Effect of Bacterial Polysaccharide Colonizing Environmental Surface on the Affinity and Deposition of Nanoparticles

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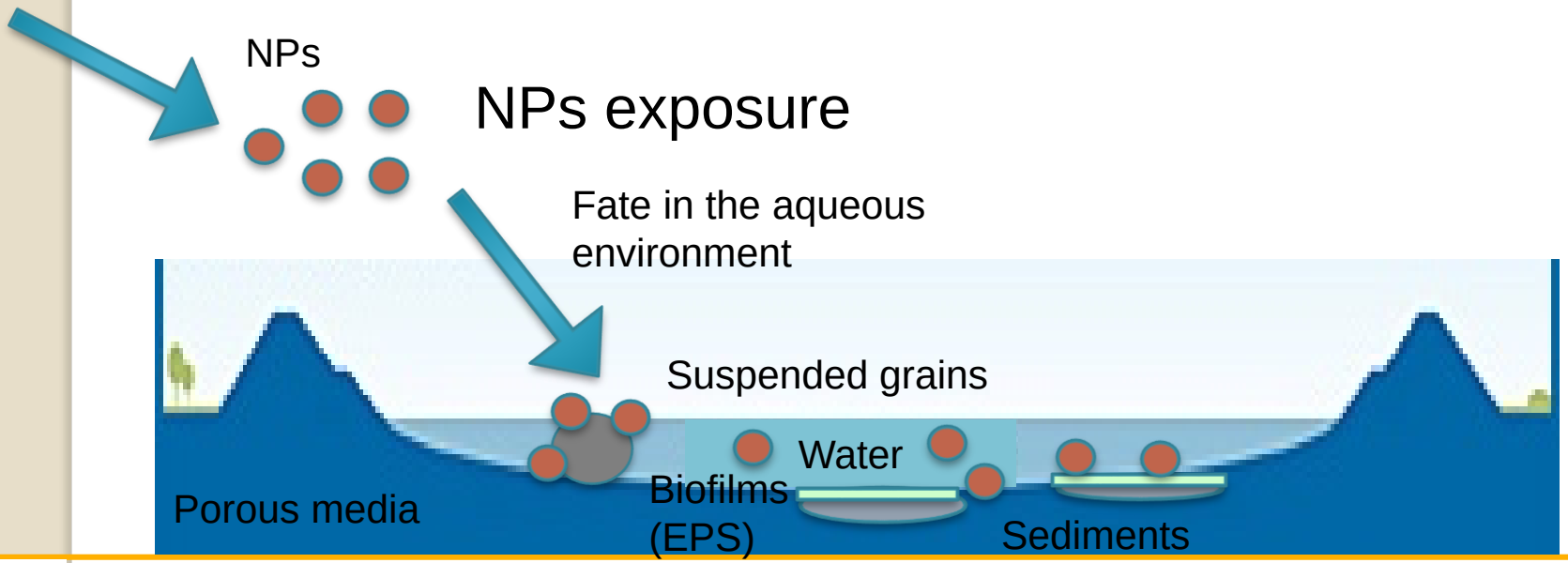
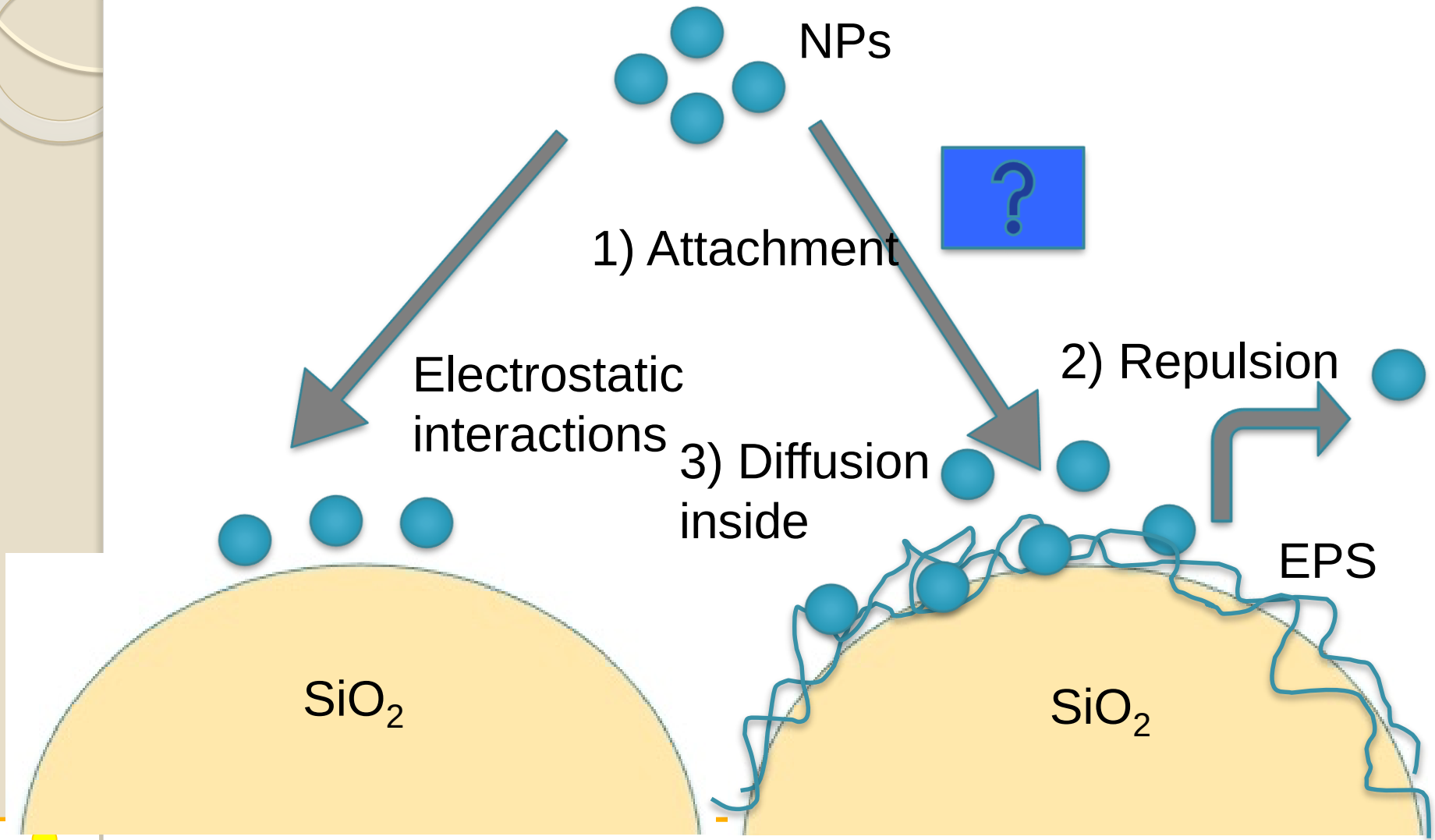
Problematic

- Nanoparticles (NPs) interact with particulate matter in aqueous environment
- Mineral collectors are usually coated with biofilms
- Biofilm – filtrating layer retaining or repelling NPs
- What is the effect of organic coating on the collector on the affinity and deposition of NPs?

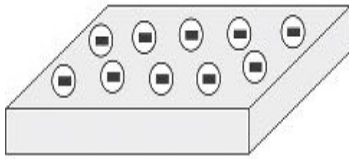


Effect of organic coating on the collector on the NPs deposition



Approach

Parameters variable	Favorable	Unfavorable
NPs	TiO_2 – positively charged (8 nm)	PAA-TiO_2 – negatively charged (70 nm)
Collector surface	Soligel, bacterial polysaccharide (EPS): negatively charged Bare SiO_2: negatively charged	
pH	pH 3	pH 3 & 5.6
Ionic strength	(10^{-5}M NaCl – 10^{-2}M NaCl)	10^{-3}M NaCl



Experimental Approach

Substrate types

SiO_2

EPS

Dipping

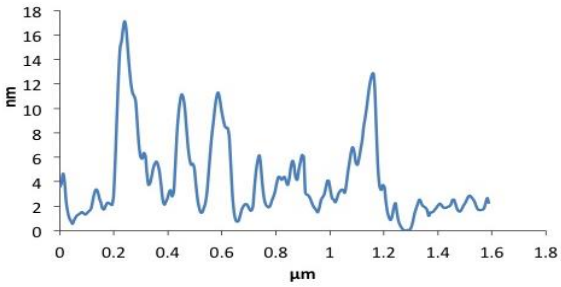
NPs:
- TiO_2
- PAA-TiO_2

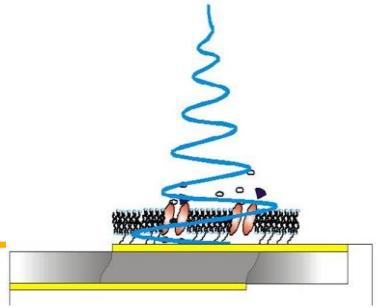
Solution
- pH
- NaCl range

Deposit analysis by AFM

AFM tip

Deposited NPs





AFM after dipping
QCM-D in flow mode

$\Delta f \propto \Delta m$

$\Delta D \propto$ stiffness

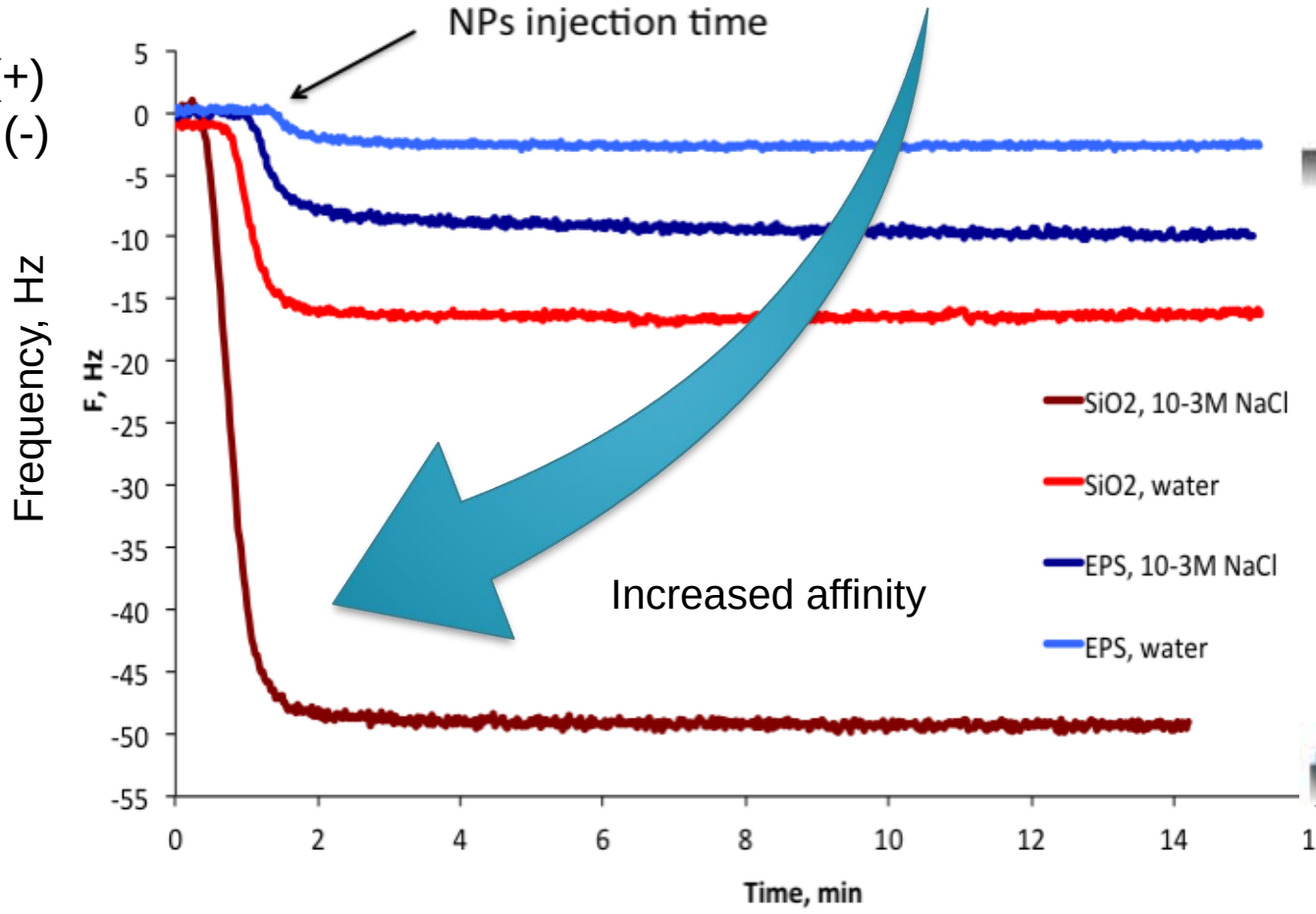
TiO_2 deposition (by QCM-D)

Favorable deposition:

pH 3

TiO_2 NP (+)

Collector (-)



Deposited mass, mg/m²
0,5133
2,1872
3,186
8,673

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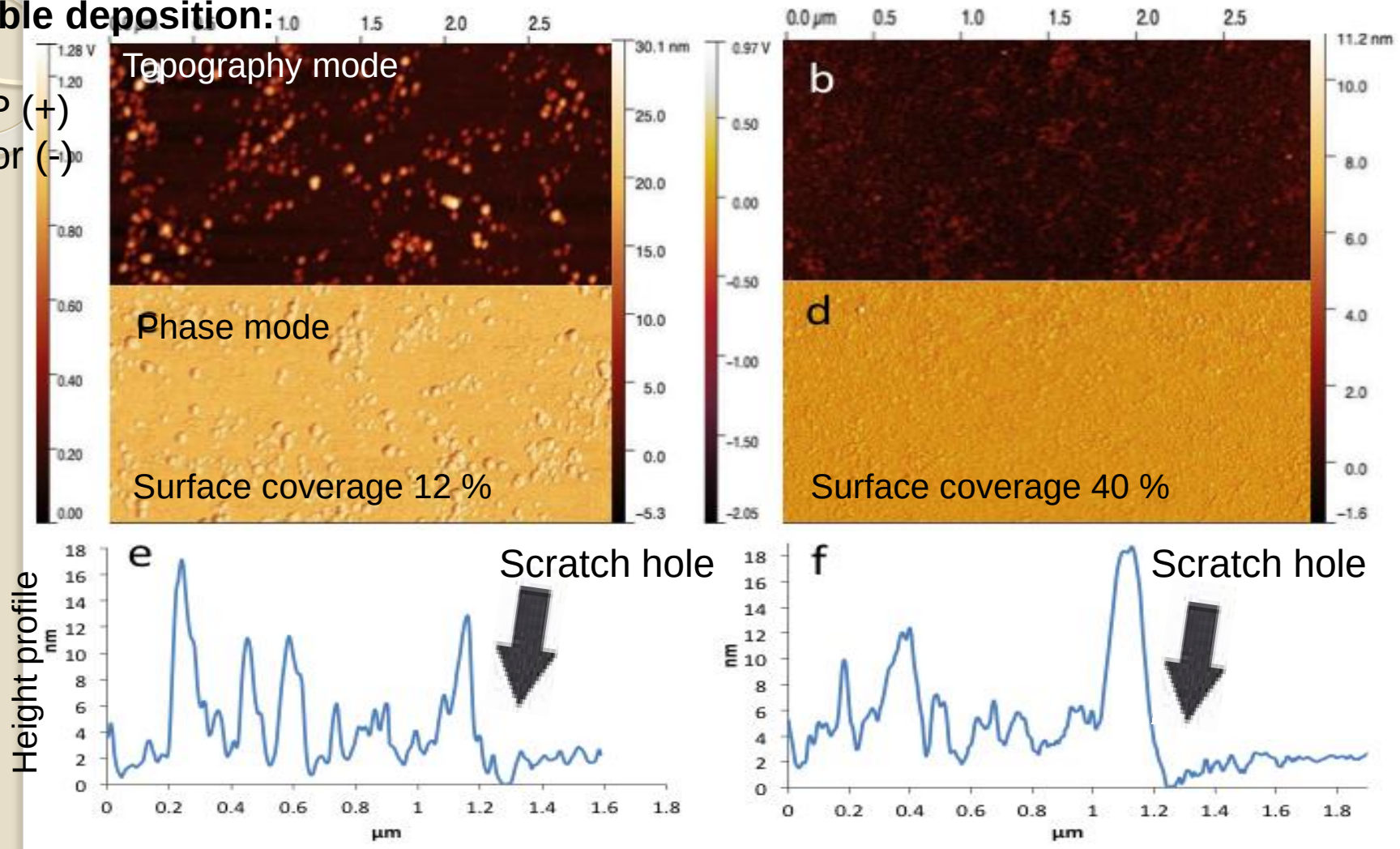
TiO_2 deposition (by AFM)
EPS Substrate

NaCl-free solution

10^{-3}M NaCl solution

Favorable deposition:
pH 3
TiO_2 NP (+)
Collector (-)



TiO_2 deposition (by AFM)
SiO_2 Substrate

NaCl-free solution

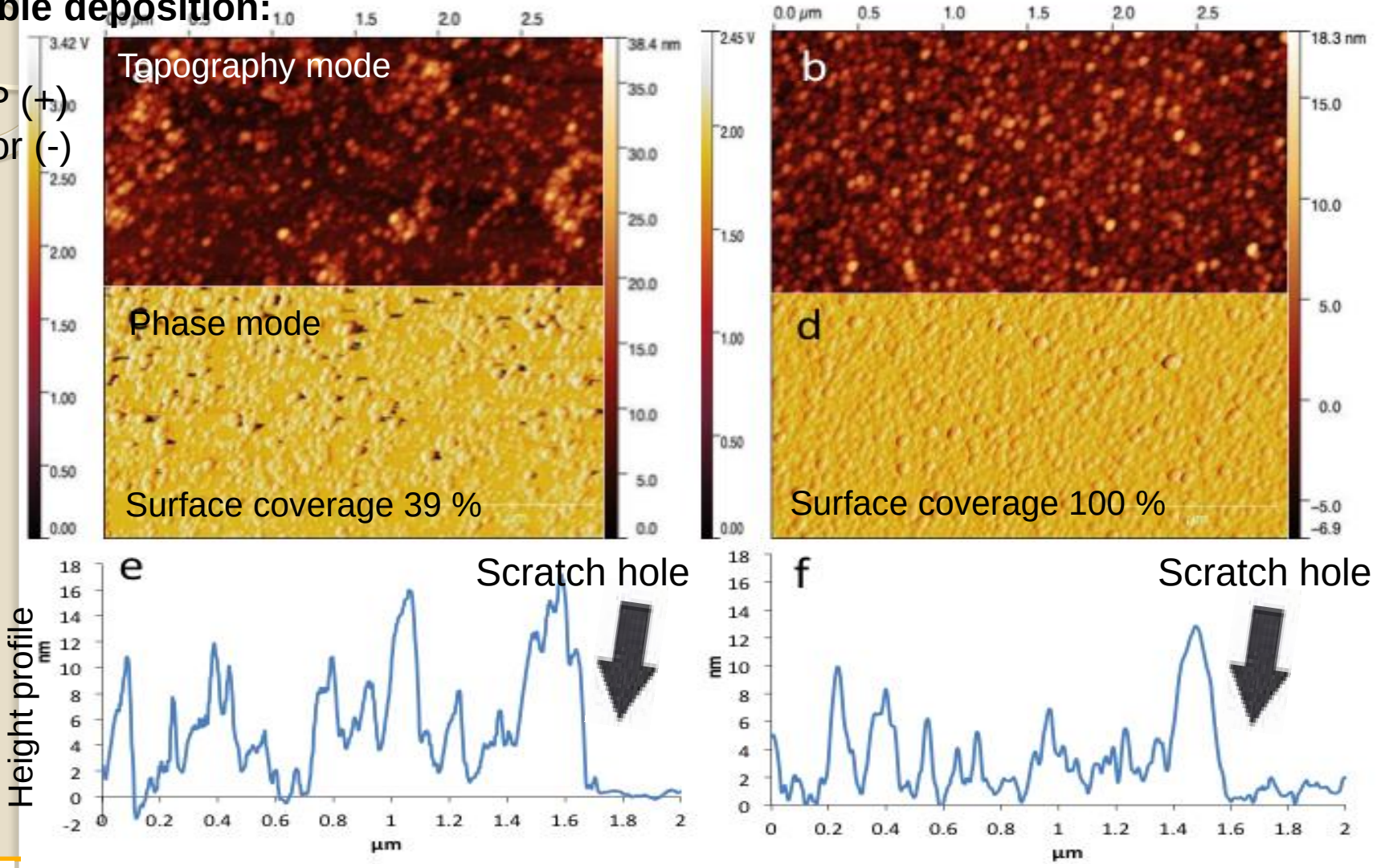
10^{-3}M NaCl solution

Favorable deposition:

pH 3

TiO_2 NP (+)

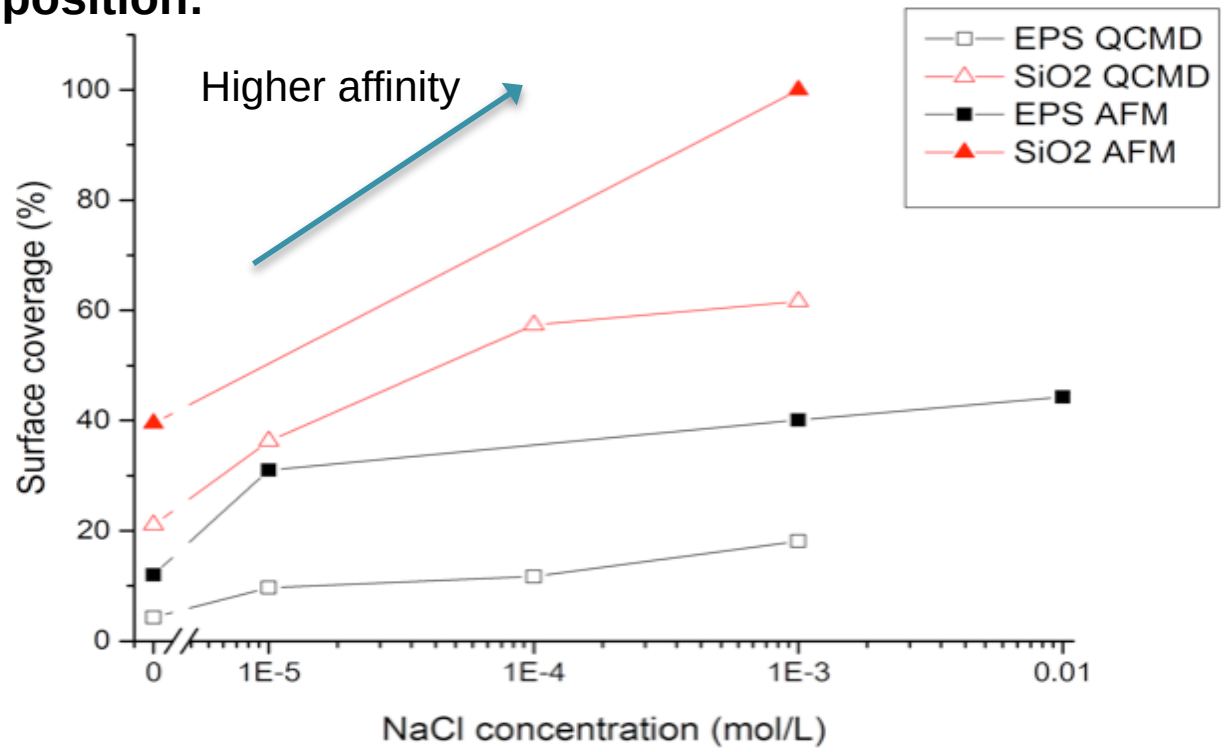
Collector (-)



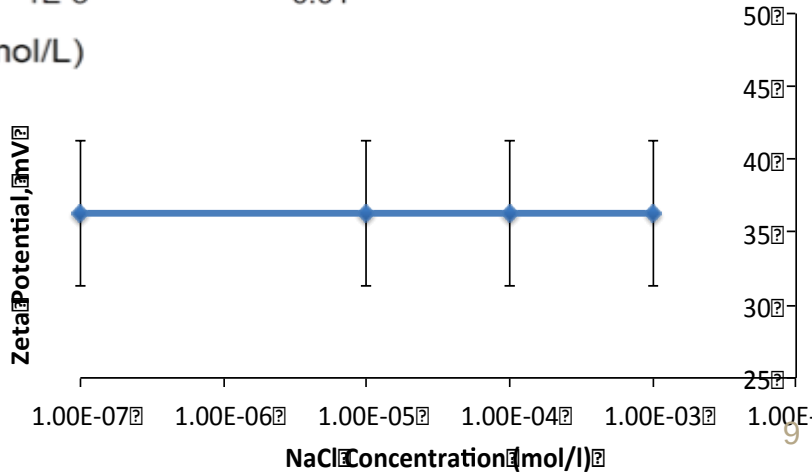
Serenade

Surface Coverage of TiO_2 NP *vs* IS

Favorable deposition:
pH 3
TiO_2 NP (+)
Collector (-)



- AFM overestimates surface density because of limited resolution
- Higher affinity for SiO_2 (0.49 (-) per nm^2 than for EPS (0.14 (-) per nm^2)
- IS locally screens electrostatic repulsions between NPs near the substrate



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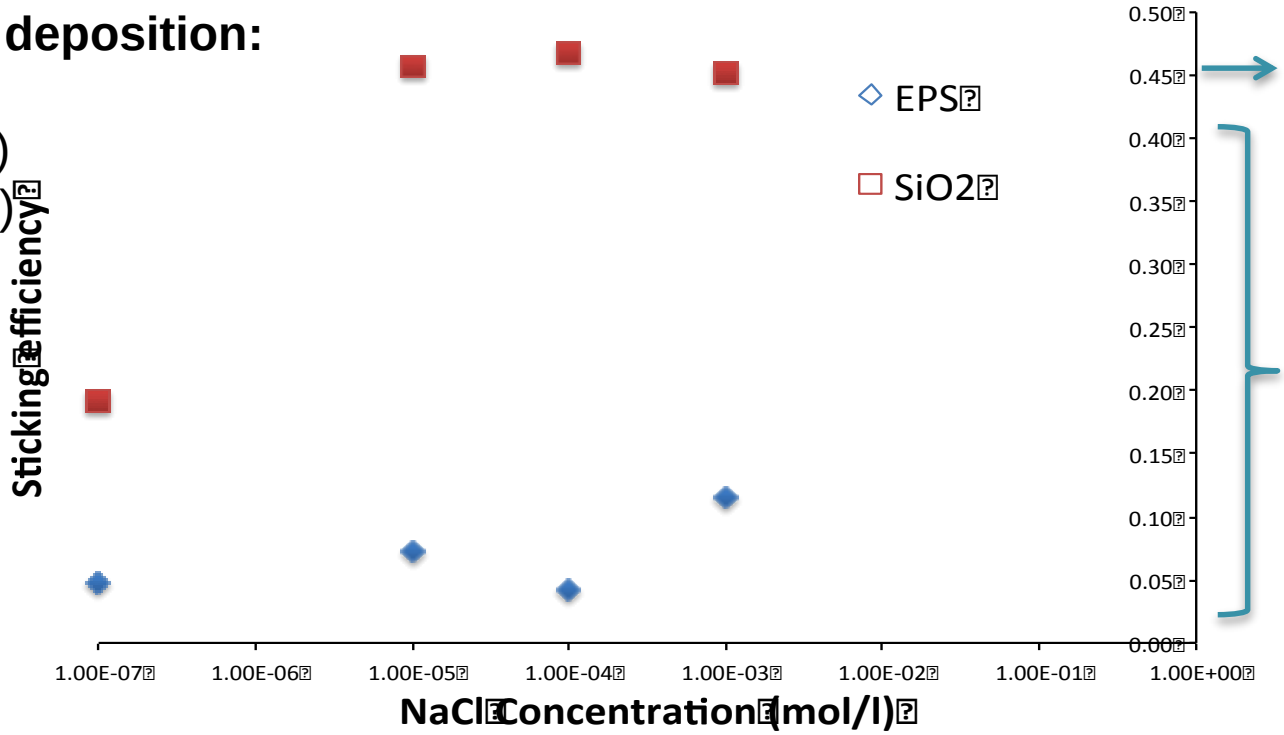
Sticking Efficiency of TiO_2 NP *vs* IS

Sticking efficiency of NPs to collector calculated from deposition rate

Favorable deposition:
pH 3
TiO_2 NP (+)
Collector (-)



Limited by transport

Limited by sticking reaction

- 2 regimes of NPs deposition:
  - limited by the sticking reaction
  - limited by transport

Approach

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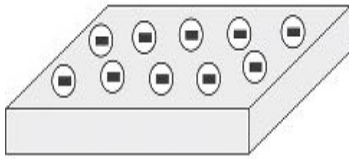
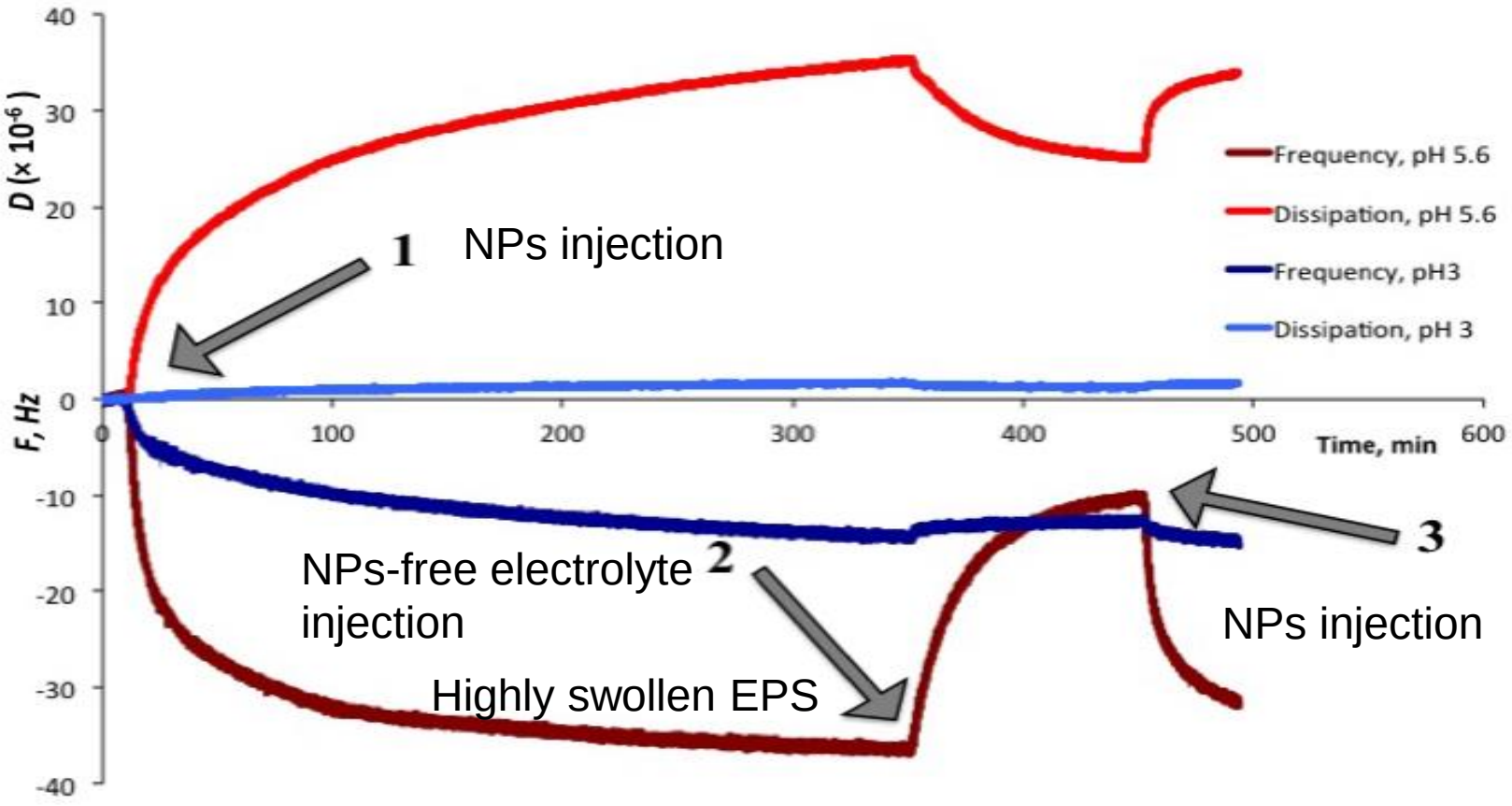


Unfavorable Conditions



pH 3 – lower deposition & reversibility pH 5.6 – higher deposition & reversibility

- 2 processes drive the NPs deposition: irreversible interactions & physical catchment

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Serenade

Conclusions

- Physicochemical conditions influence strongly the mode of NP deposition.
- Under attractive interaction, higher deposition and deposition rate were observed on the mineral collector in comparison with the EPS coated collector in the same conditions.
- The NP deposit density increased with the ionic strength for both collector surface types (EPS coated & SiO_2).
- The thickness analysis of the NP deposit on the substrate revealed that multilayer was never formed.
- Under repulsive electrostatic interactions, a weak and partially reversible NP deposition was measured.

Thank you for your attention!

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