

Facility for Light Scattering: Current Projects



Sara M. Hashmi, Ph.D., Director

Department of Chemical &
Environmental Engineering

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LightScattering.Yale.edu

Bridging the Gap...

Macroscale

Structure

Function

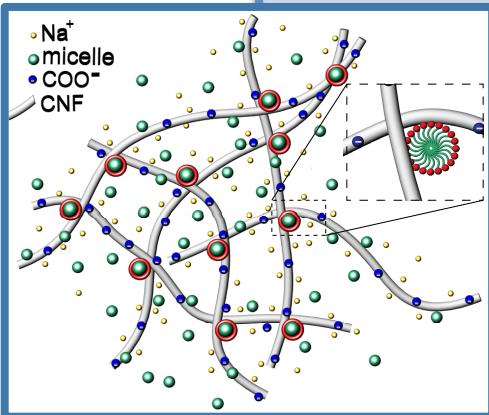
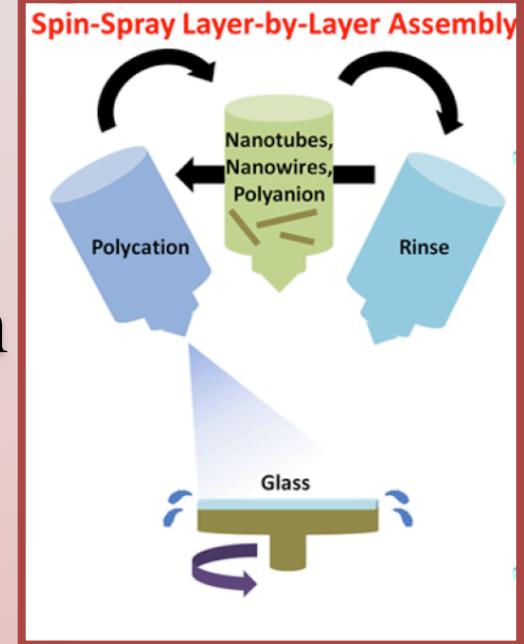
Dynamics

Microscale

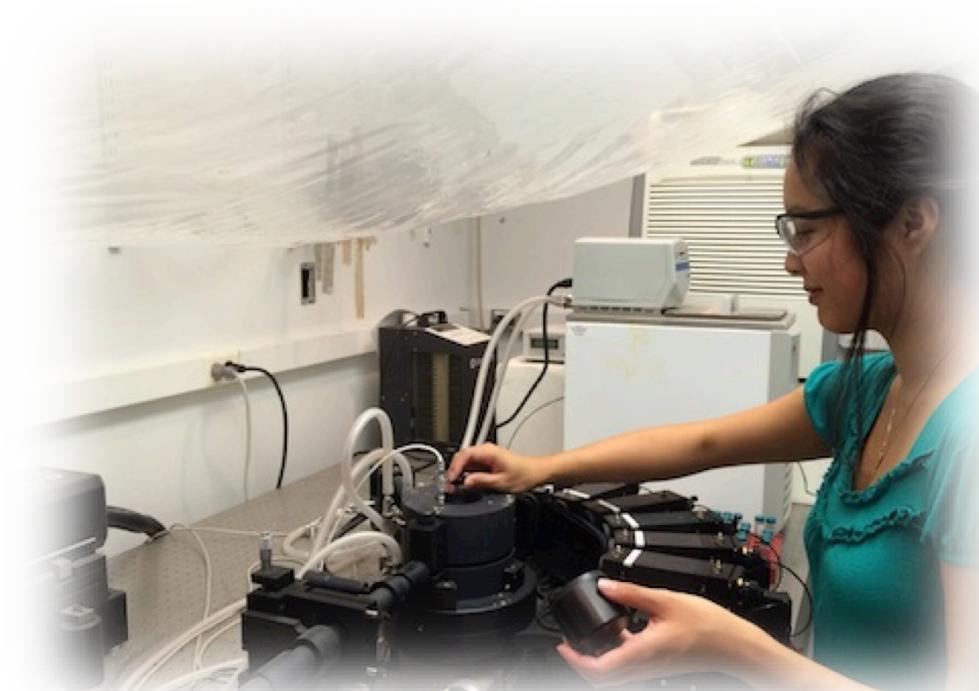
aggregation



diffusion



Facility for Light Scattering



ALV 5000 goniometer

ALV-GmbH:
DLS, MALS, SLS
Dunham 124c

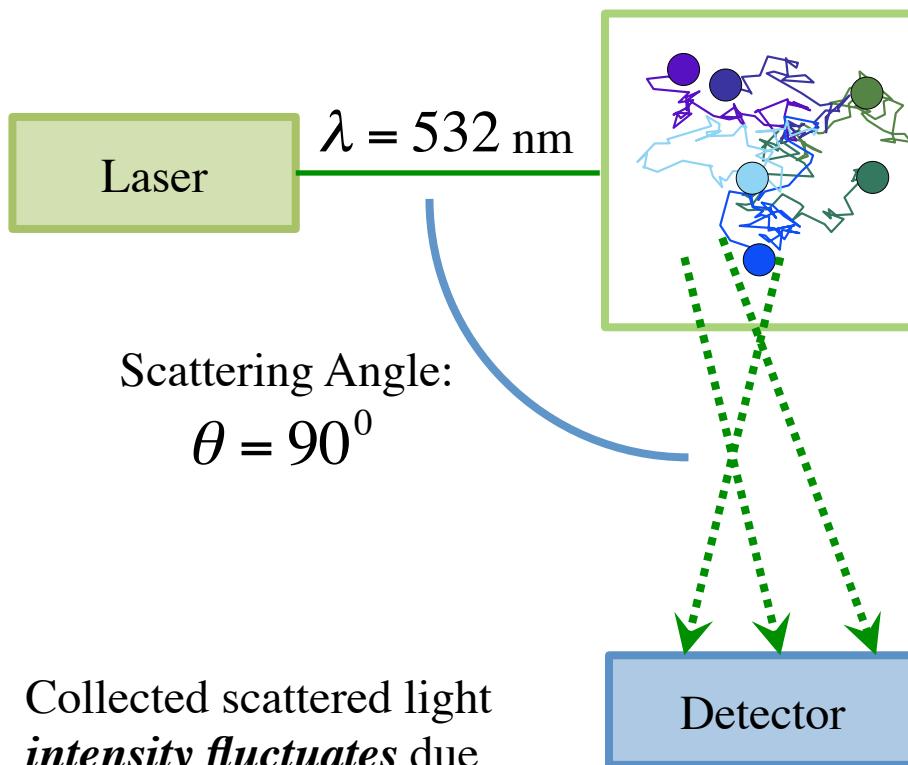
NanoBrook Omni

Brookhaven Instruments:
DLS, Zeta Potential, PZC
Mason B7



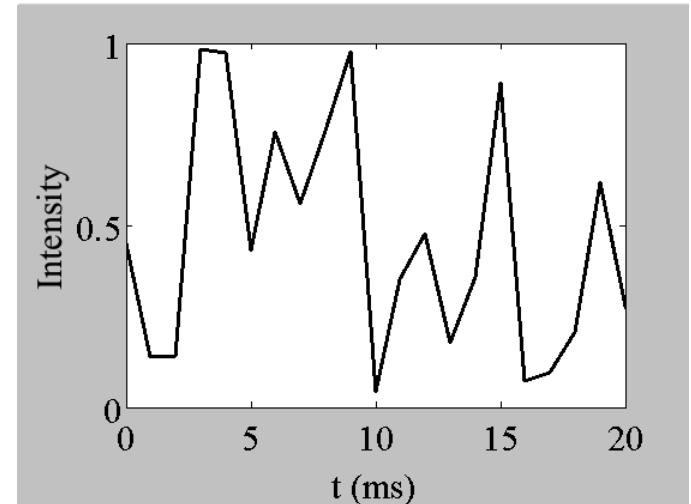
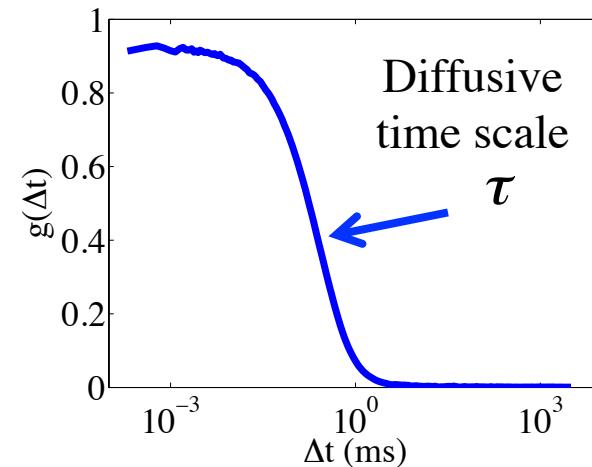
Measurement Concepts: DLS

Dynamic Light Scattering:
Assessing Diffusion in Suspension



Collected scattered light **intensity fluctuates** due to **diffusion** in the sample

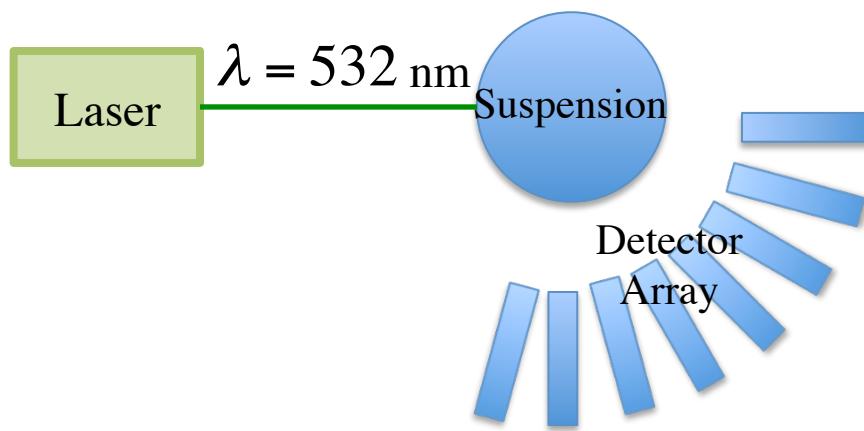
$$g(\Delta t) \approx \exp(-\Delta t/\tau)$$



How does LS work?

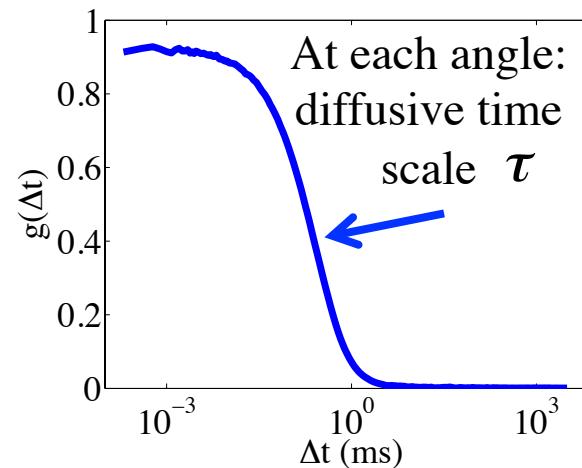
Measurement Concepts: MALS

- Multiple Angle LS
- Dynamics at all angles

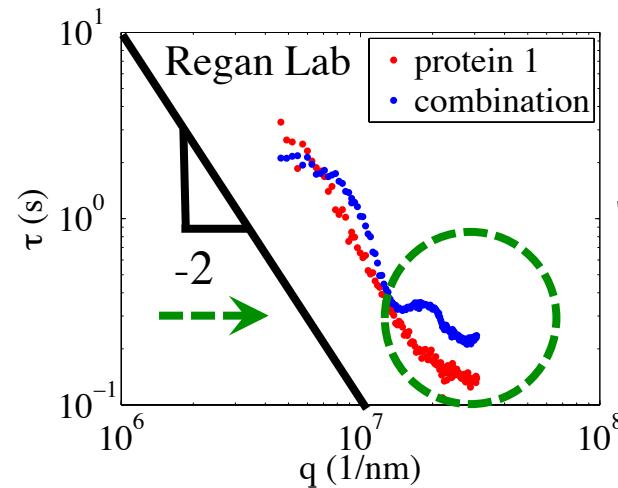


$$q = 4\pi n \sin(\theta/2)/\lambda$$

Units = [1/L]



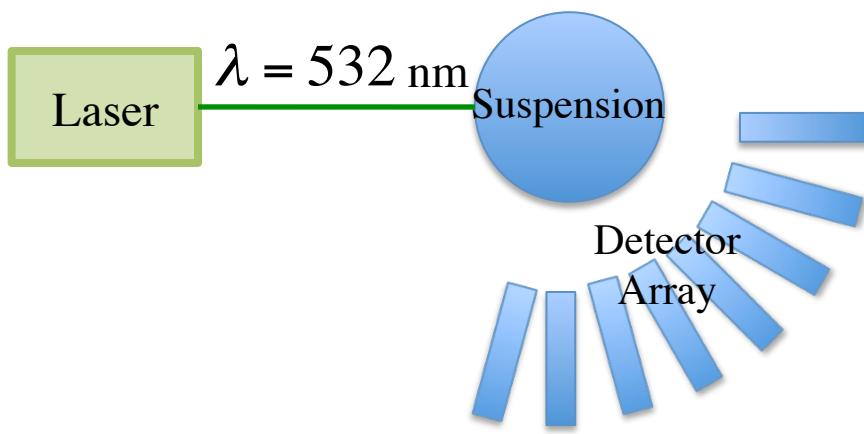
$$\text{Diffusion} = \frac{\text{Length}^2}{\text{Time}}$$



Sub-diffusive motion on shortest length scales

Measurement Concepts: SLS

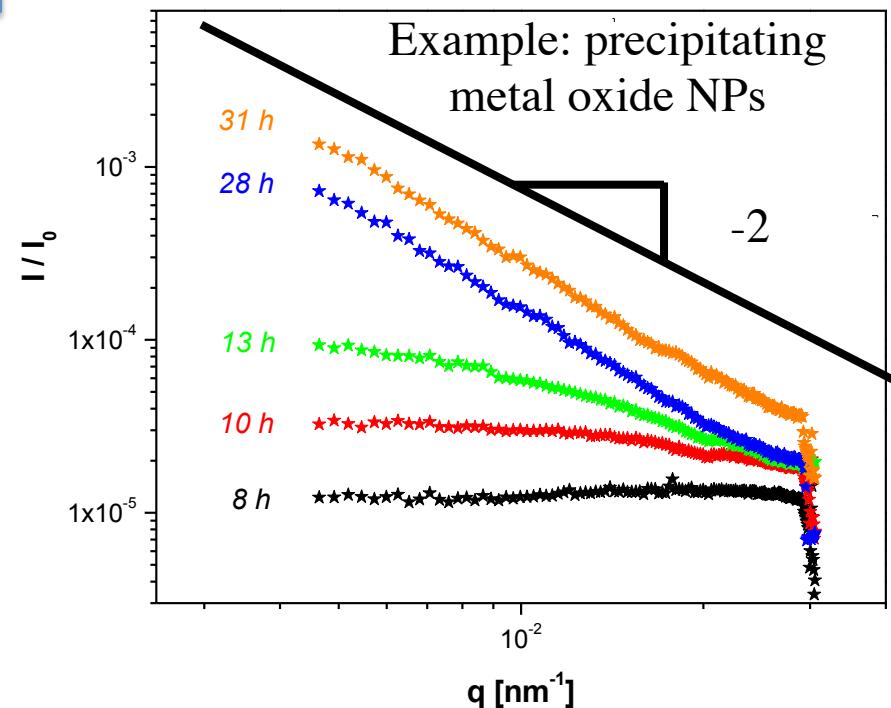
- Static Light Scattering: measure profile $I(q)$
- Analog of XRD



$$q = 4\pi n \sin(\theta/2) / \lambda$$

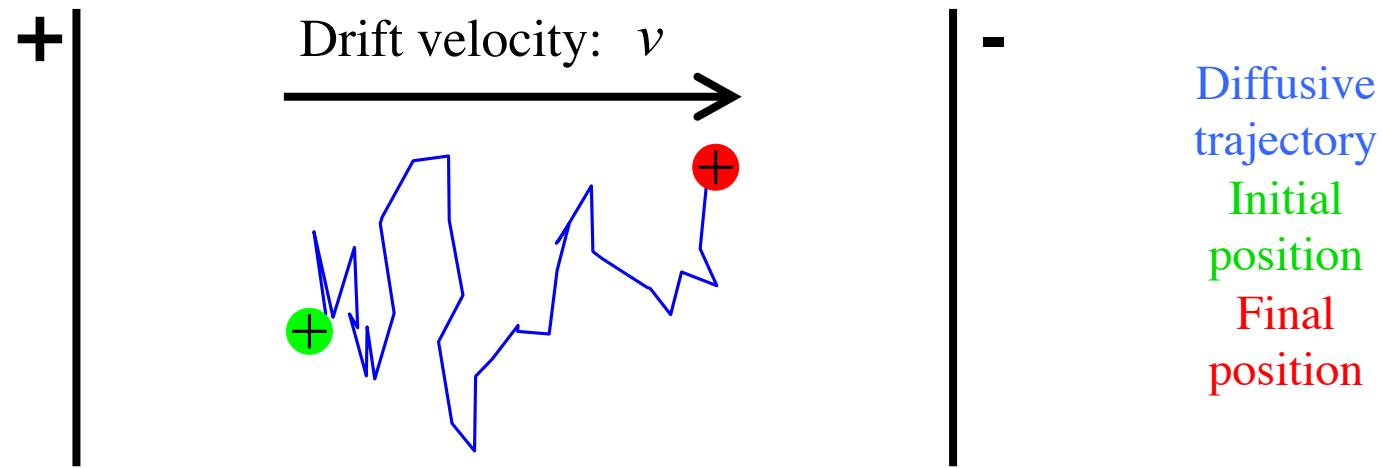
Units = [1/L]

Isotropic scattering from <20nm particles
Profile scales as $I \approx q^{-D_f}$ when size $\rightarrow 1/q$



Measurement Concept: Zeta Potential

with electric field E : diffusion with drift



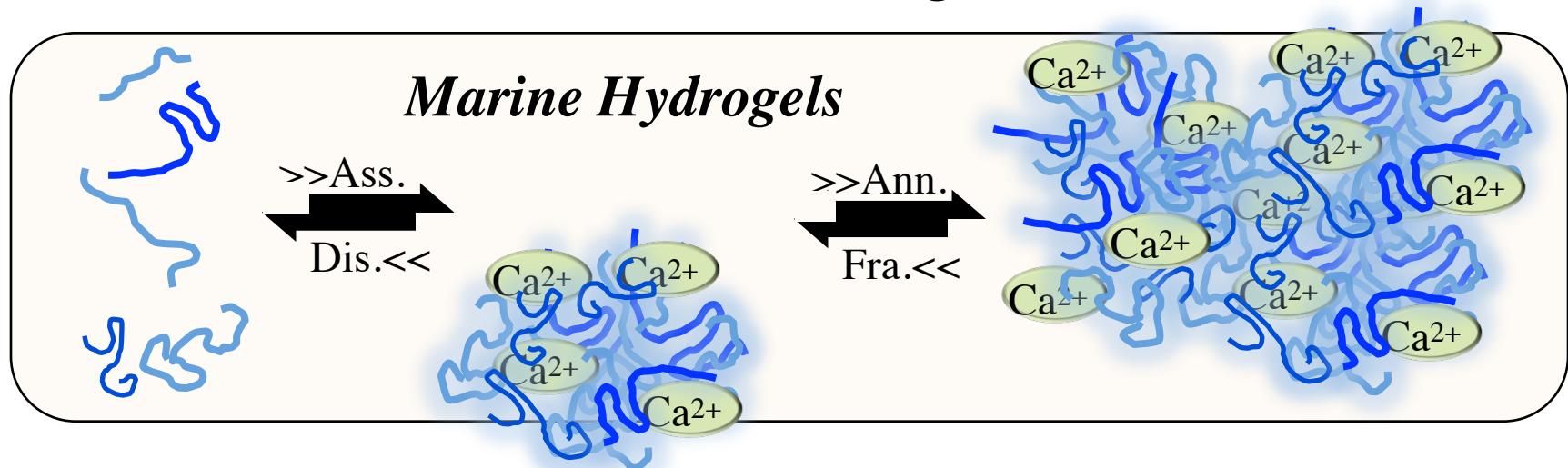
Electrophoretic mobility: $\mu = \frac{v}{E}$

Balance electrostatic and hydrodynamic forces: $\mu \approx \frac{Qe}{6\pi\eta a}$

Zeta Potential is measured *via* Phase Analysis Light Scattering (PALS)
Analogous to Doppler shift, with oscillating electric field

Understanding Dynamics

- Particle size distributions and morphology
- Precipitation processes, gel growth
- Aggregation (often driven by electrostatics)
- Sedimentation (or creaming)

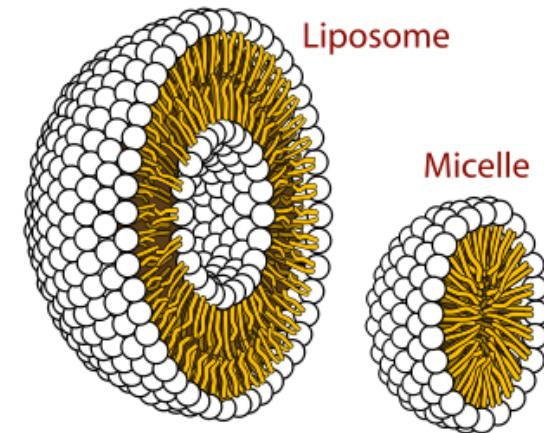
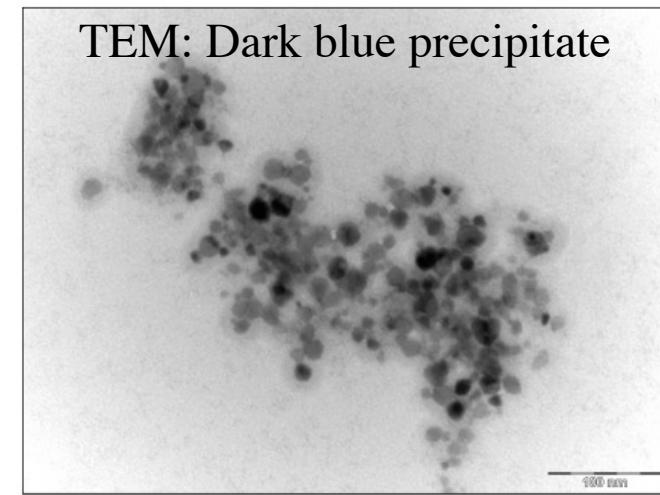
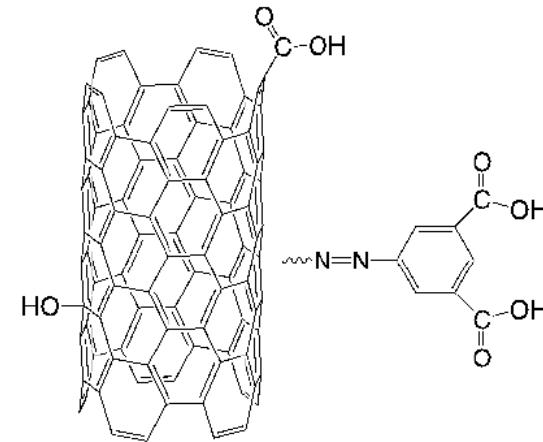
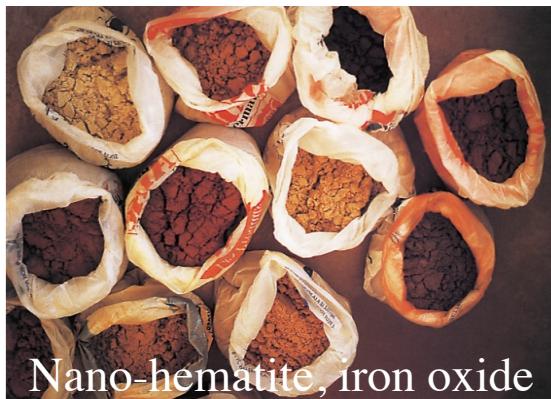


Dynamics Reveals Mechanisms & Interactions

What do we measure?

Materials Characterization

- Nanotubes & Nanowires
- NPs (metal oxides, polymers)
- Liposomes & micelles
- Emulsions, gels, & proteins



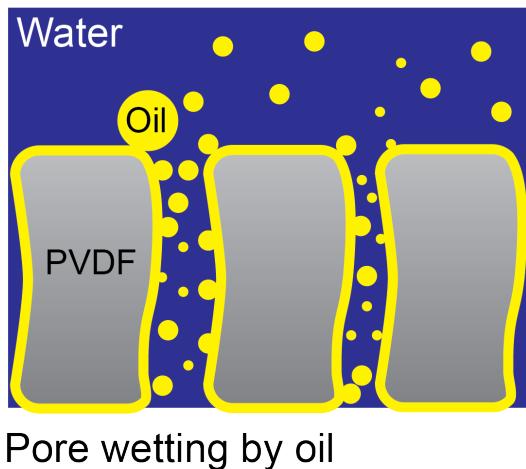
Structure Determines Function

Application: Emulsion Filtration

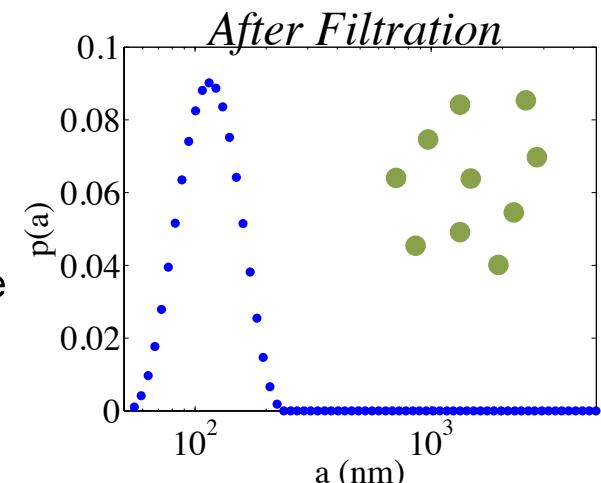
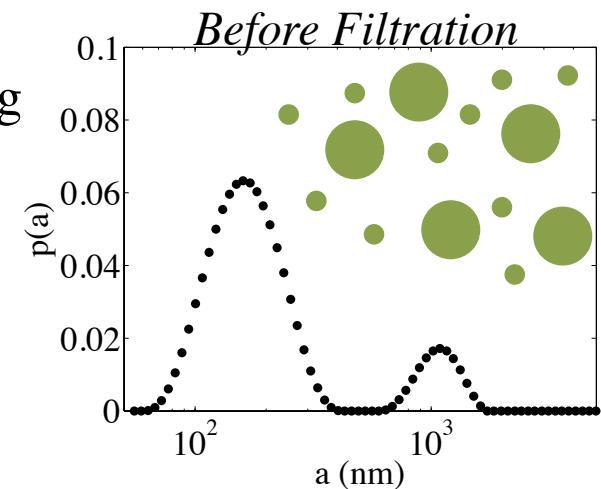
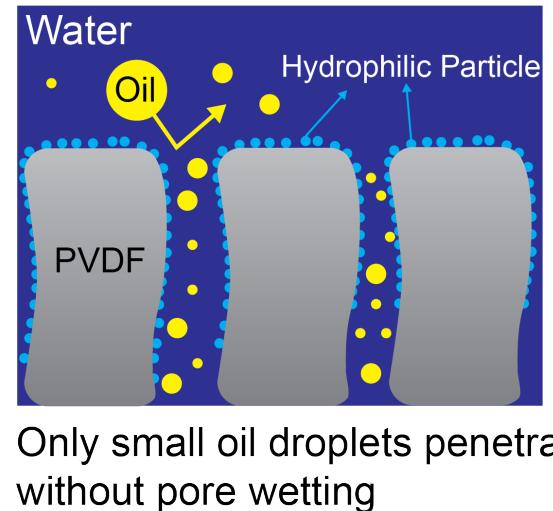
Mineral oil in water, 0.01g/mL, with Tween 80

GOAL: Enhance water permeability and reduce oil fouling through super-hydrophobic/omniphobic membranes

(A) Without Particle

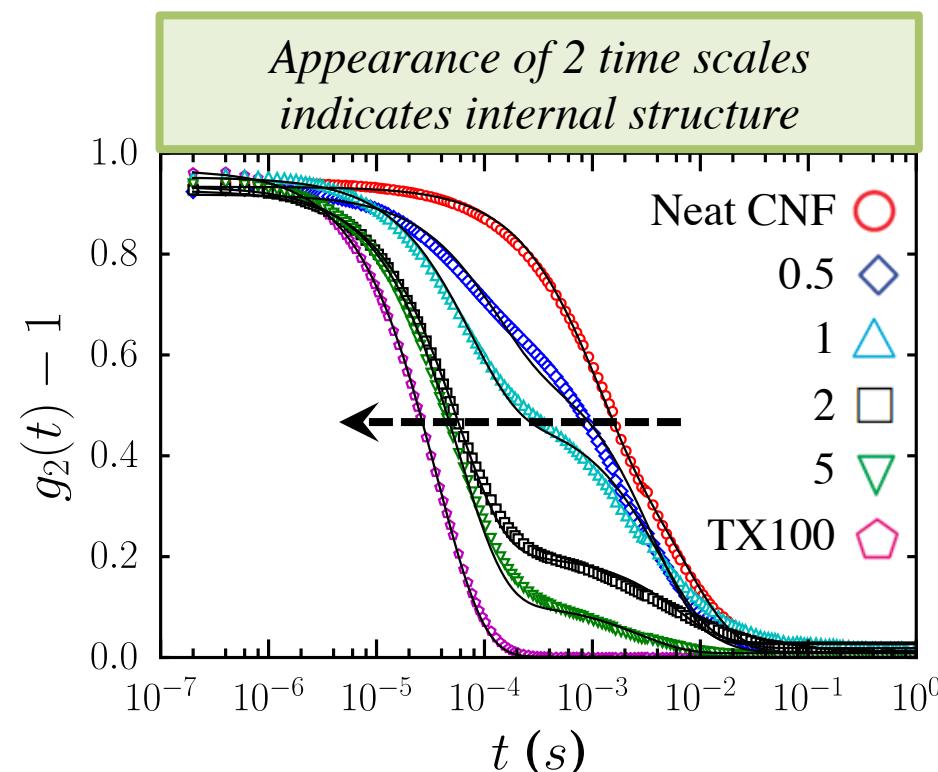
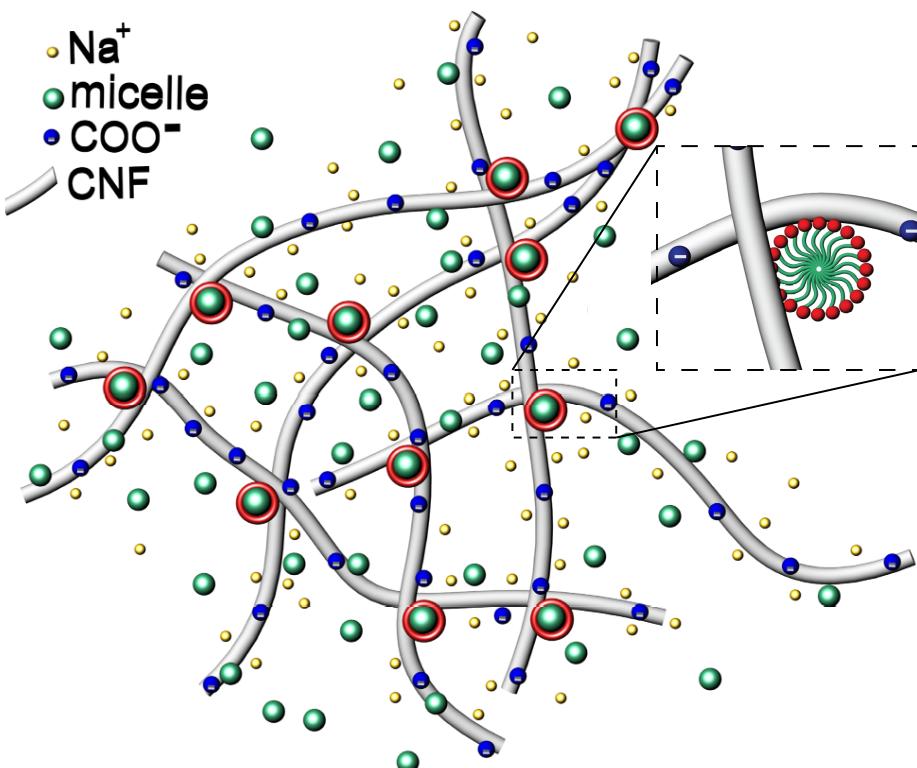


(B) Coated with Hydrophilic Particle



Cellulose Nanofibers

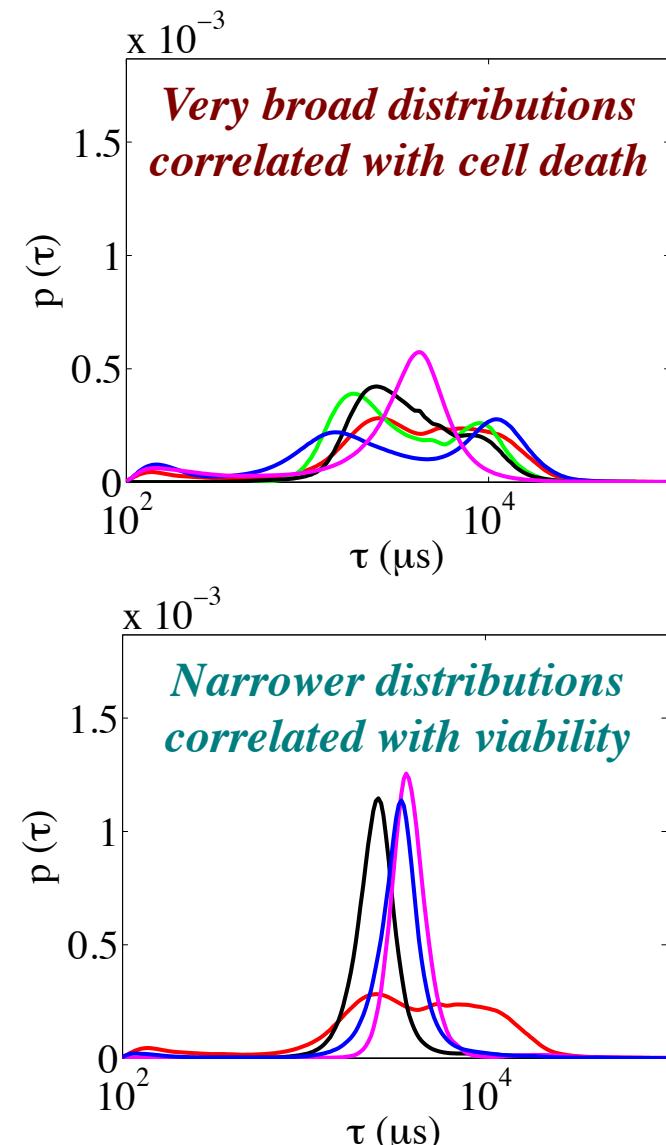
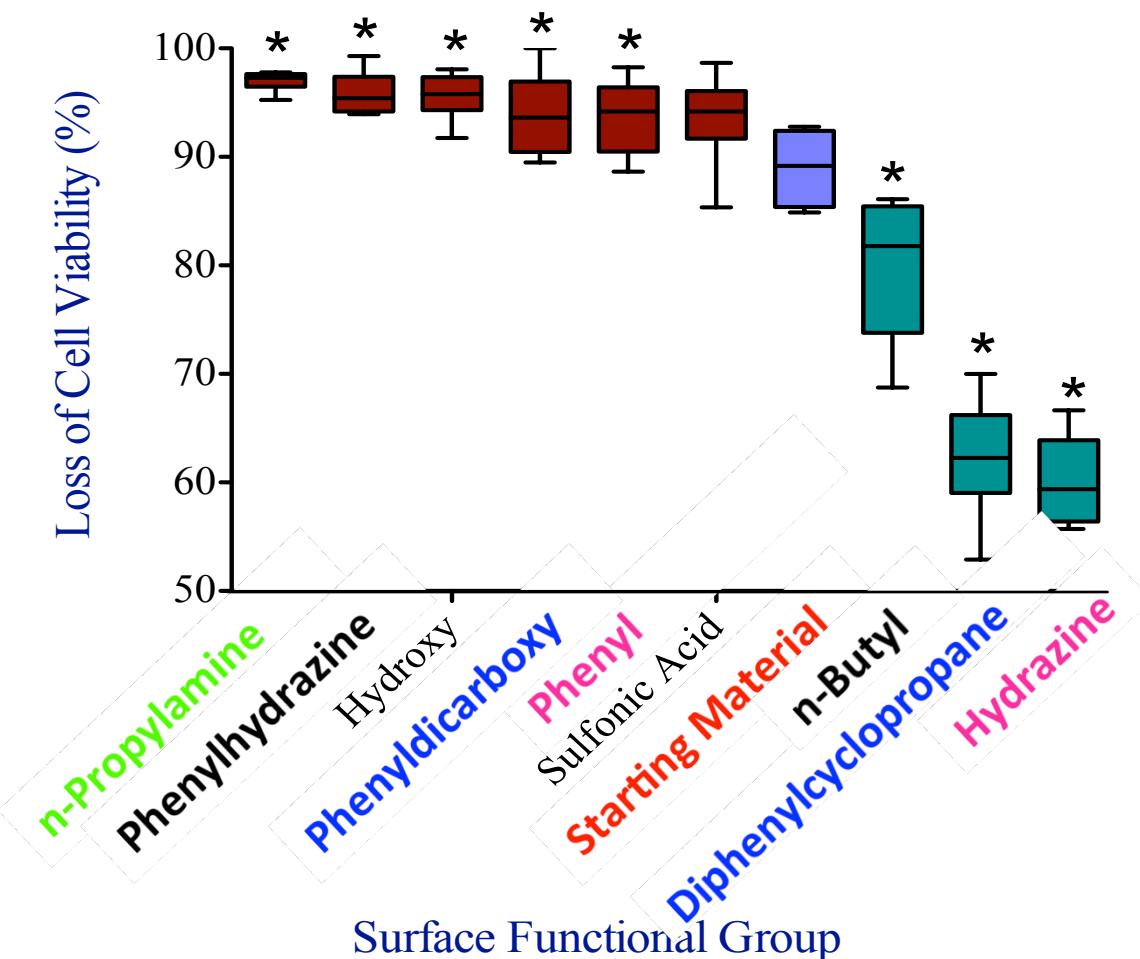
Triton X-100 micelles facilitate CNF bridging



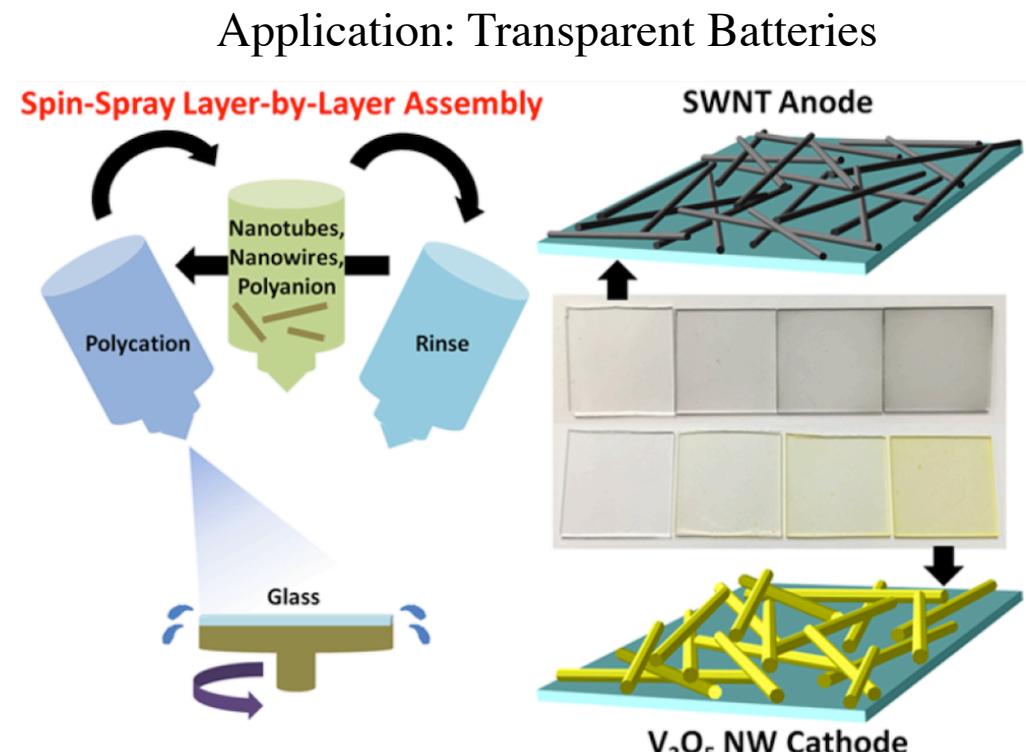
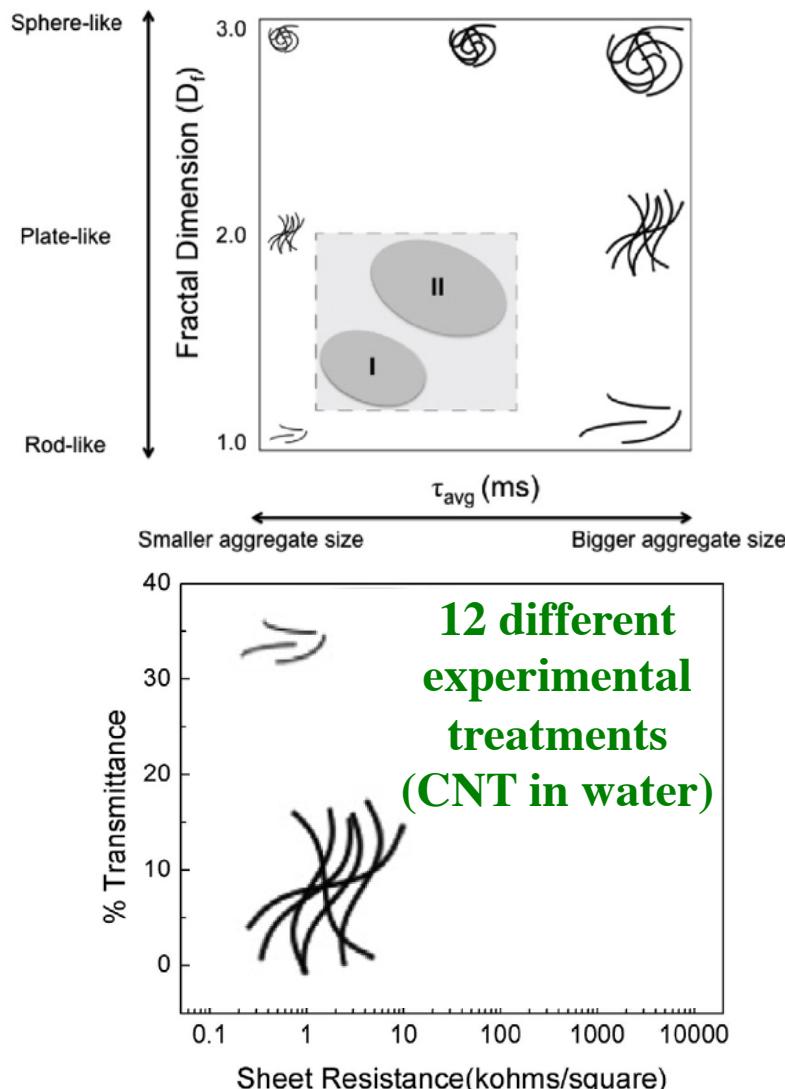
Application: Rheological Modification

Structure \longleftrightarrow Function

CNT Dispersion Quality Determines Cytotoxicity
...also Absorption, Reactivity



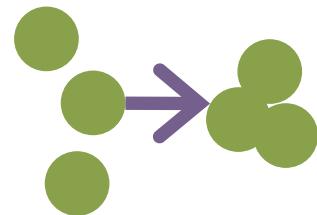
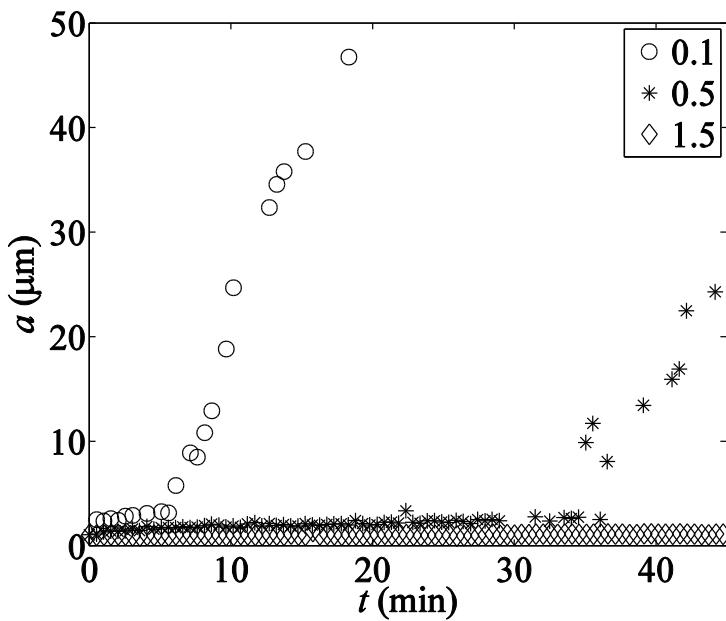
Nanotubes & Nanowires



Better dispersion of nanotubes (CNT) and nanowires (V_2O_5) → more uniform films with better optical & electronic performance

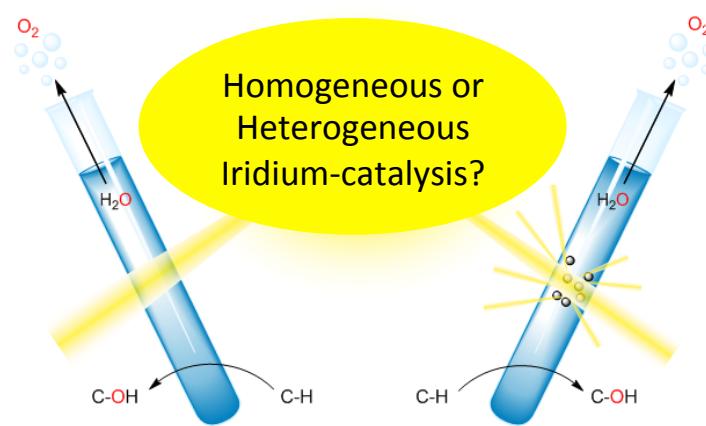
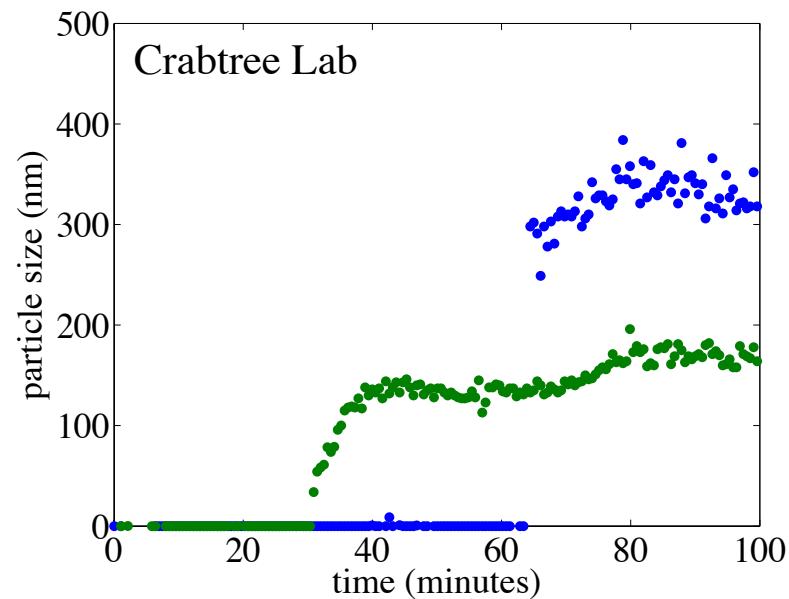
Precipitation & Aggregation

Aggregation of colloidal asphaltenes
(PAH) with dispersants in oil



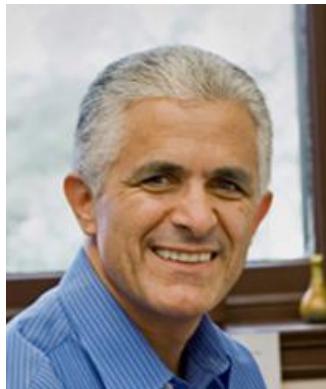
Dispersant can slow or halt aggregation

Precipitation of Iridium Oxide
Nanoparticles during water oxidation



THANK YOU!

Acknowledgments



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Paul van Tassel

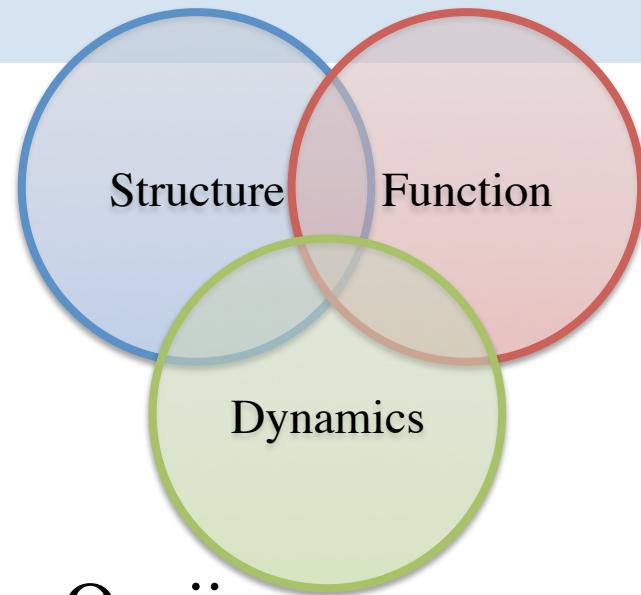
Jongho Lee, Chanhee Boo

Nawal Quennouz, Chinedum Osuji

Leanne Pasquini, Seyla Azoz, Lisa Pfefferle,
Julie Zimmerman

Forrest Gittleson, Andre Taylor

Crabtree Lab



Questions? Contact:

WEB:

LightScattering.yale.edu

EMAIL:

Sara.Hashmi@yale.edu

OFFICE:

Mason Lab 208A