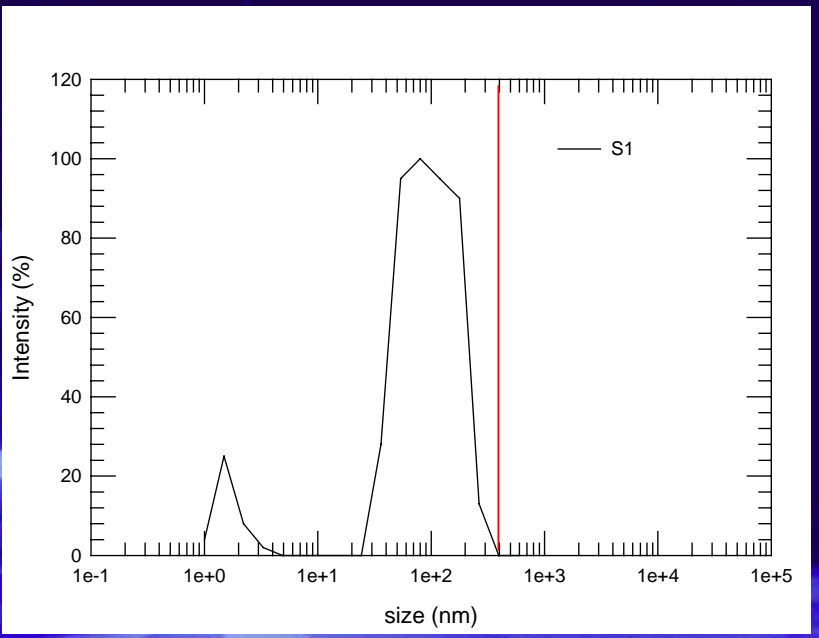
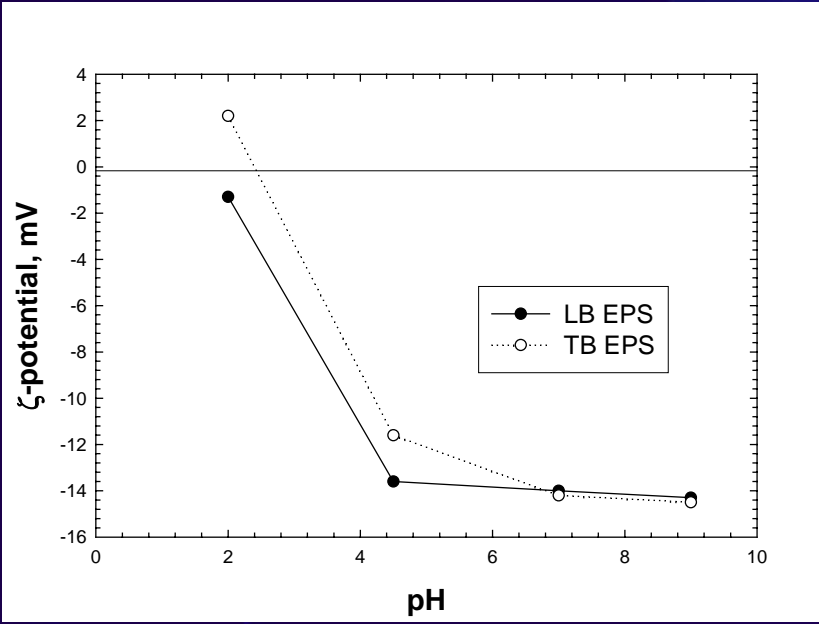
Liquid

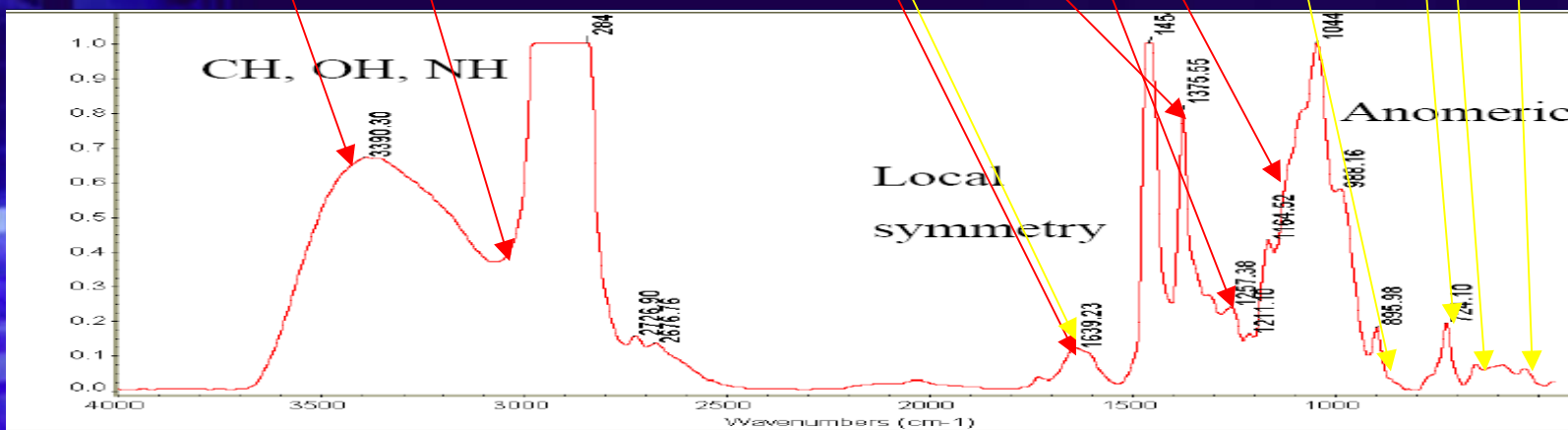
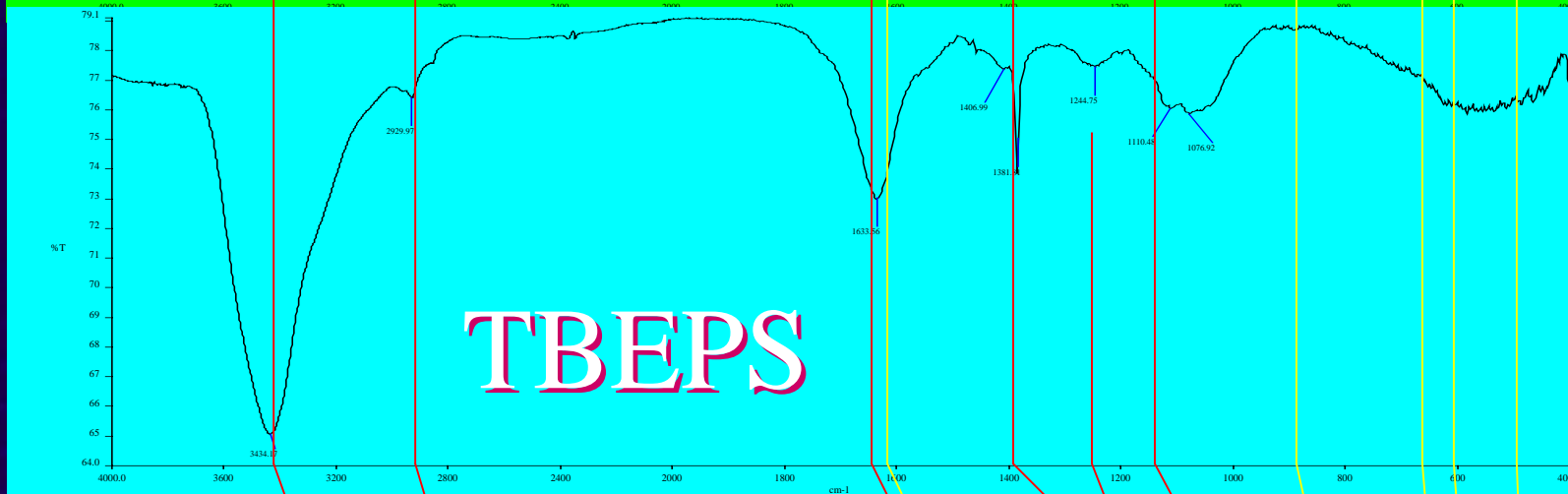
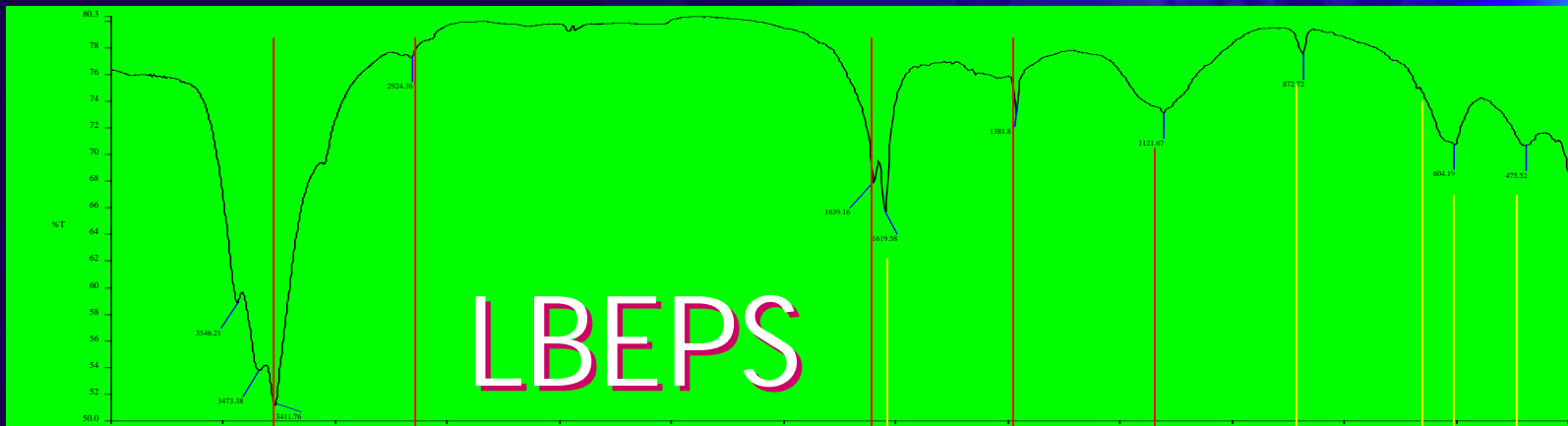
TB EPS

Solids

Solids

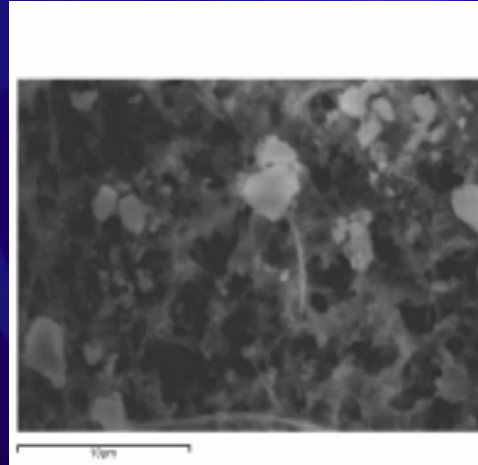
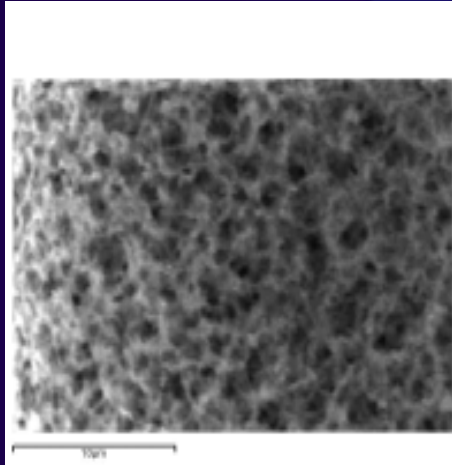
Residue



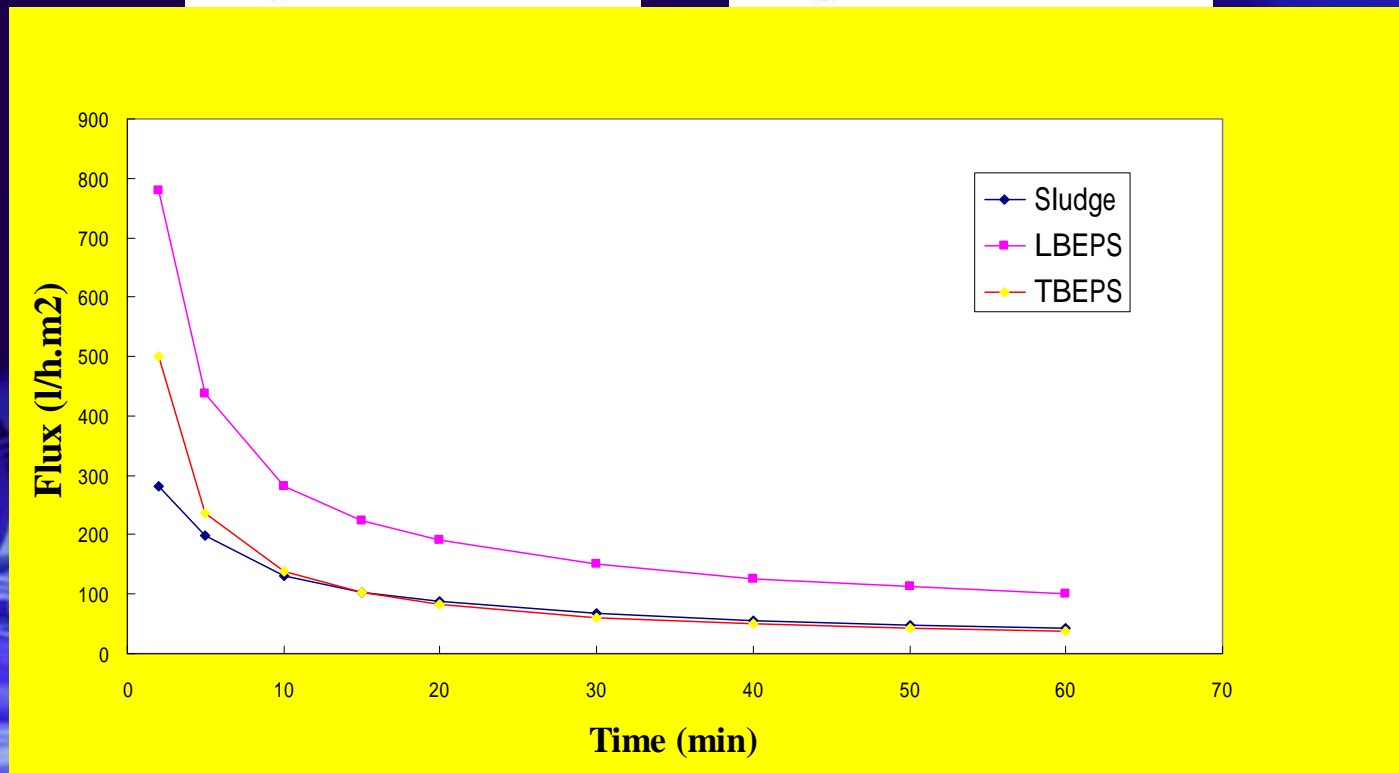


Clean membrane

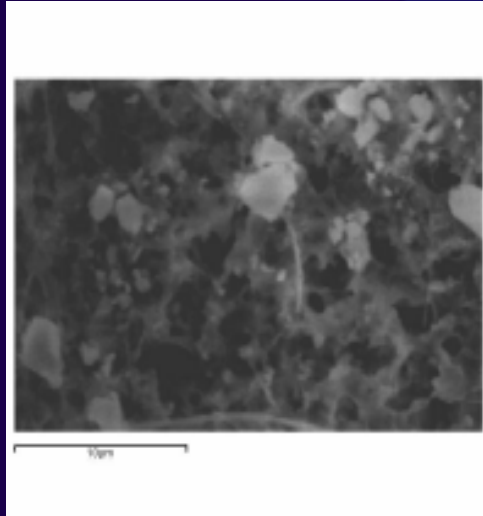
Fouled membrane



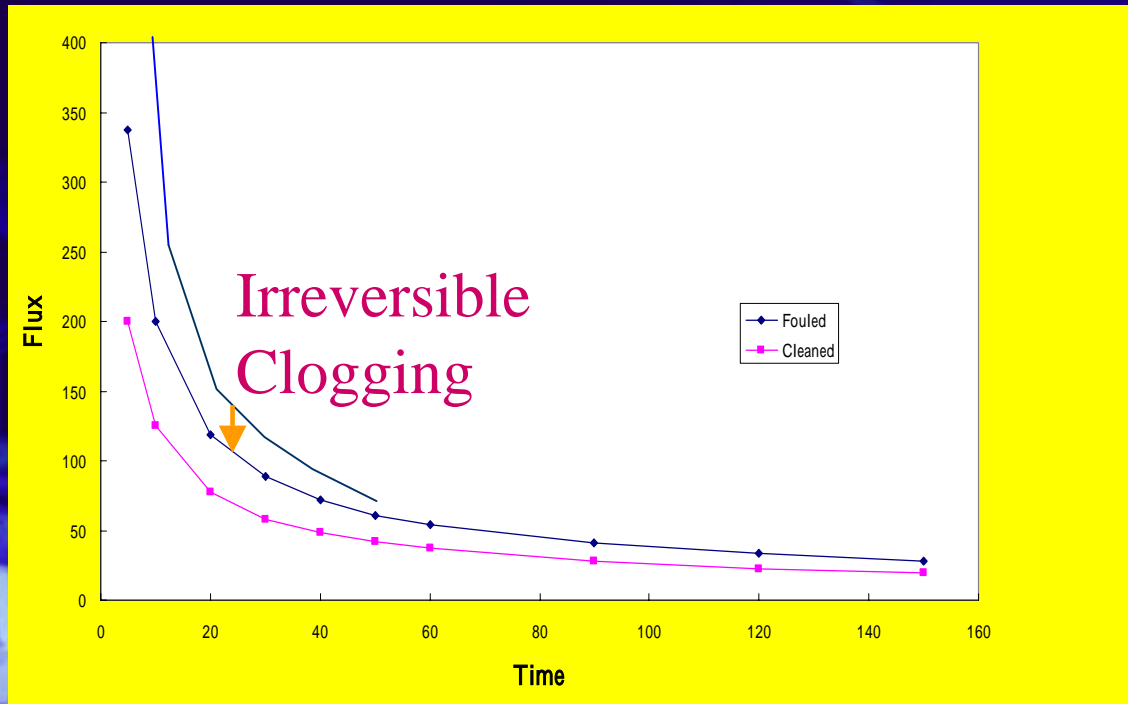
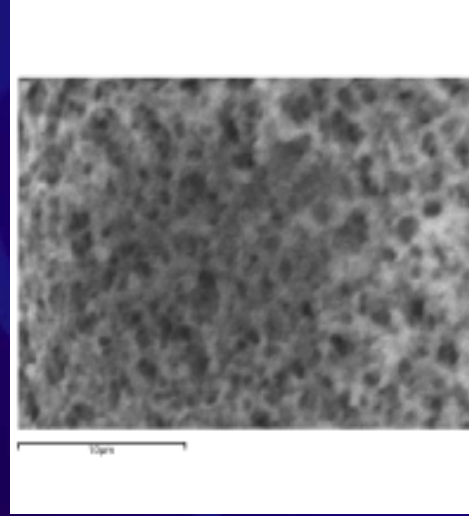
Low MLSS

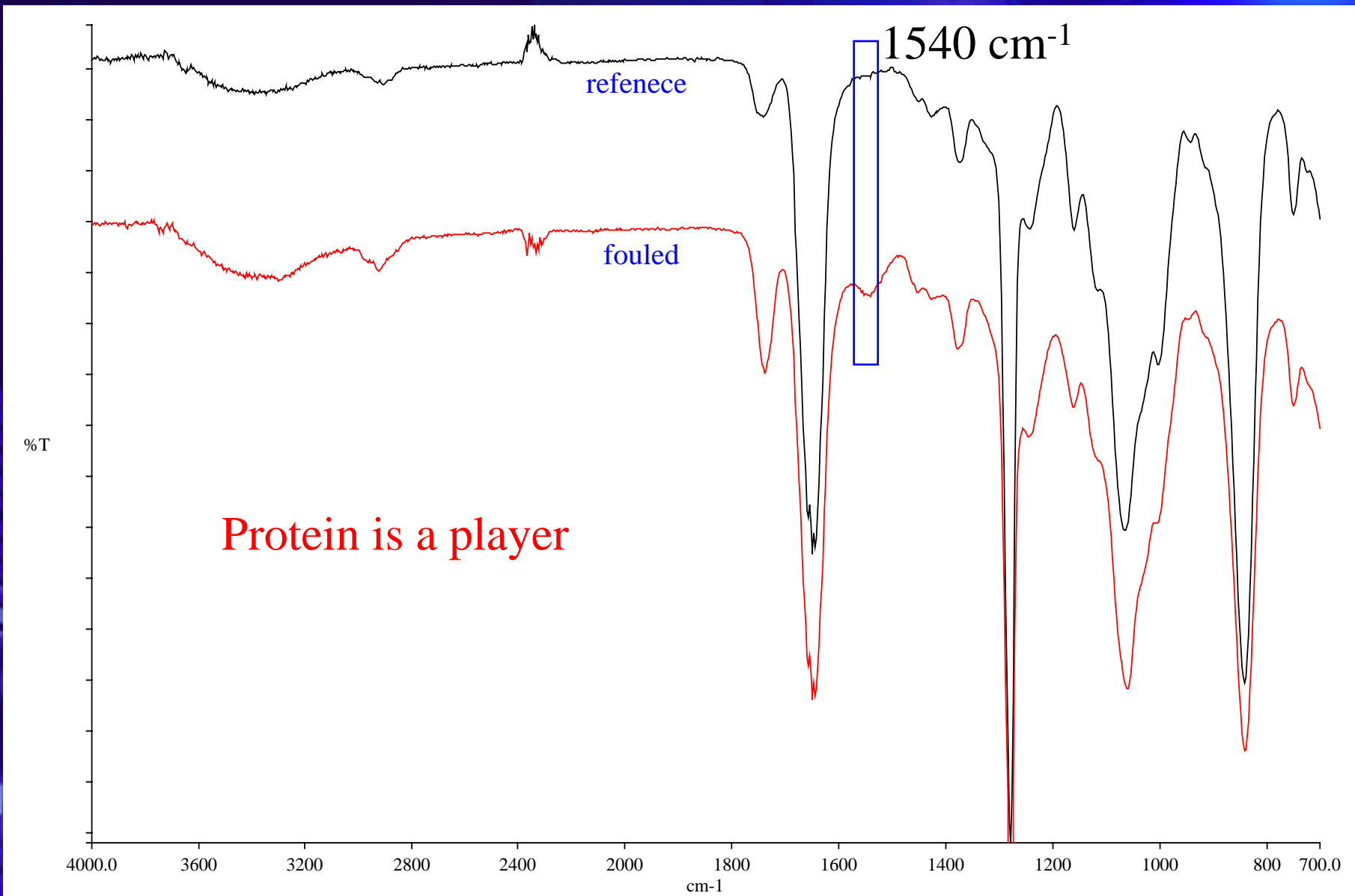


Fouled membrane



Cleaned membrane





FTIR-Microscope
Perkin Elmer spectrum 1
Measured down to 10 x 10 μm .



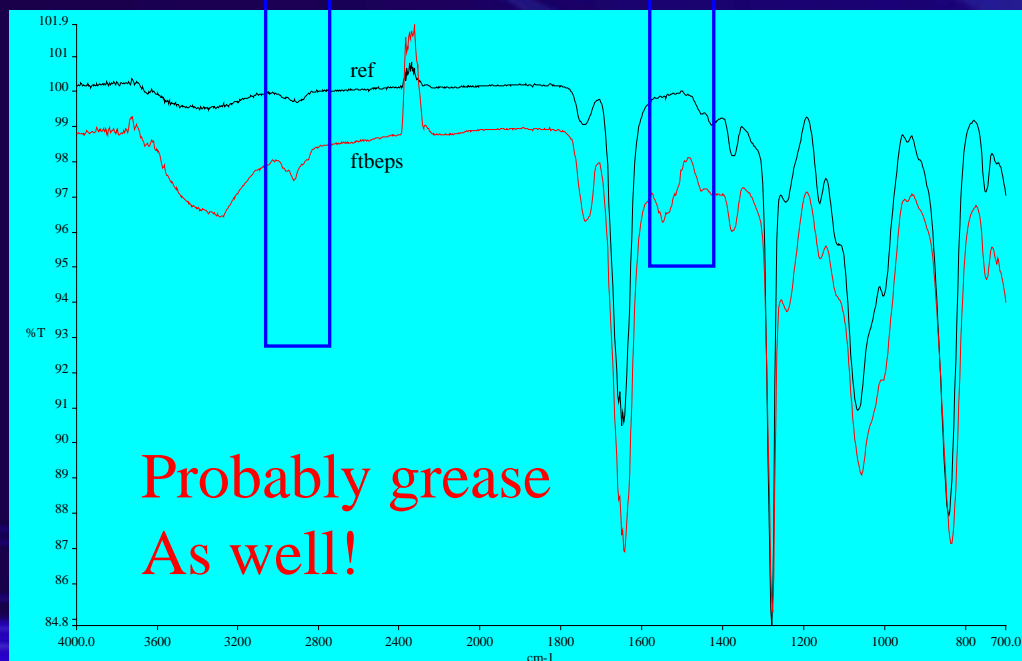
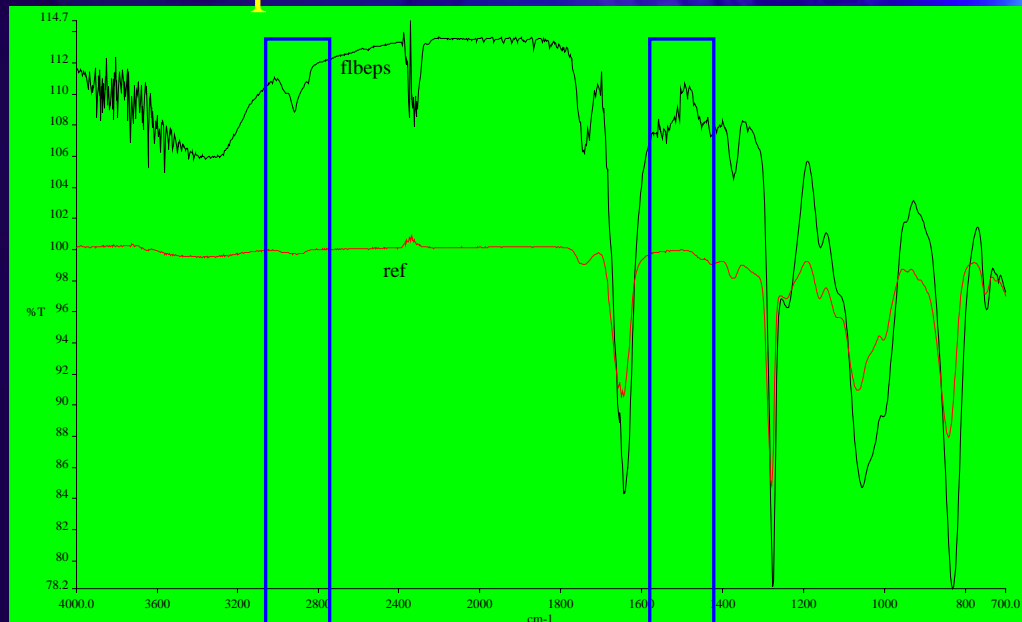
LBEPS fouled

&

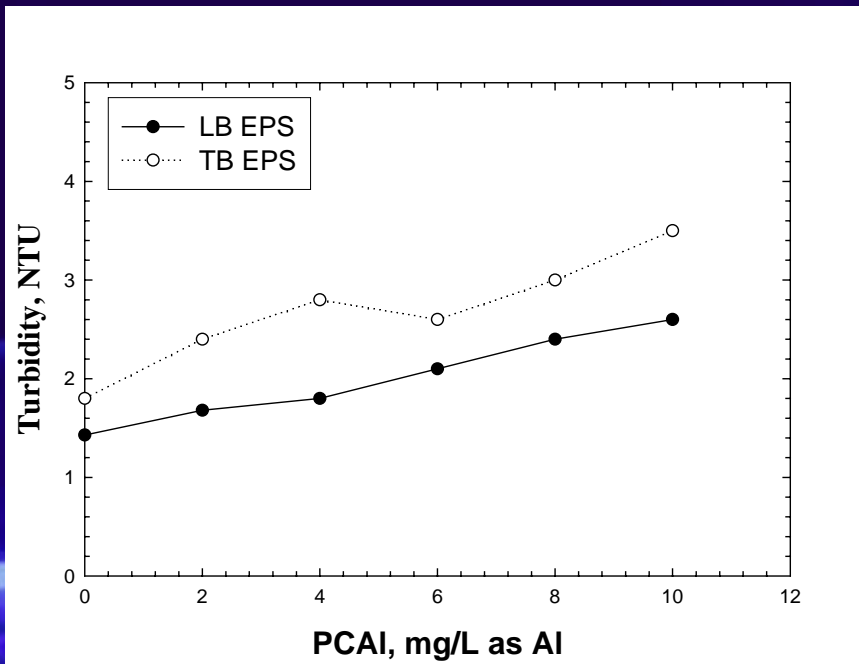
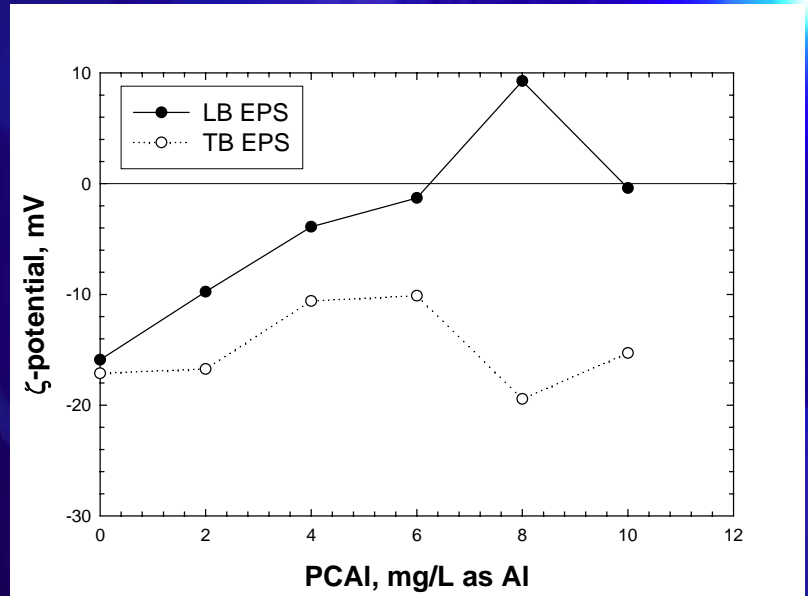
TBEPS fouled
membranes

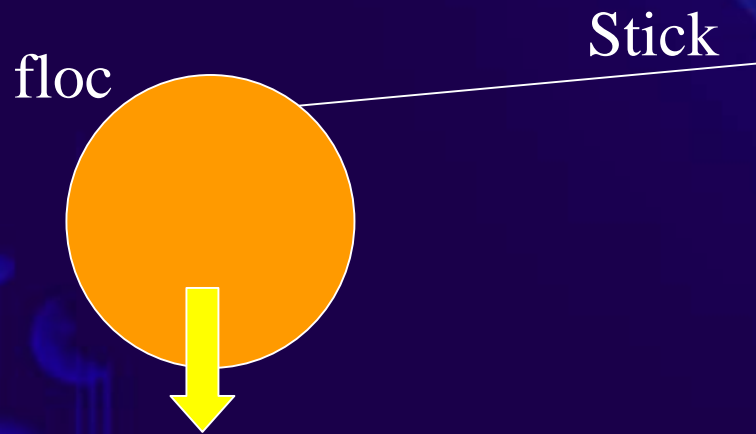
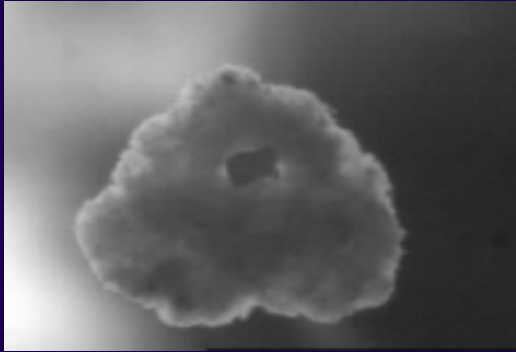
Aliphatic

Amide

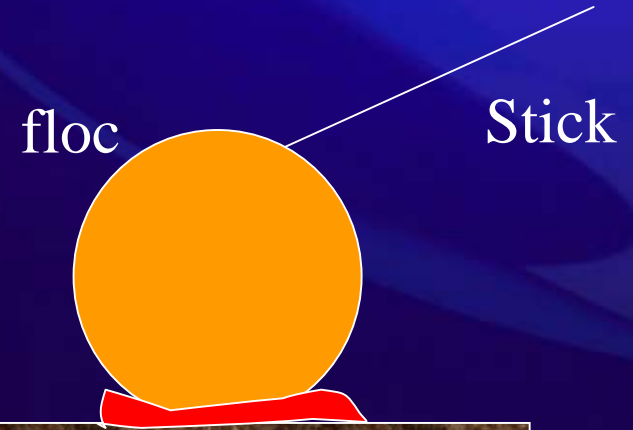


PACl coagulation is not efficient to remove EPS



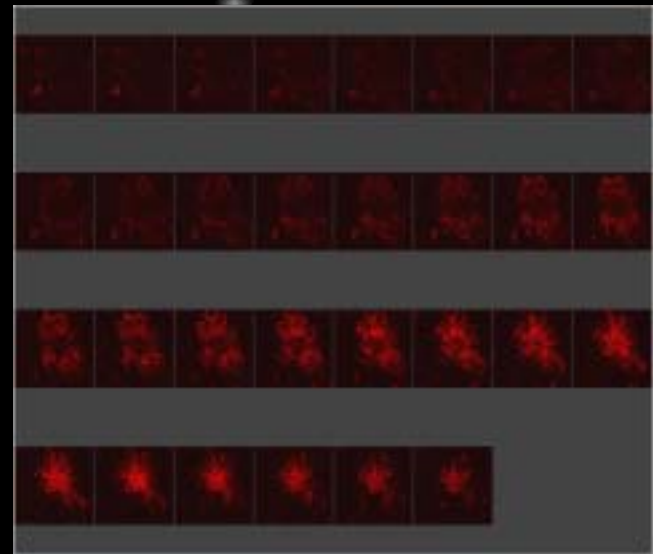
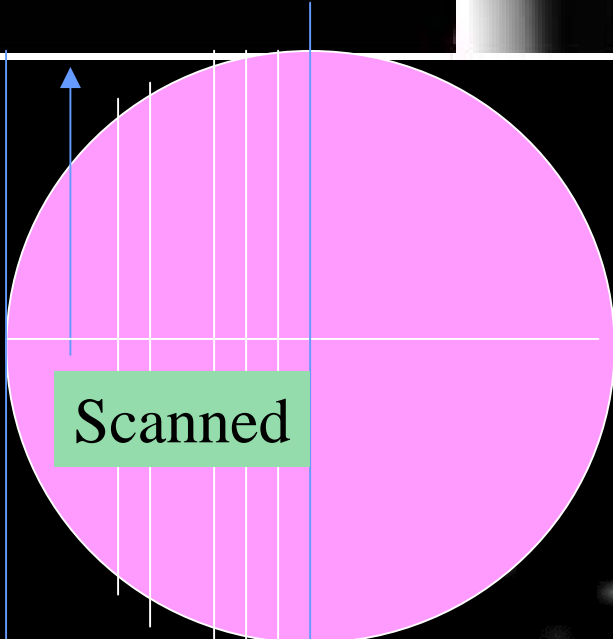
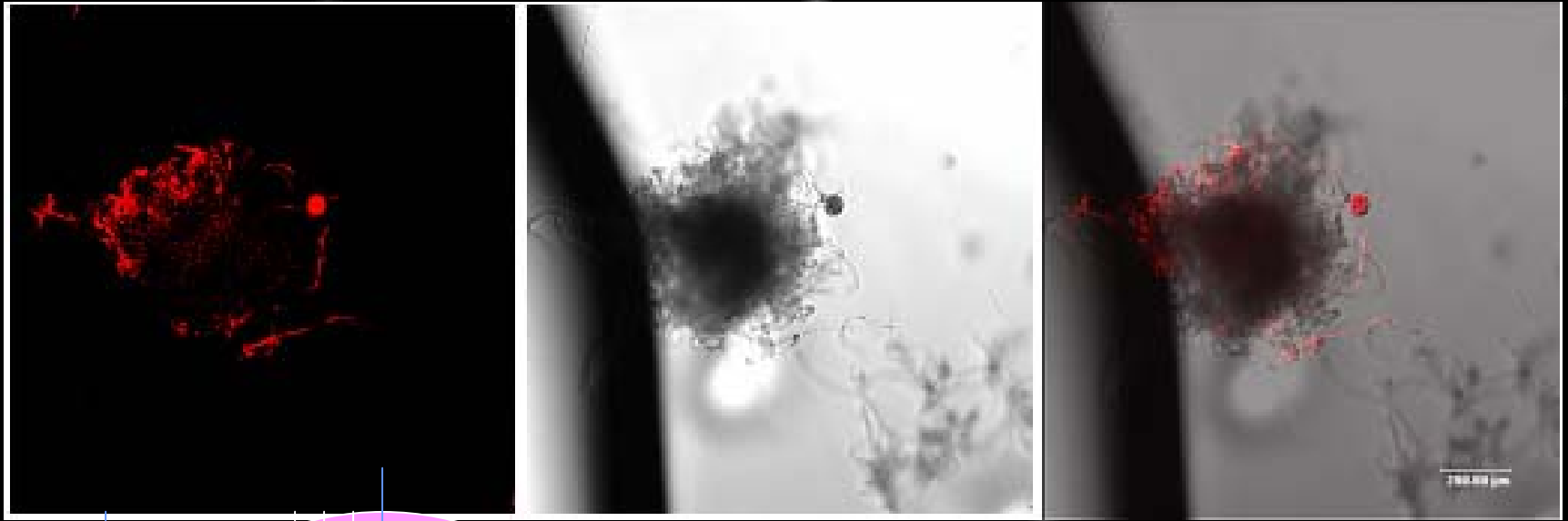


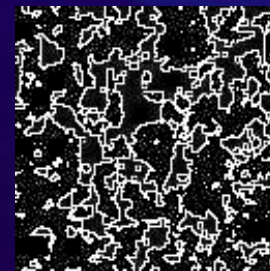
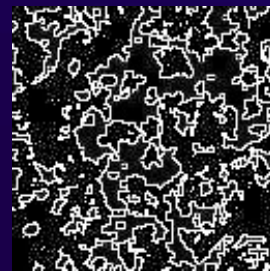
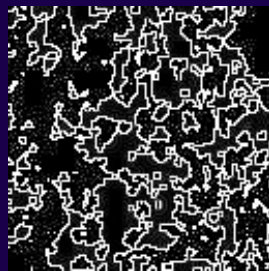
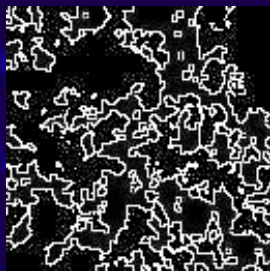
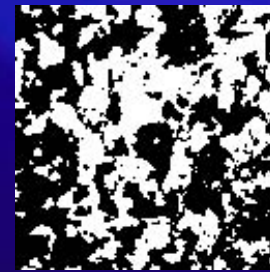
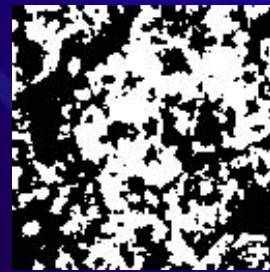
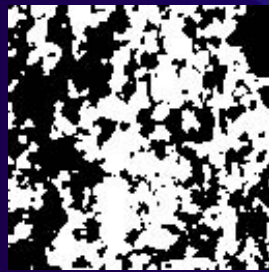
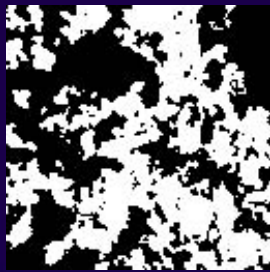
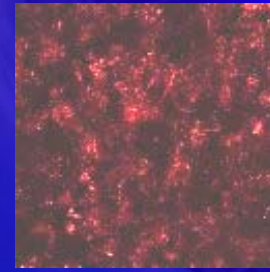
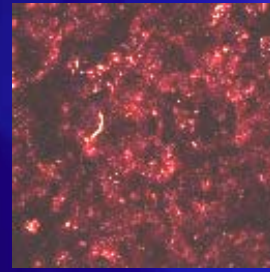
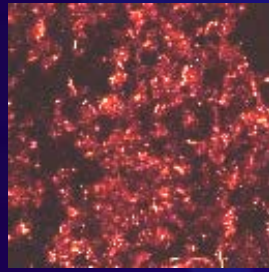
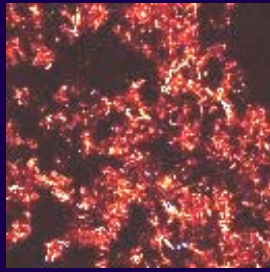
Clean membrane

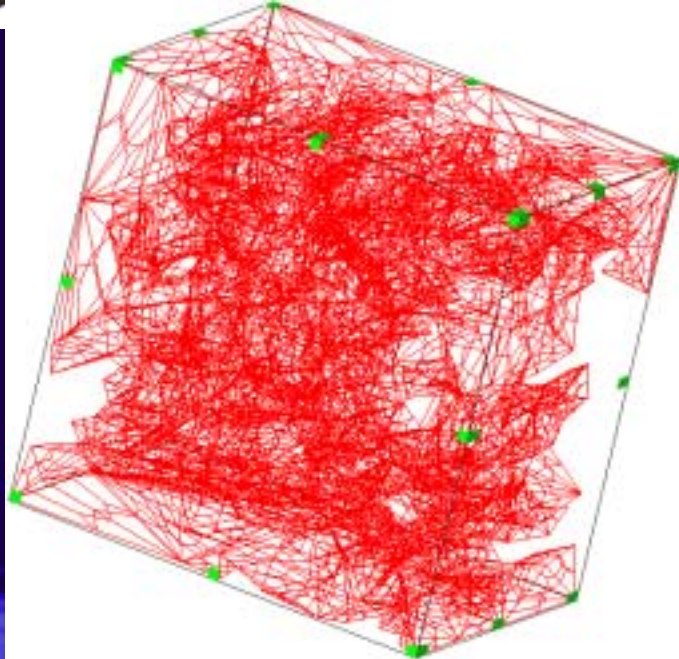
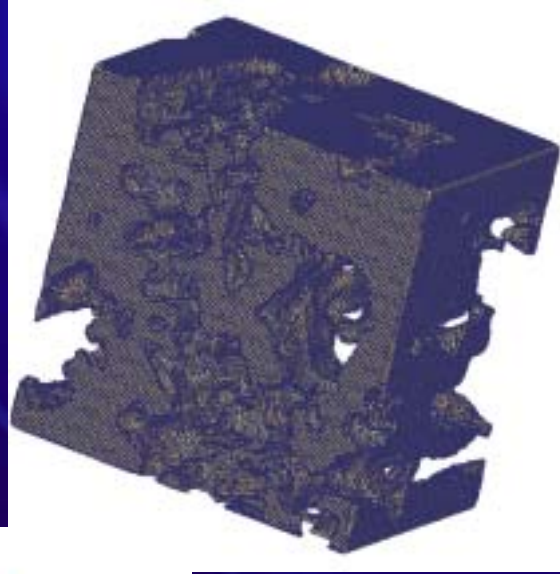
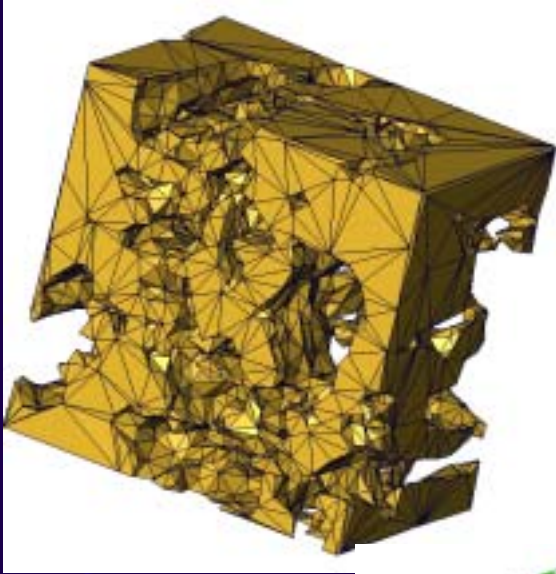


Membrane to foul

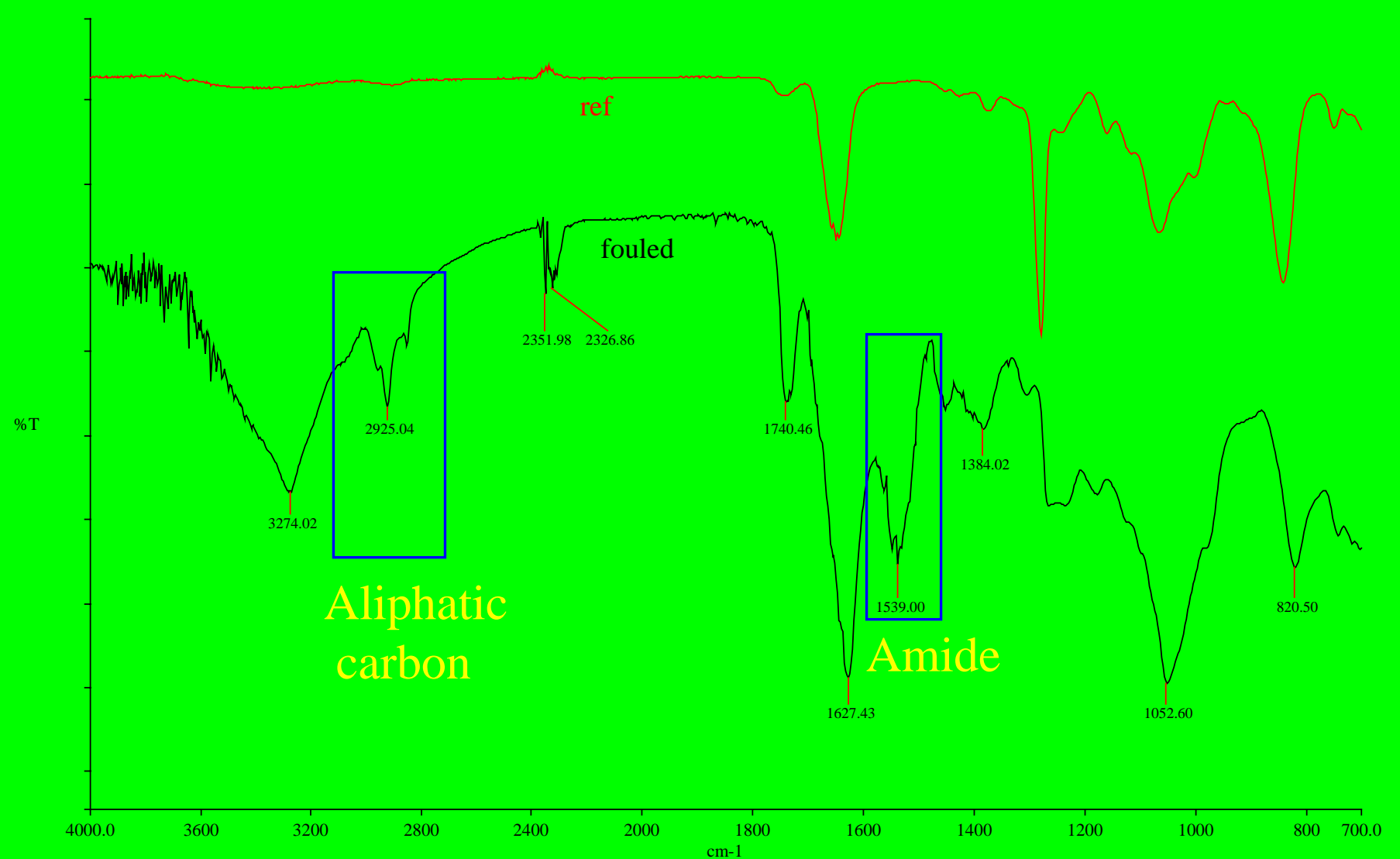
Floc on membrane



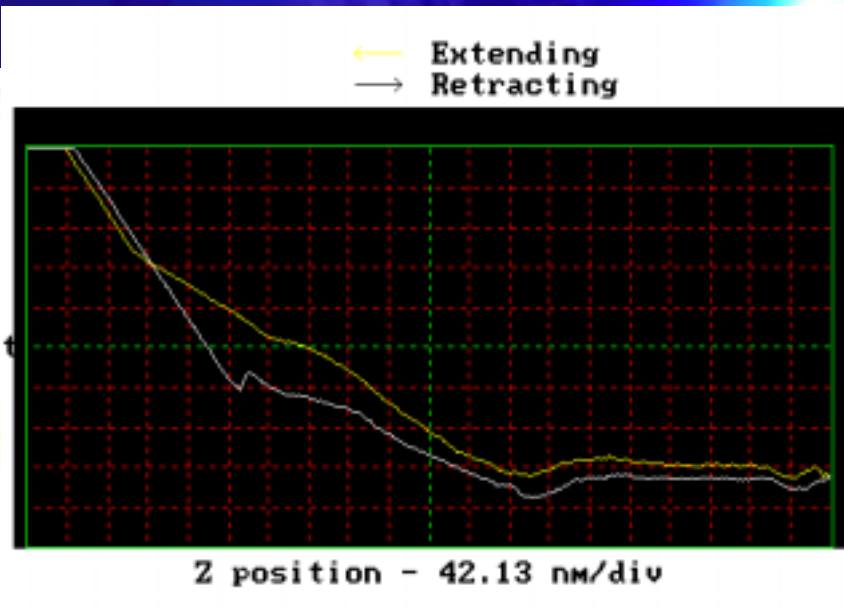
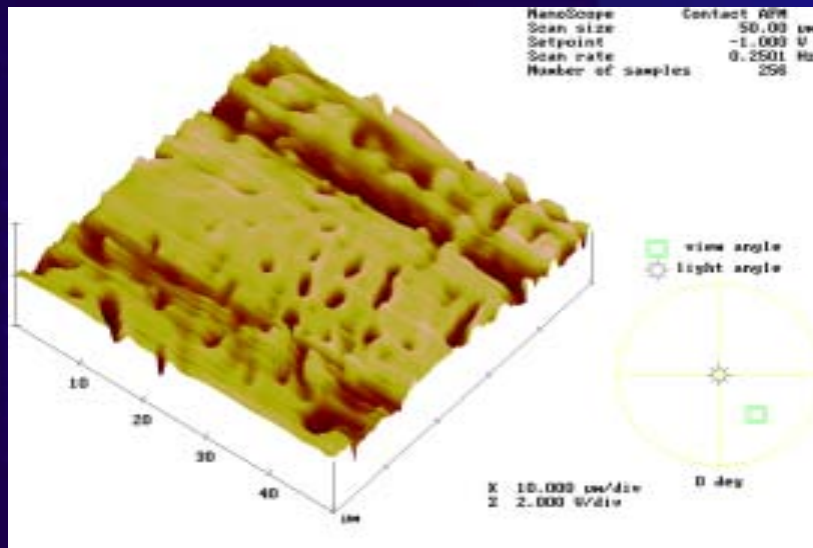




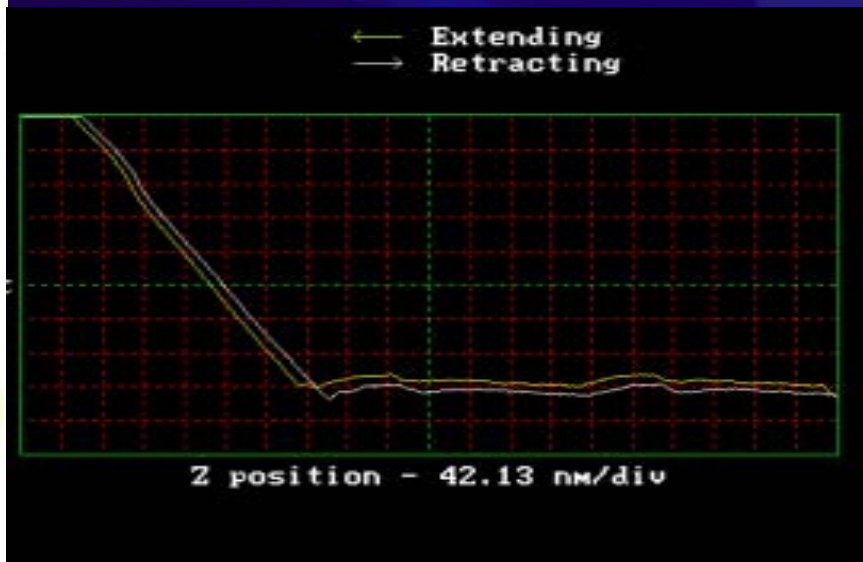
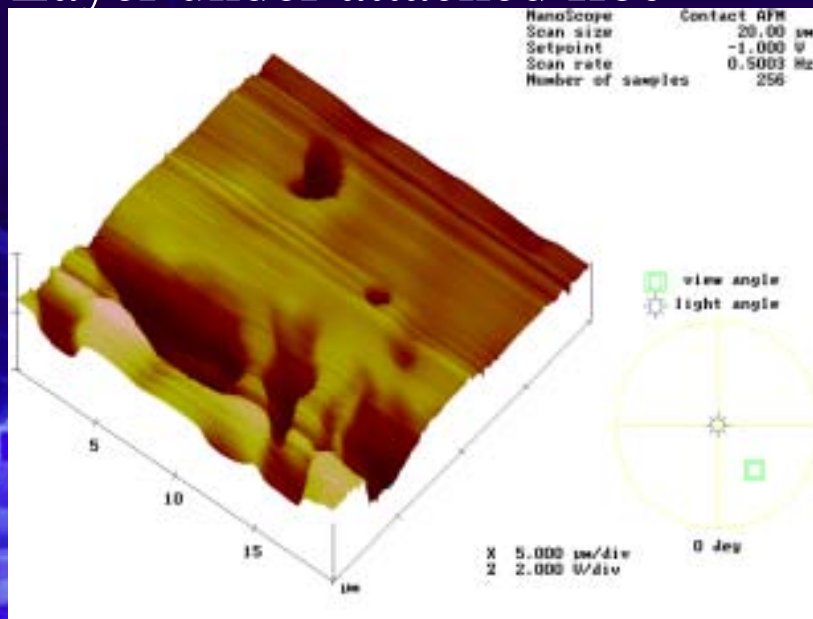
Fouled and Clean Membranes



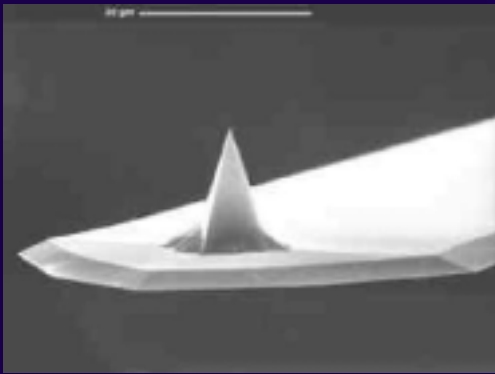
Fouled membrane with TBEPS



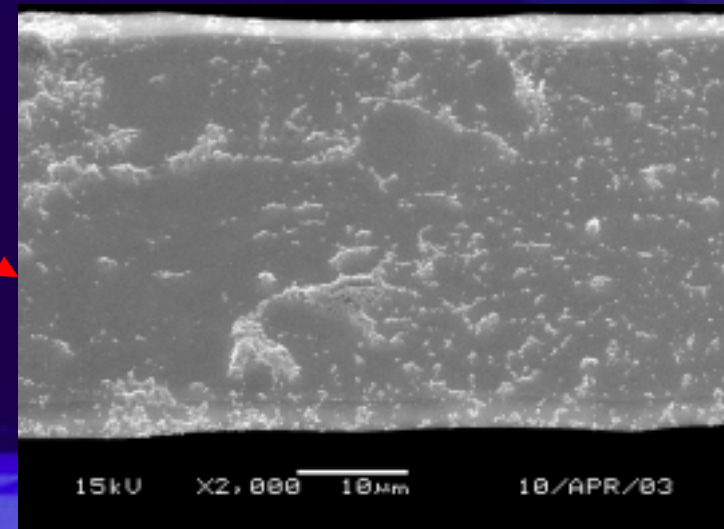
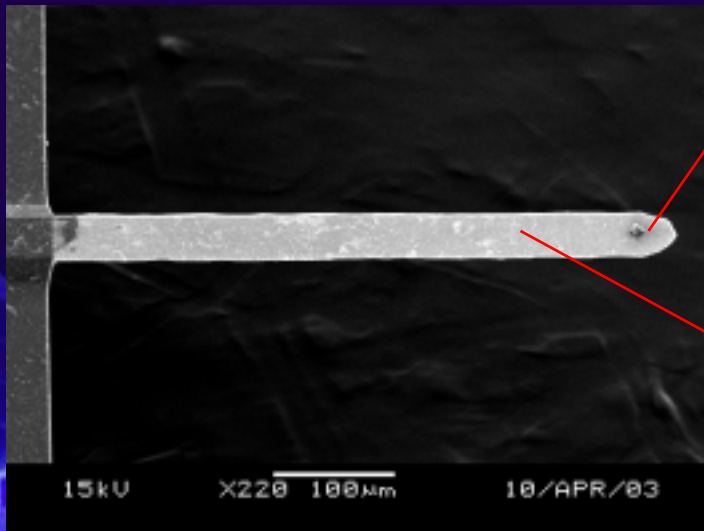
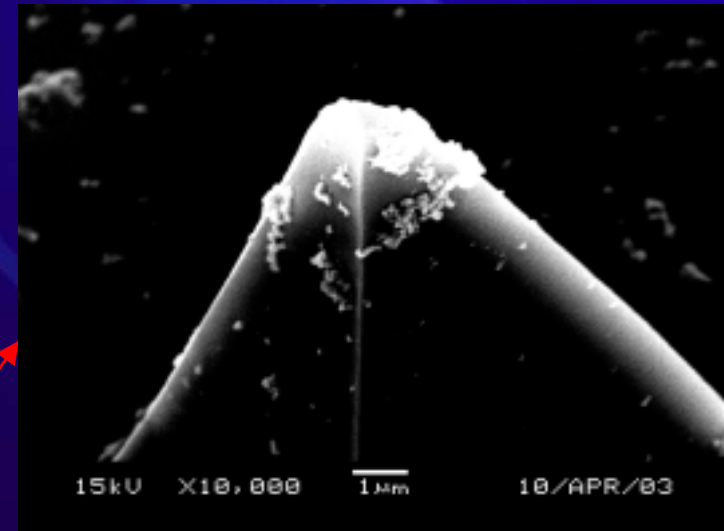
Layer under attached floc



Fouled Tip



force constant = 0.2 N/m
Length = 450 μm
Width = 50 μm
Thickness = 2 μm
Tip height is 10-15 μm

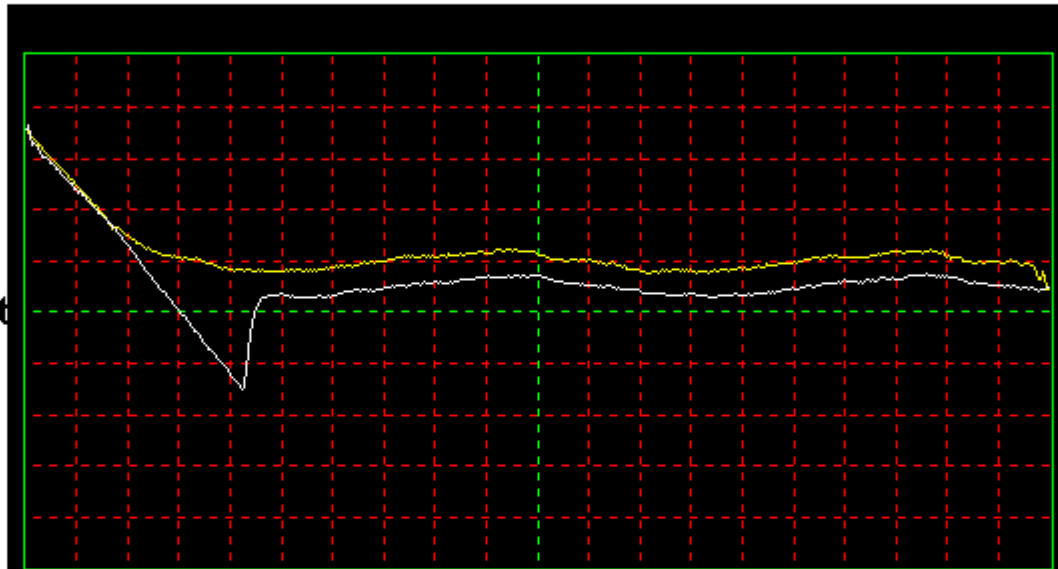


Force Calibration Plot

← Extending
→ Retracting

Tip
Defl
1.92 nm/div

Setpoint

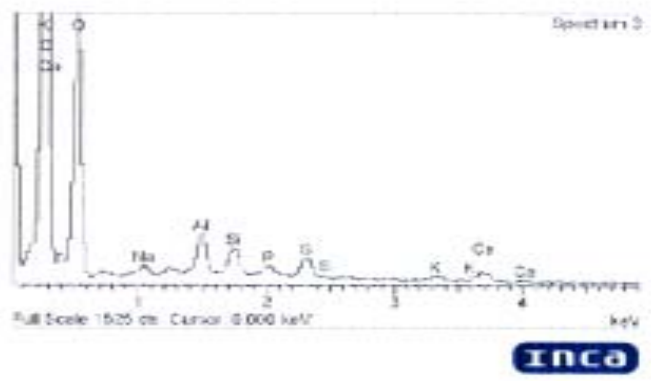
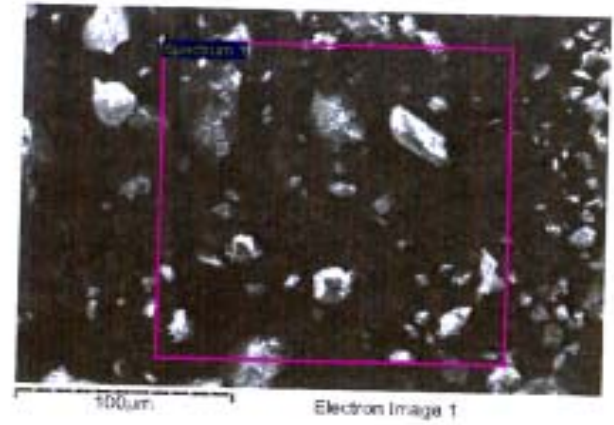
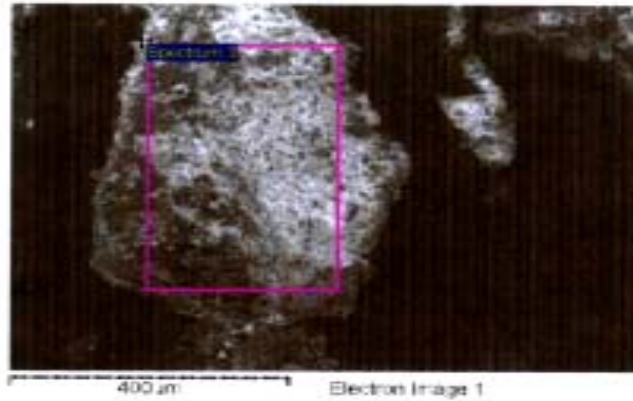


Z position - 33.44 nm/div

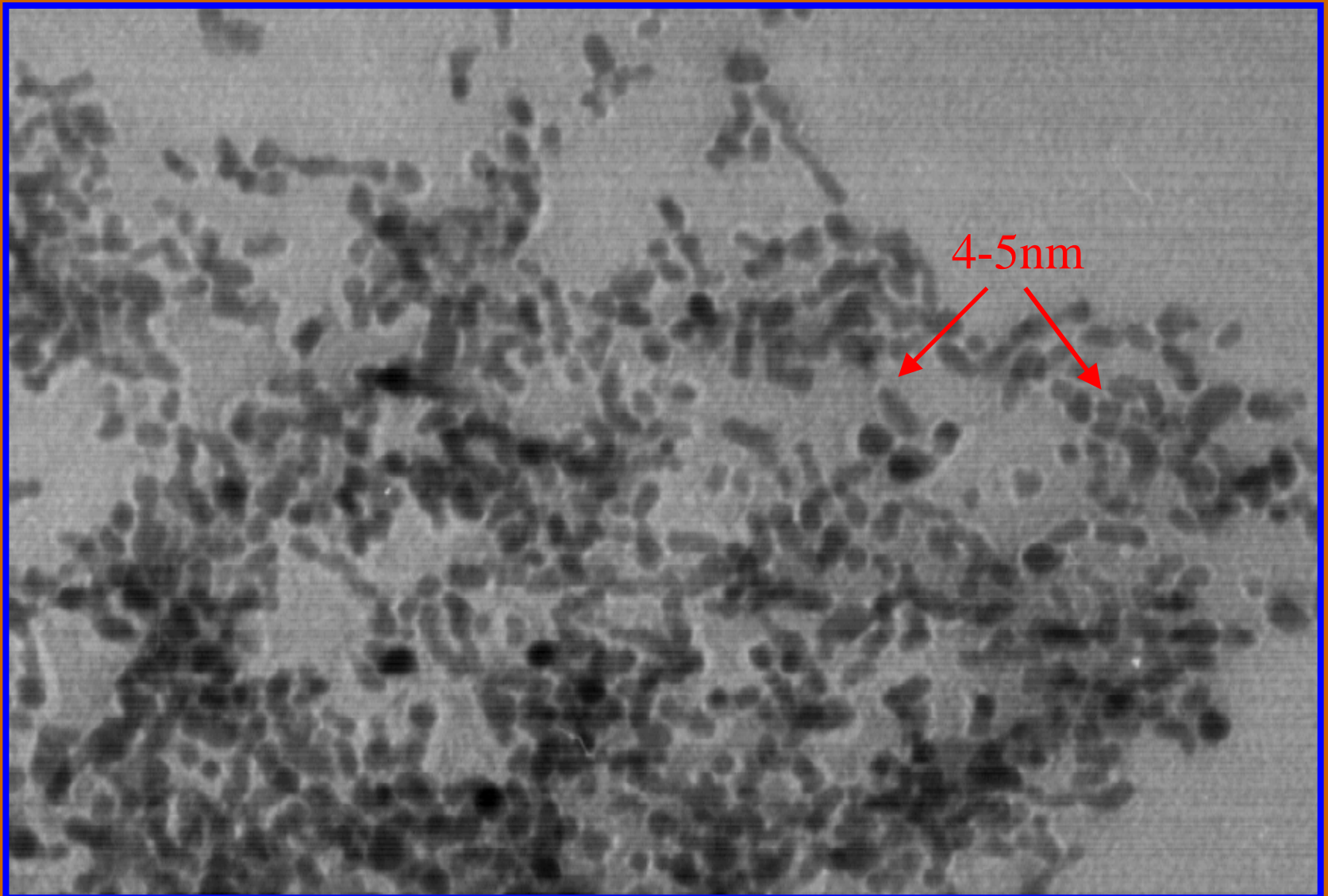
NanoScope
Z scan size
Setpoint
Z scan rate
Z range

Contact AFM
668.7 nm
-1.450 V
9.766 Hz
19.22 nm

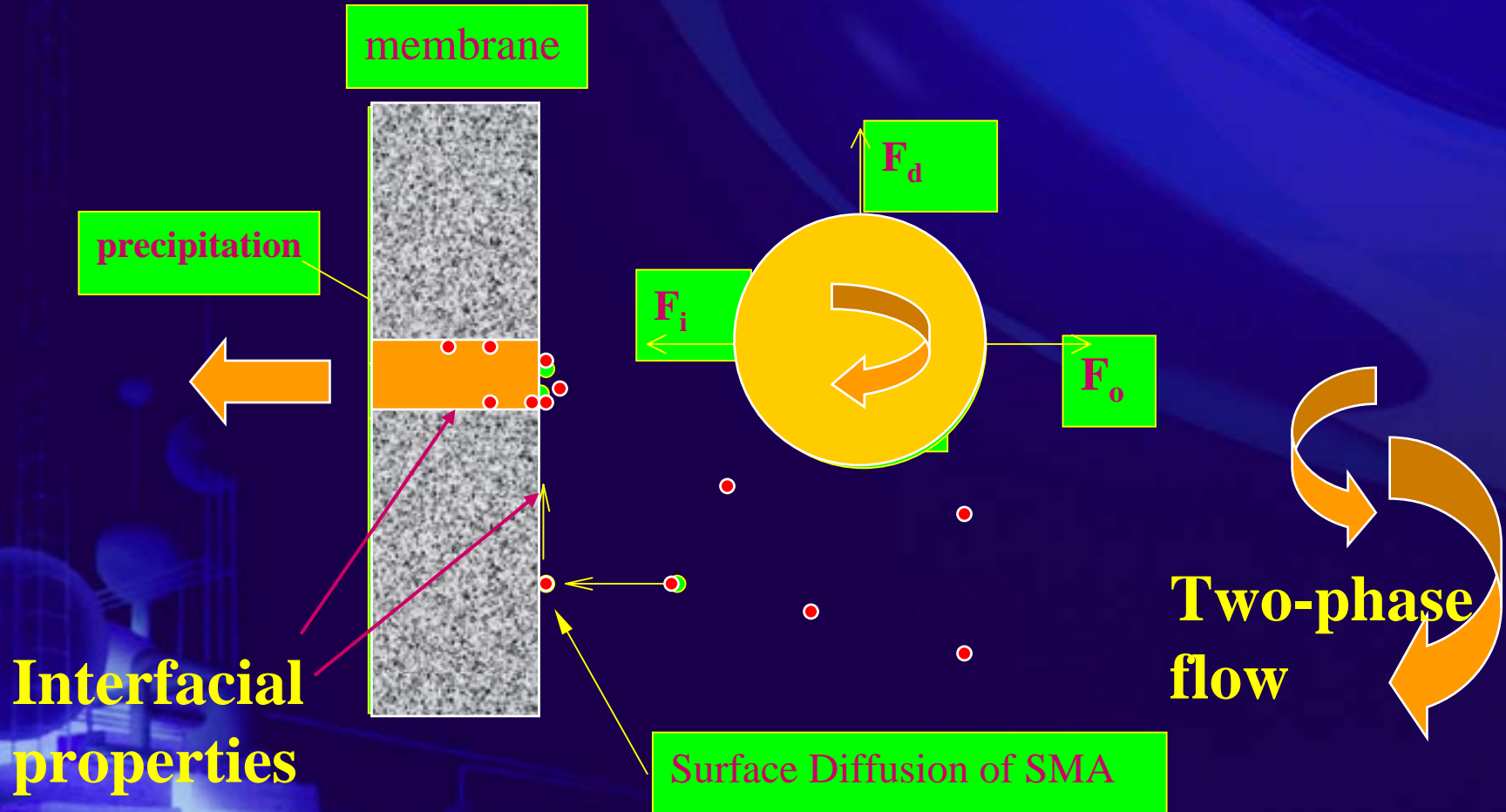
Inorganic deposition on membrane

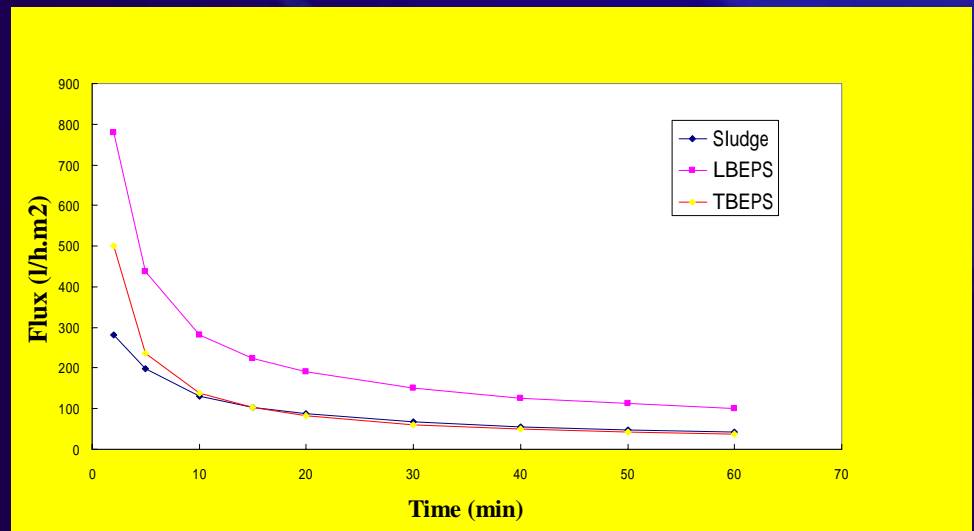
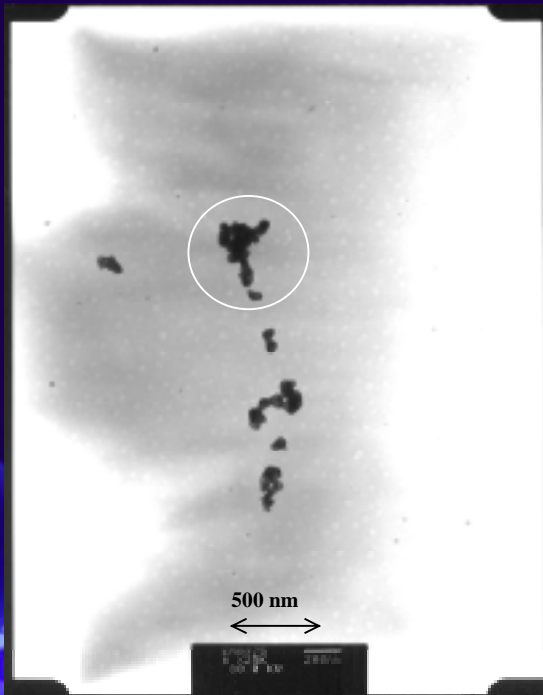
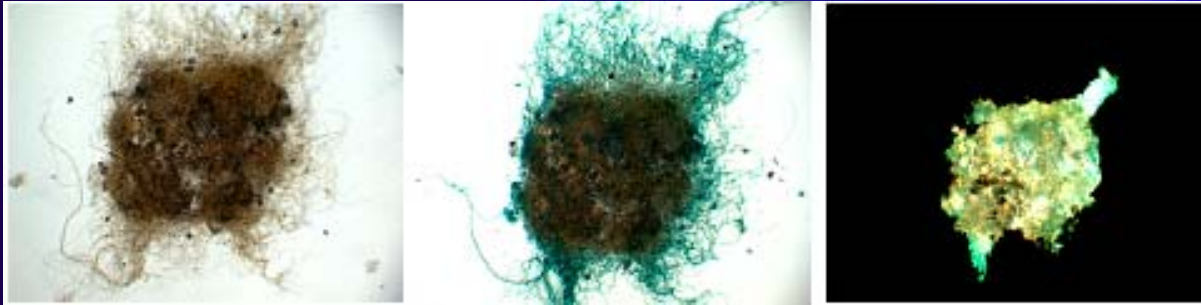


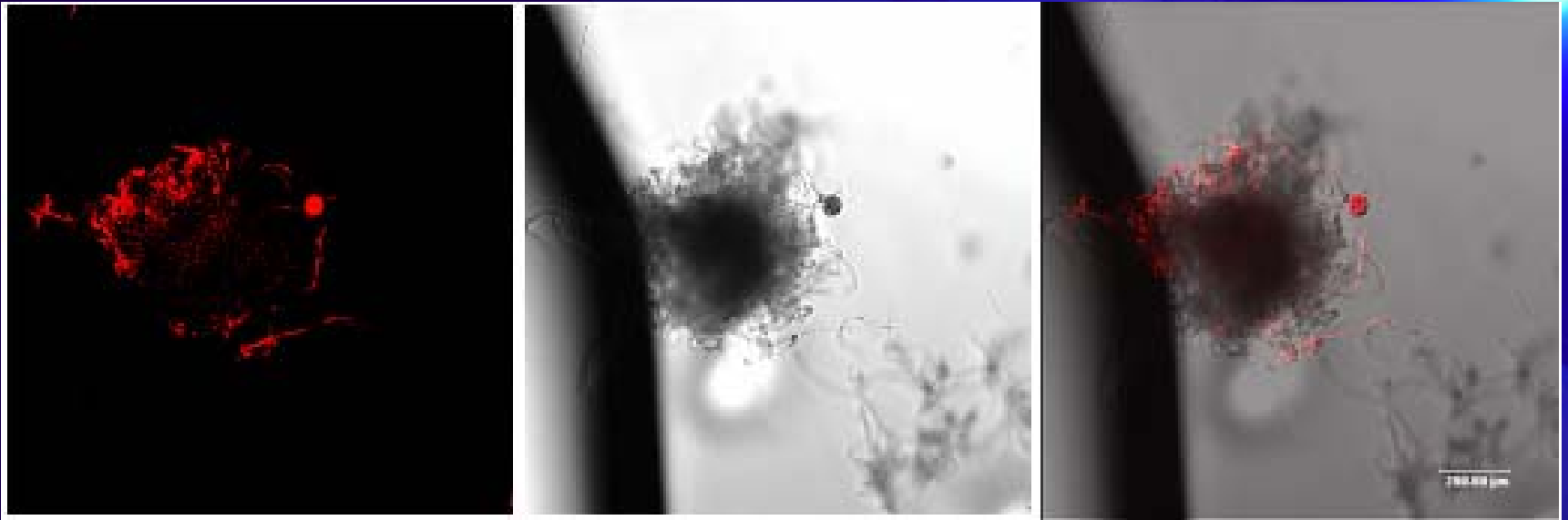
Nano CaCO_3 particles



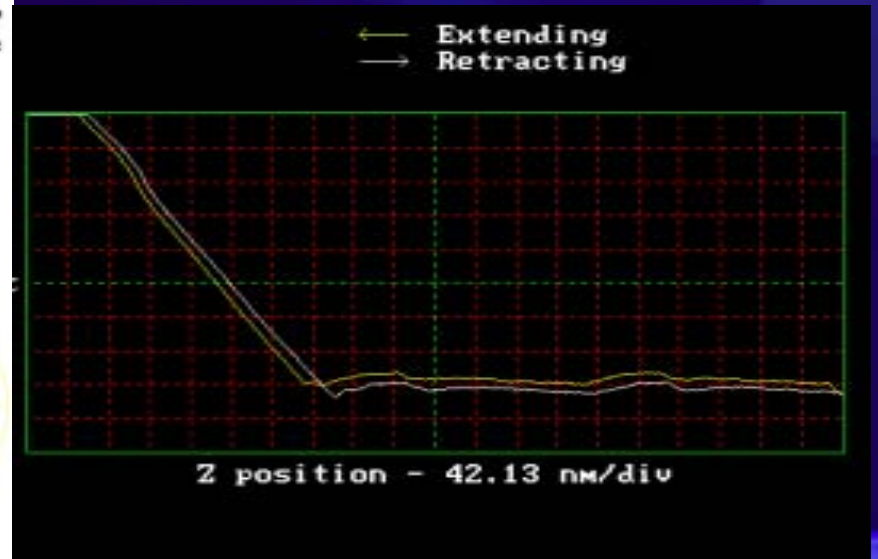
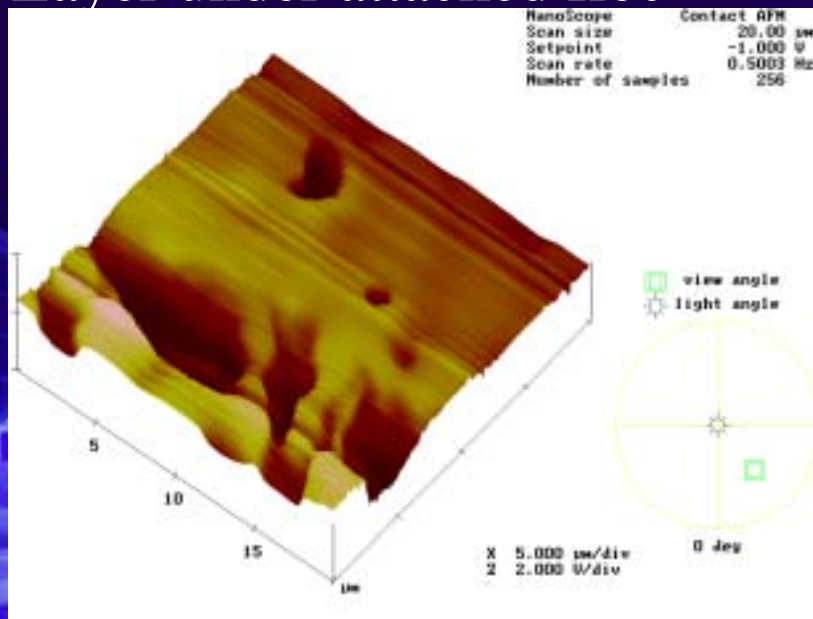
Near-Membrane Dynamics







Layer under attached floc



Proposal:

**To clearly identify the terms used
Interpret data in a unified way
Provide fundamental information**

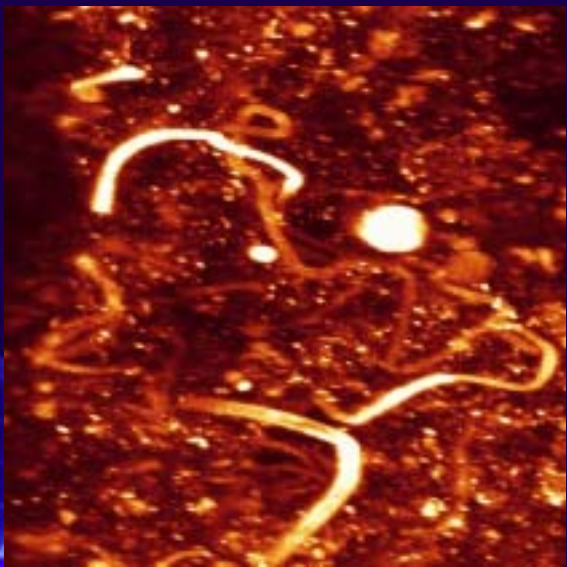
**In order to provide comprehensive data base
For better design/control of MBR.**

黃帝曰：


「彼無為謂真是也，狂屈似之，我與汝終不近也。夫知者不言，言者不知，故聖人行不言之教。道不可致，德不可至。仁可為也，義可虧也，禮相偽也。故曰：『失道而後德，失德而後仁，失仁而後義，失義而後禮。』」

《莊子·外篇·知北游第二十二》

Thank you O!







NITROCELLULOSE/MCE MEMBRANE; CELLULOSE NITRATE
MEMBRANE; MIXED CELLULOSE ESTER (MCE) MEMBRANE;
MIXED CELLULOSE ESTER MEMBRANE FILTER; MIXED
CELLULOSE ESTER (MCE); MIXED ESTERS OF CELLULOSE
MEMBRANE; NITROCELLULOSE MEMBRANE; PURE
NITROCELLULOSE MEMBRANE

CAS NUMBER: 9004-70-0 EC NUMBER