# Oil Anti-deposition Agent for Near-Shore and Inland Water Treatment

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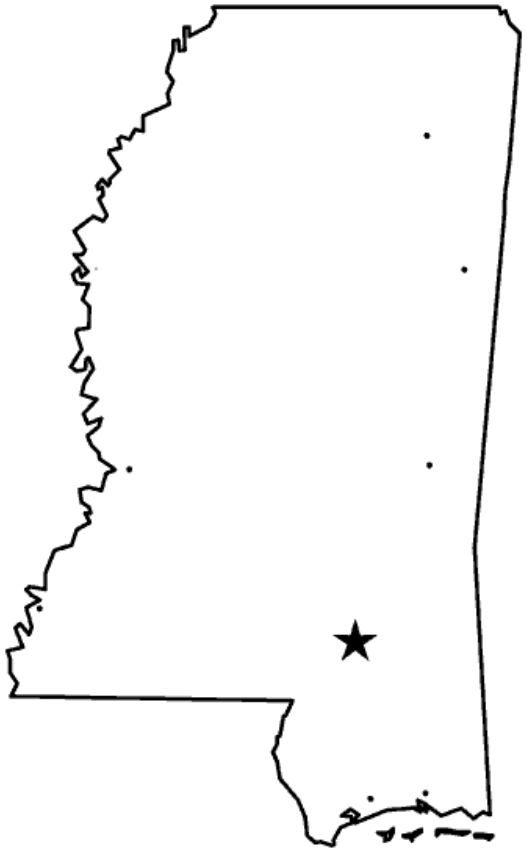
# Our Team's Call to Action

## Deepwater Horizon – April 2010

U.S. Coast Guard via Getty Images



# 1.84 Million Gallons of Dispersant Used

Other oil clean-up methods used:

- Controlled burns
- Boom/sorbents
- Skimming

John Kepsimelis/U.S.Coast Guard via Bloomberg/Getty Images

# Recent Spill on MS River – Jan 2013

- Released >1,000 gals of light crude oil
- Clean up:
  - 5,300 ft of boom
  - 159 workers
  - 10 day clean up effort
  - 16 miles of MS River closed for 4 days
    - 1,000 barge queue
  - >250,000 gals of oil/water mix recovered

# Our Initial Questions

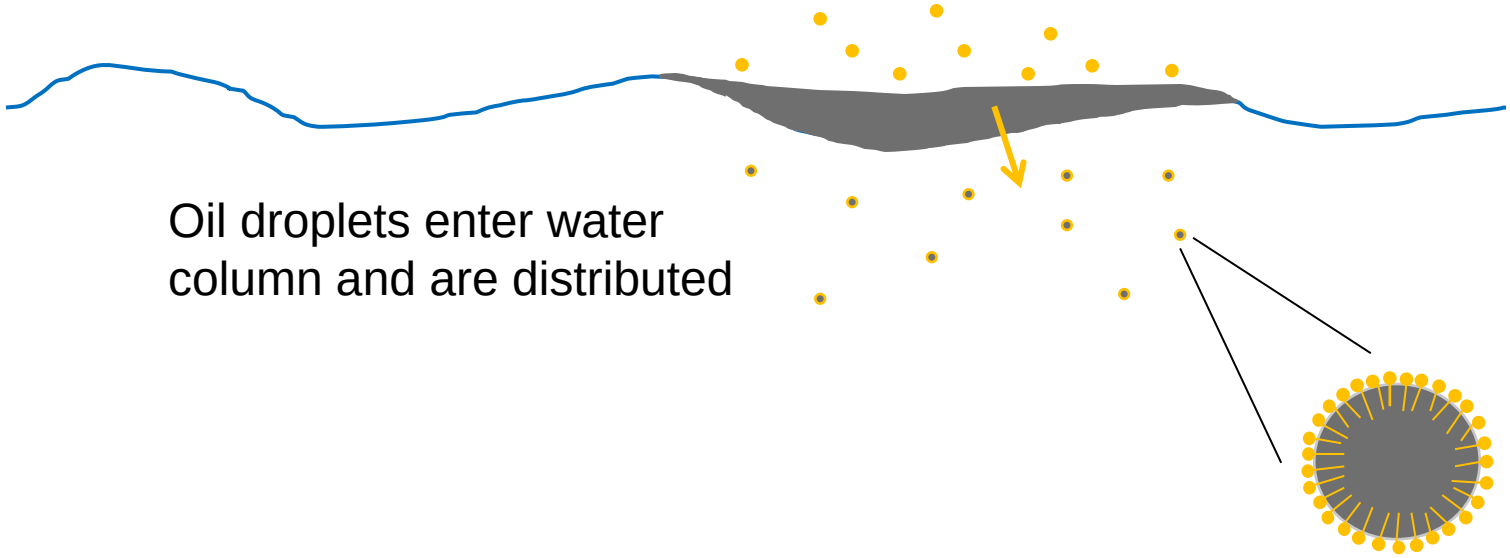
- What do we need to disperse?
  - Alkanes, Alkynes, Aromatics, Phenanthrenes, and Asphaltenes
- Disperse for microbial degradation?
- Flocculate for collection?
- Anti-deposition strategy for fresh water & sea water?
- What materials are readily available in large quantities at short notice?

***Can we create a system that works for near-shore or inland water spills?***

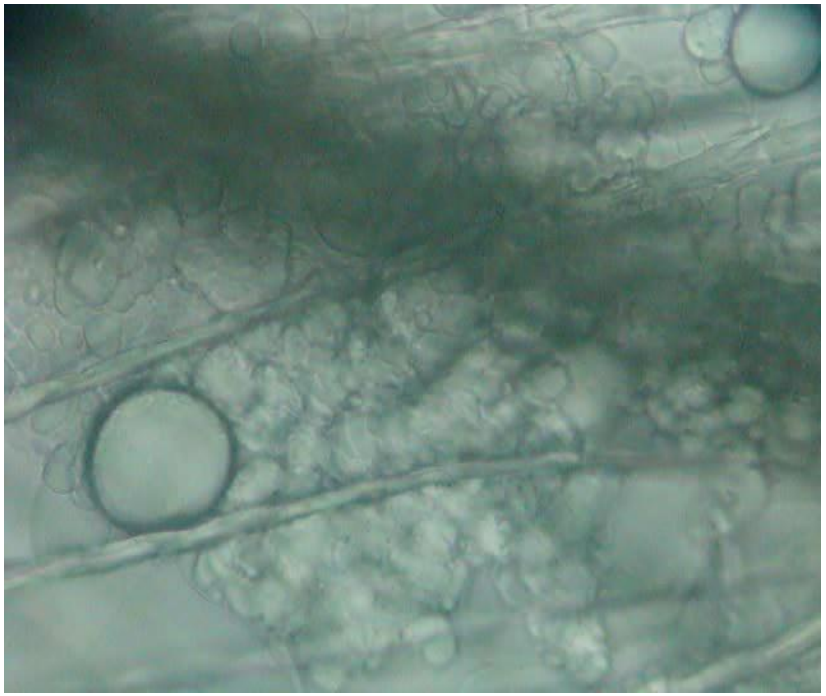
# Dispersants - Current Formulations

Disperses oil into small droplets and distributes through water column

- Petroleum based solvents
- Good wetting agents
- Even with safety of dispersant, oil is toxic



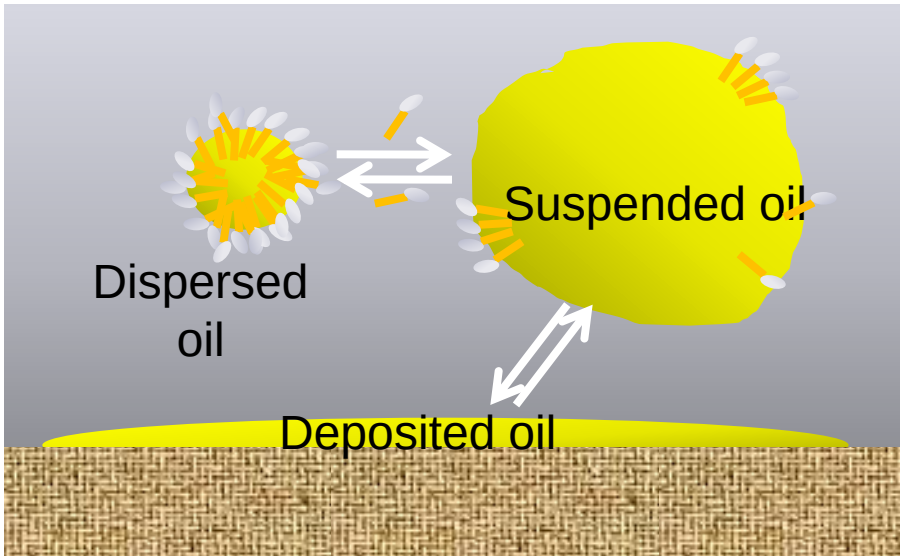
# Dispersed Oil Can Still Wet Feathers



Oil droplets formed using traditional dispersants

# How do you get “Non-Stick” Behavior?

## Inspiration: Laundry Soil Anti-Deposition

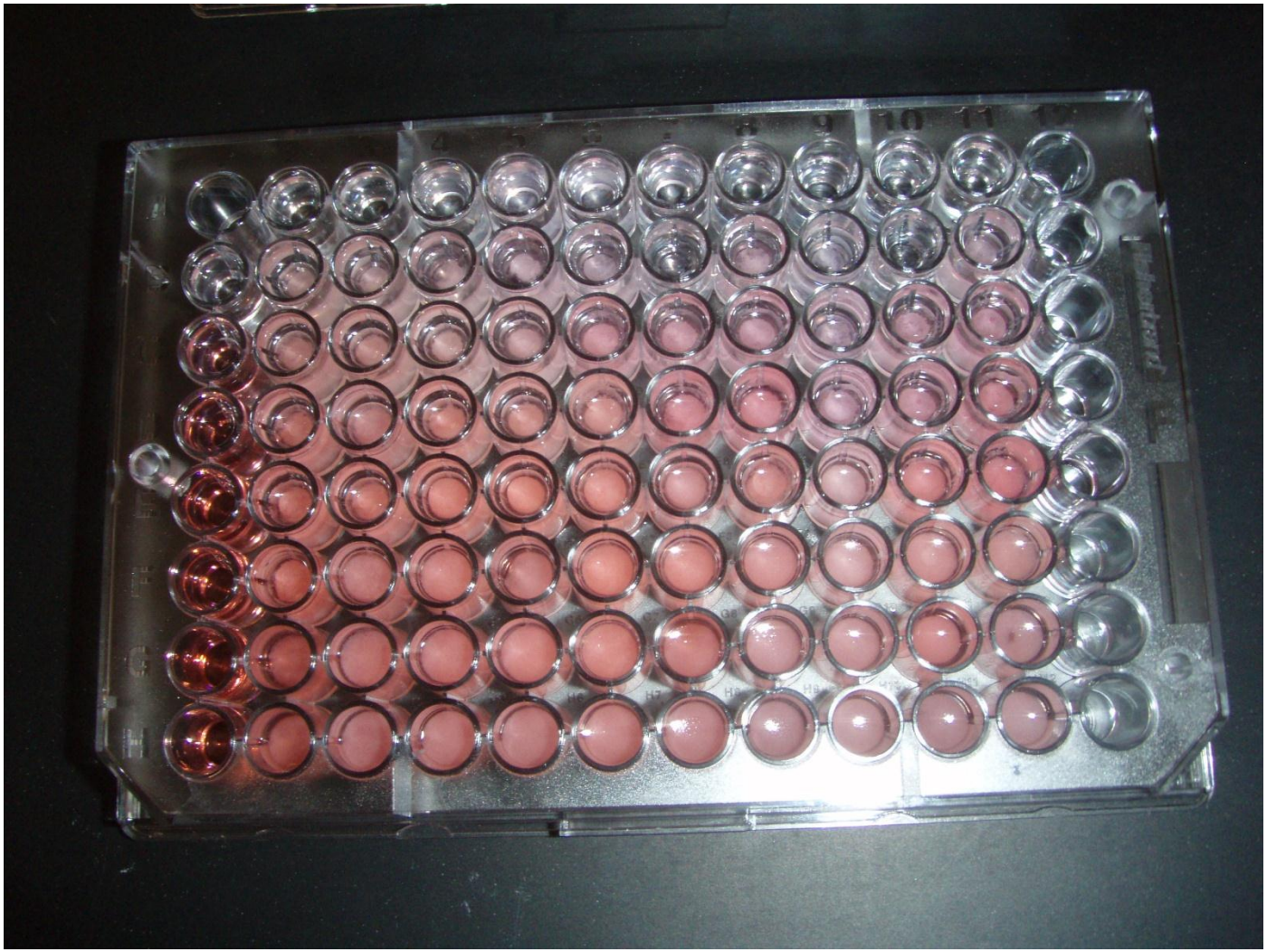



In the presence of insufficient conventional dispersants, there is a three-way equilibrium between dispersed oil, suspended oil, and oil deposited on adjacent surfaces.


Adsorption of lyophilic polymer on the oil droplets and on the substrate causes repulsion between the droplet and the surface, and mitigates deposition. Sufficient anchoring on the oil droplet can prevent deposition even on ‘bare’ surfaces.

# Robotic Liquid Handling – Rapid Screening

# Oil Anti-deposition Agents?

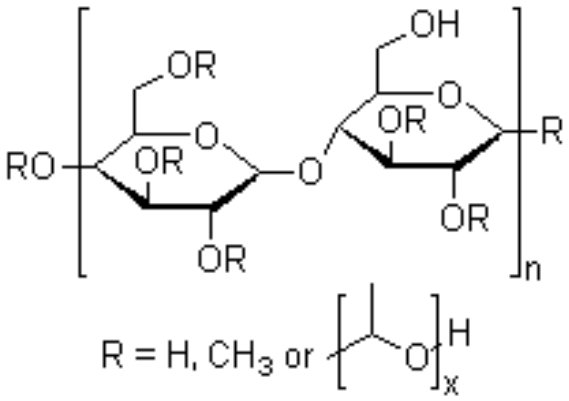


# Cellulosic Polymers

Natural polymers with good hydrophilic/hydrophobic balance and no negative impacts on the ecological environment:

## Hydroxypropyl methylcellulose

- Readily obtainable commodity
- Variety of molecular weights and side group modifications
- Biodegradable

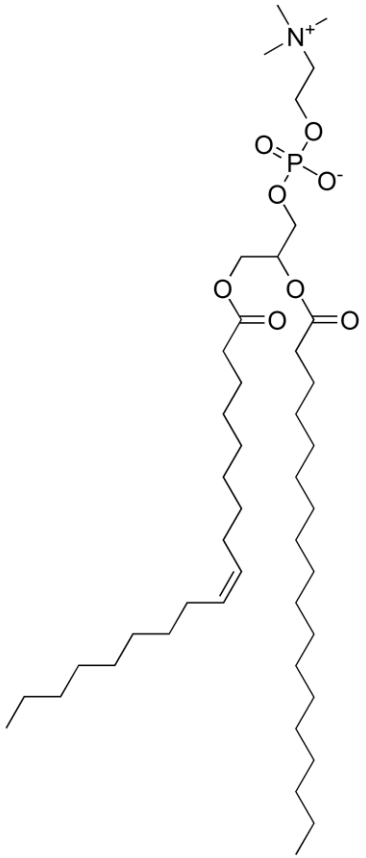


# Natural Dispersant

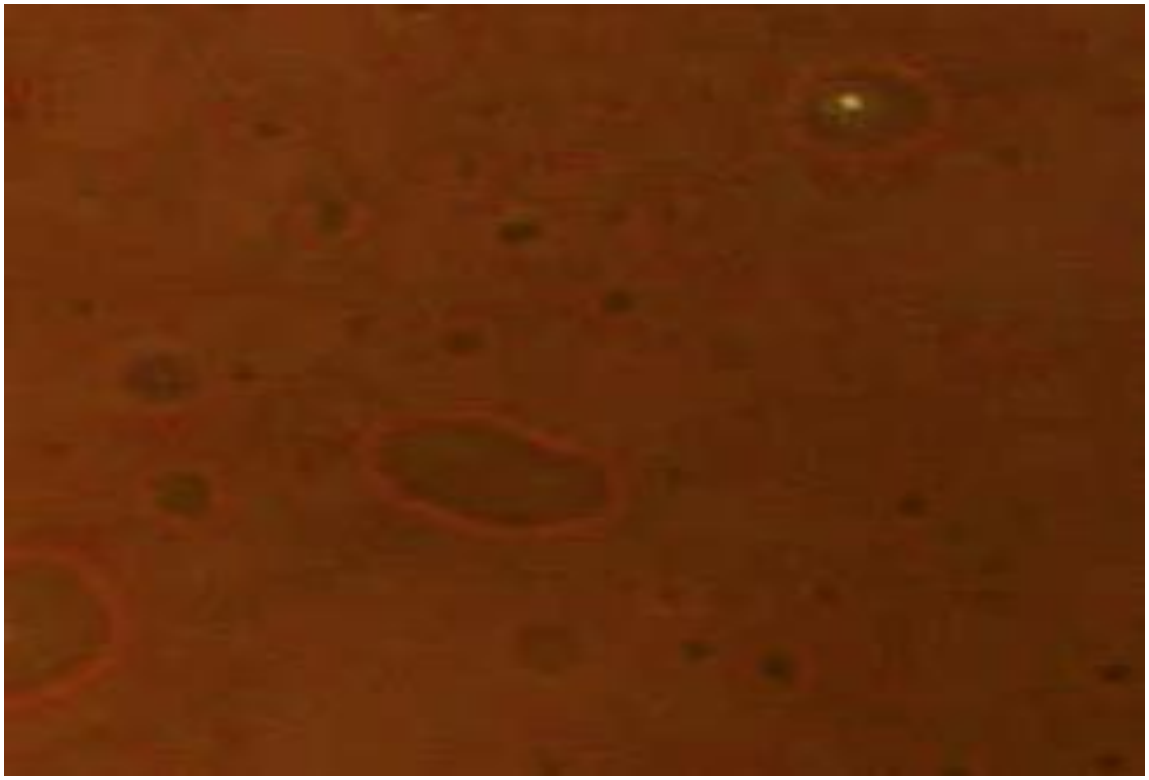
Alternative biodegradable dispersants with no negative impacts on the ecological environment:

## Soy Lecithin

- Easily obtainable commodity
- Readily forms lamellar phase – well known as an emulsion stabilizing phase
- Biodegradable and on the EPA list of acceptable substances for the marine environment



# Microbes are the First Responders



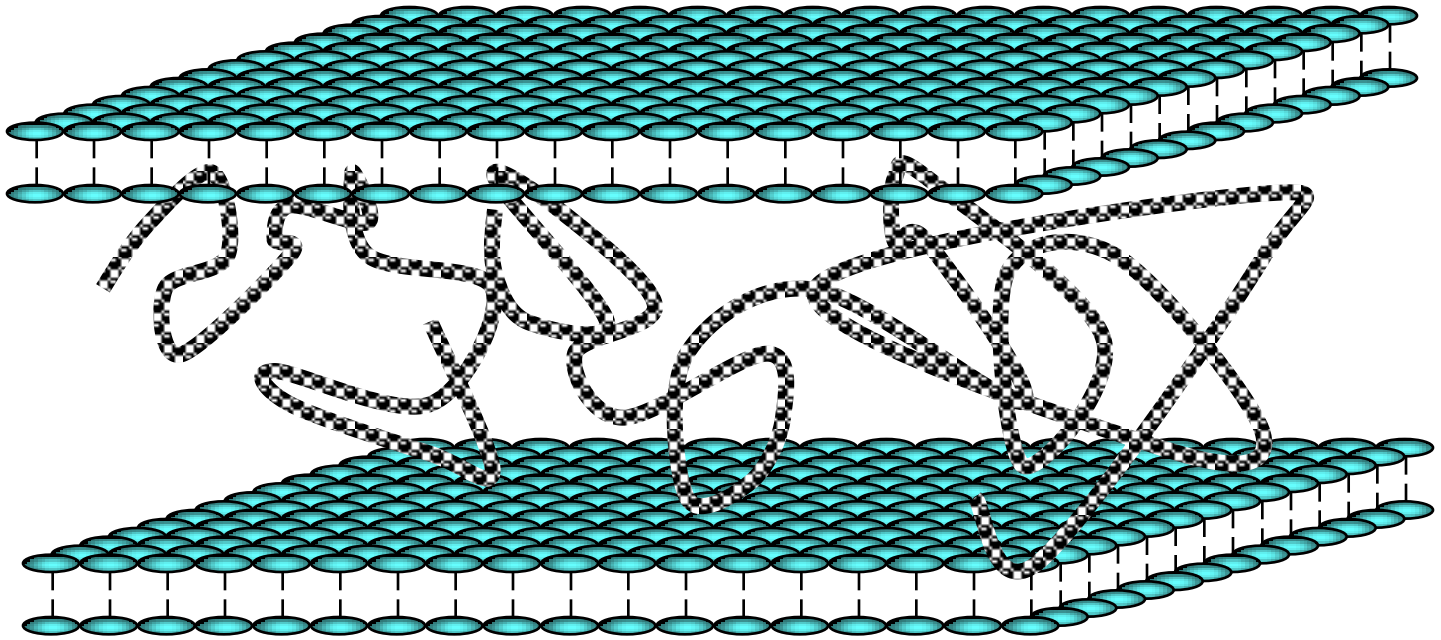
DAPI-stained bacterial cells attached to oil droplets
from the *Deepwater Horizon* site.

Source: Jay Grimes. Coastal Sciences, University of Southern Mississippi

N and P provided by lecithin can help microbes thrive while degrading the oil

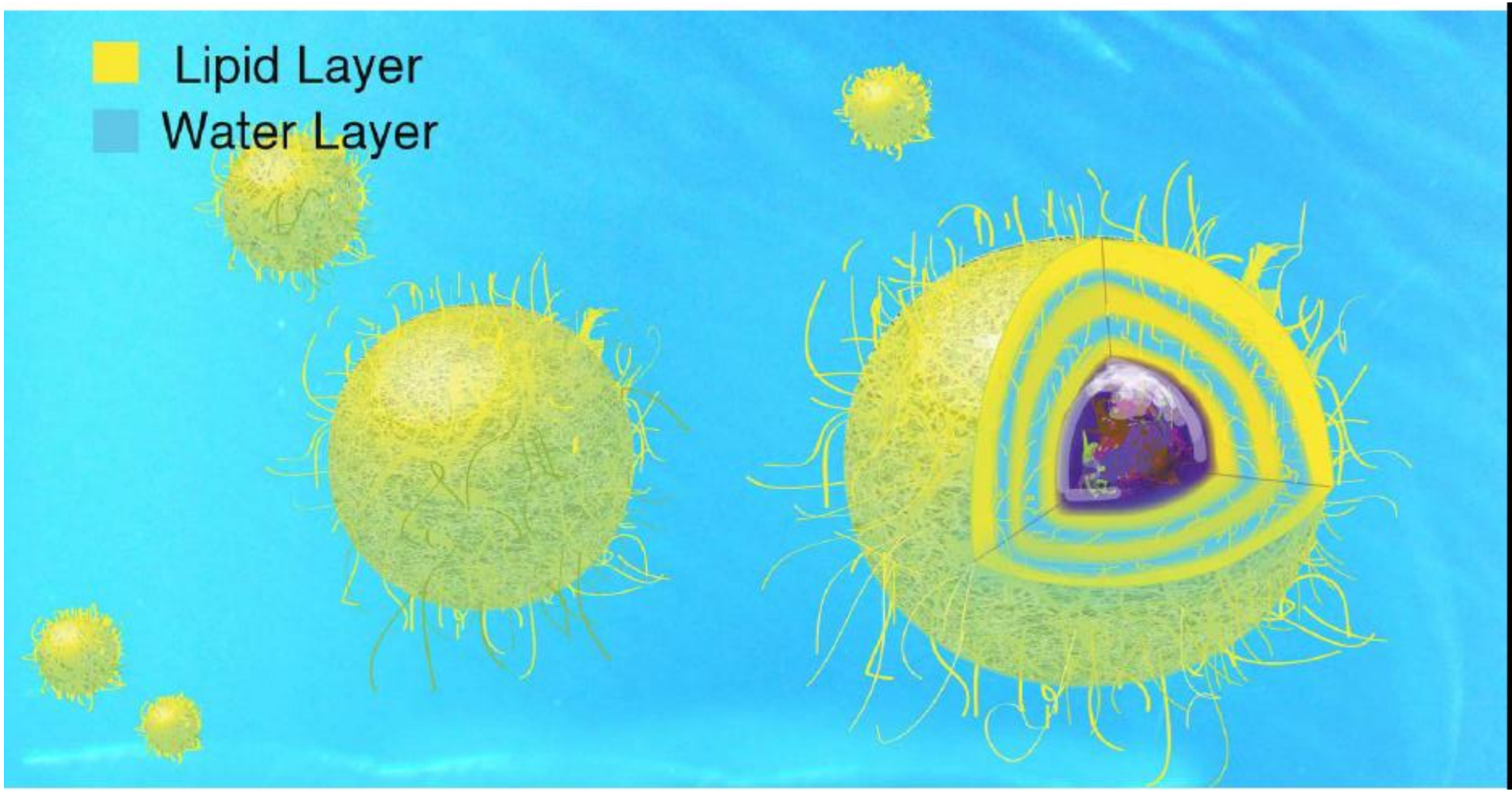
Nikolopoulou, M.; Pasadakis, N.; Kalogerakis, N. *Desalination* (**2007**), 211(1-3), 286-295.

# Lamellar Phase Stabilization

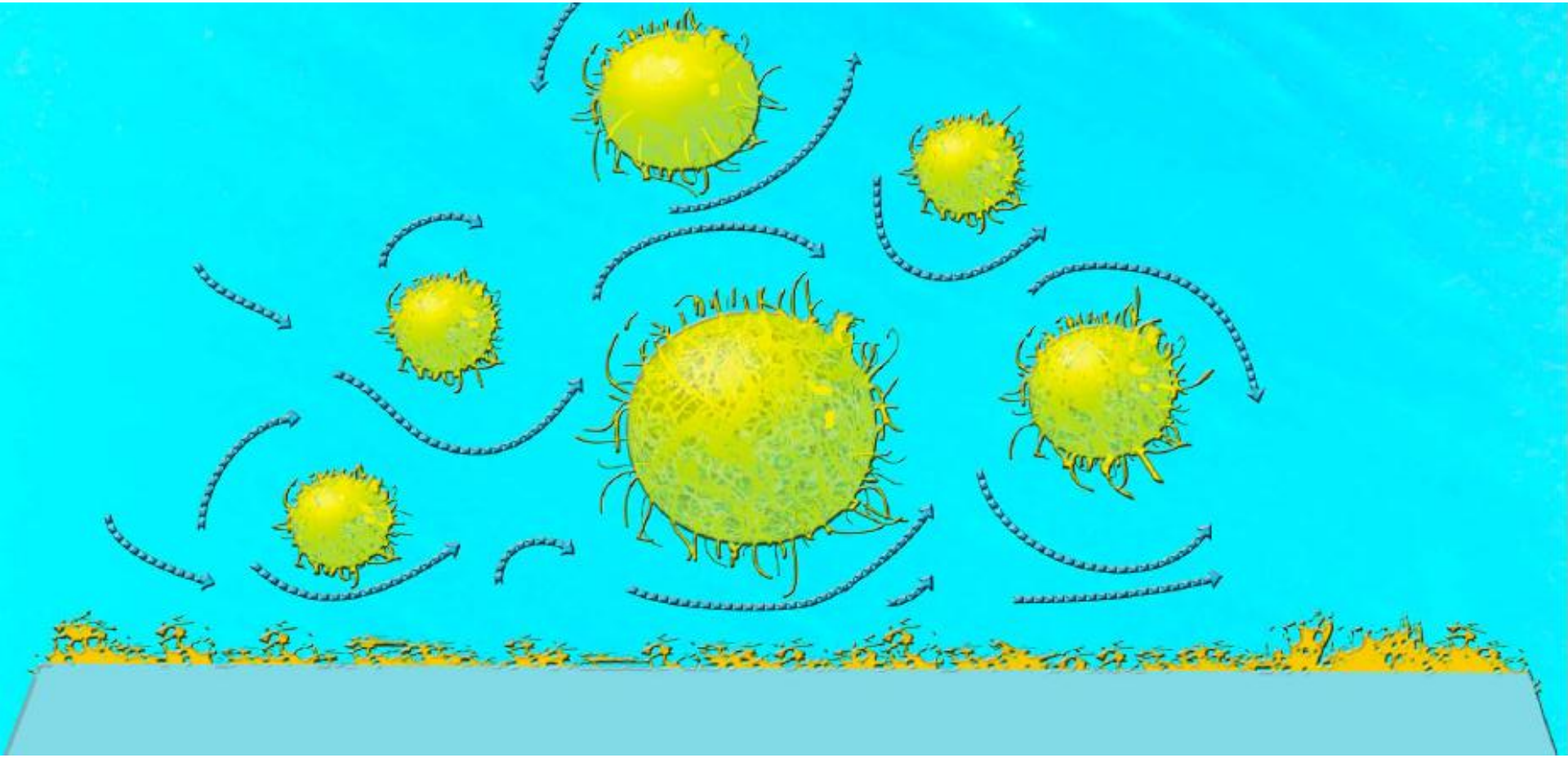


Cetyl hydroxyethyl cellulose is known to enter the d-spacing of lecthin

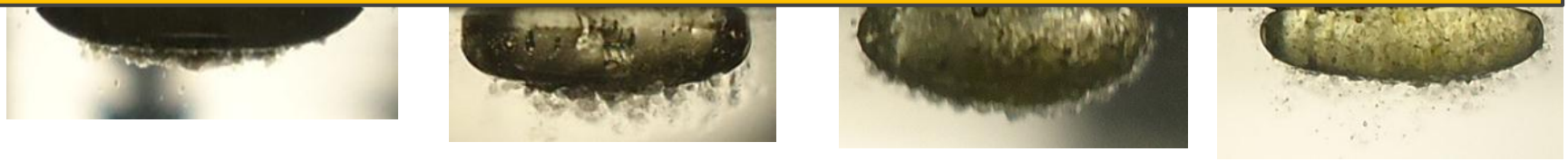
# Dispersant Complexity - Hypothesis

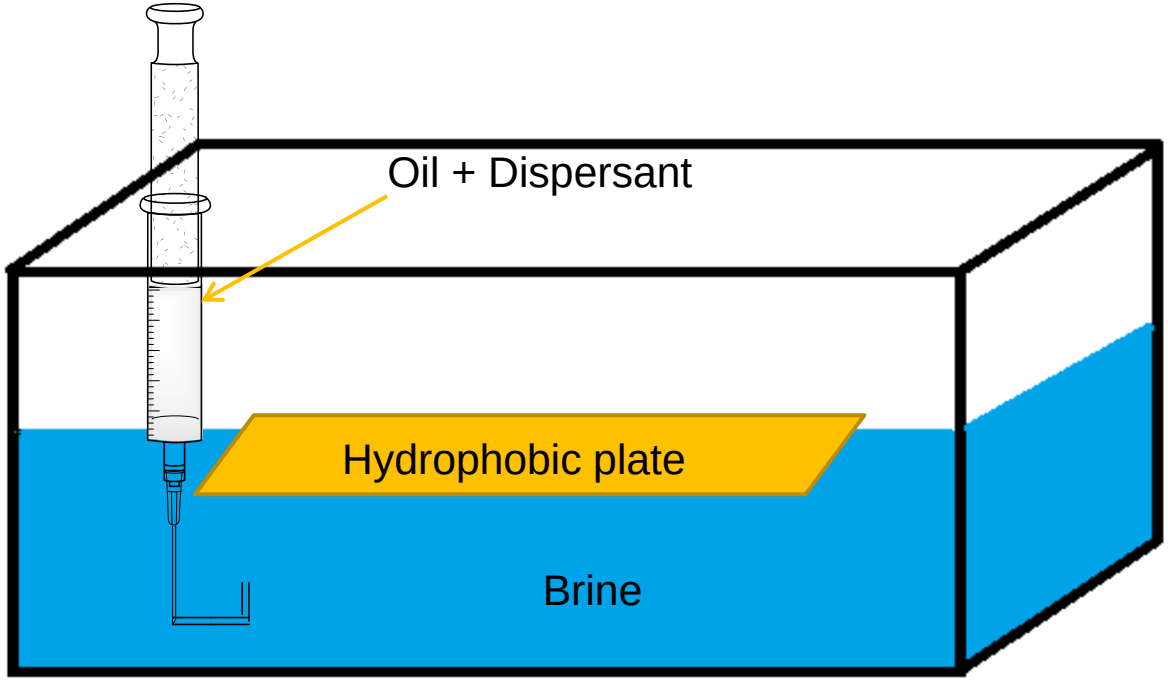


# “Non-Stick” Oil Droplets



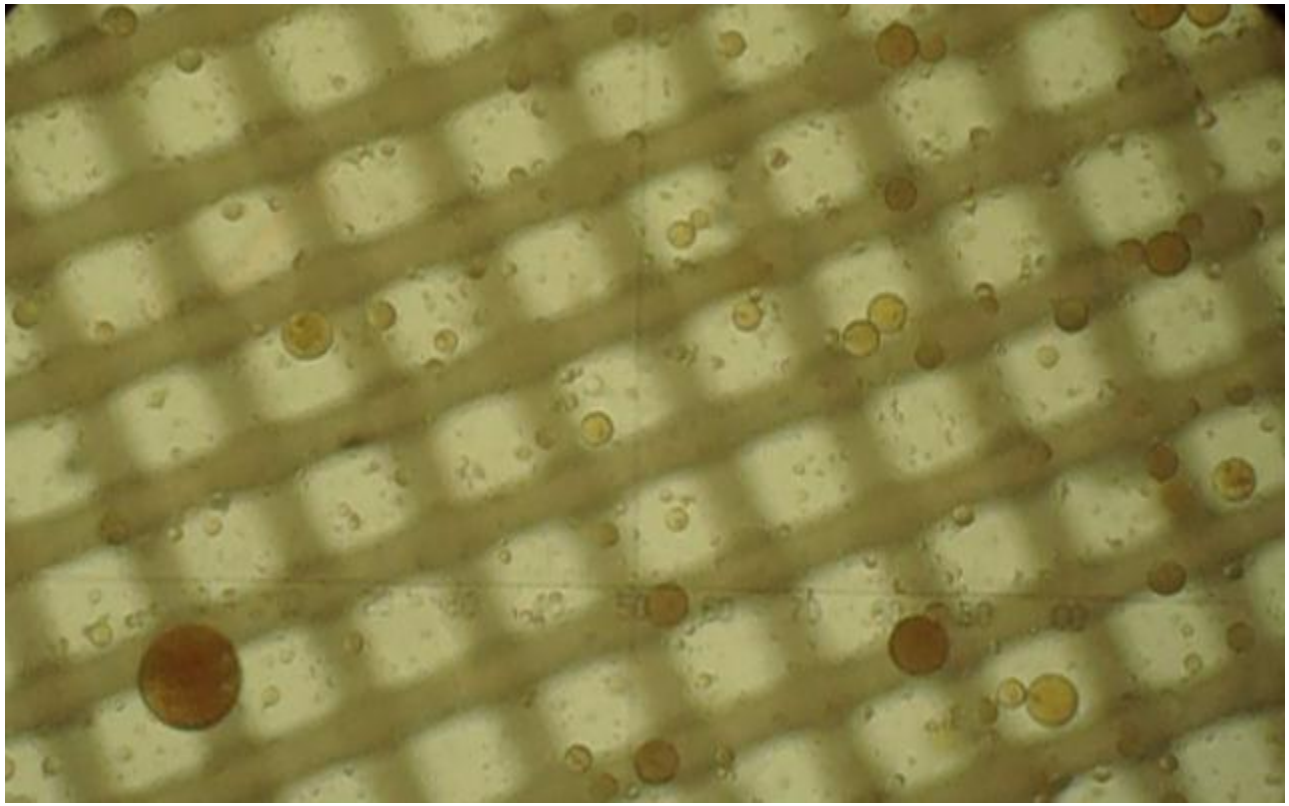
# Inverted Contact Angle Comparisons



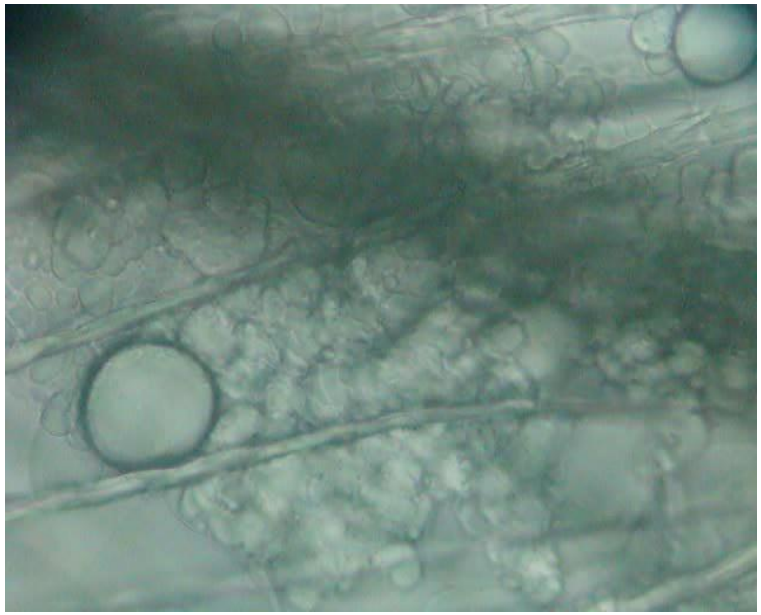


# “Non-Stick” in Action

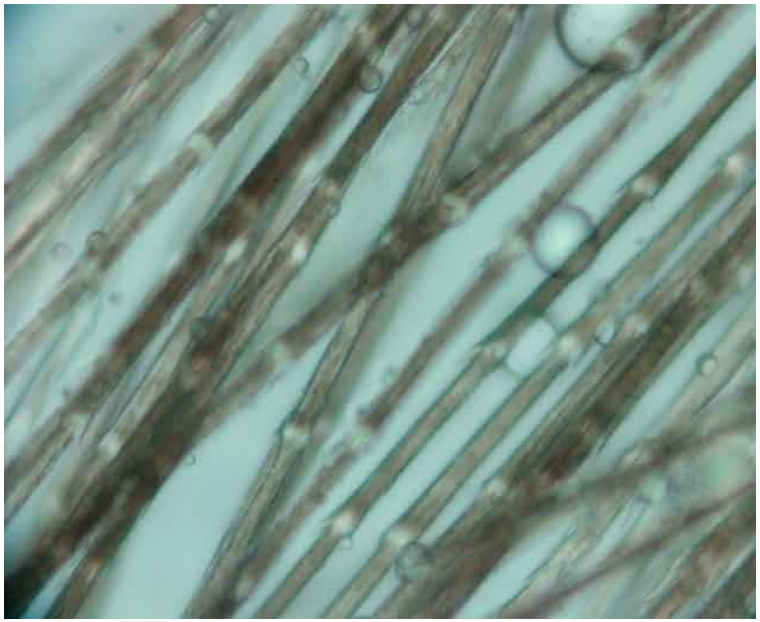
Crude oil from Deepwater Horizon on model, woven fabric



# Prevention of Oil Wetting on Feathers

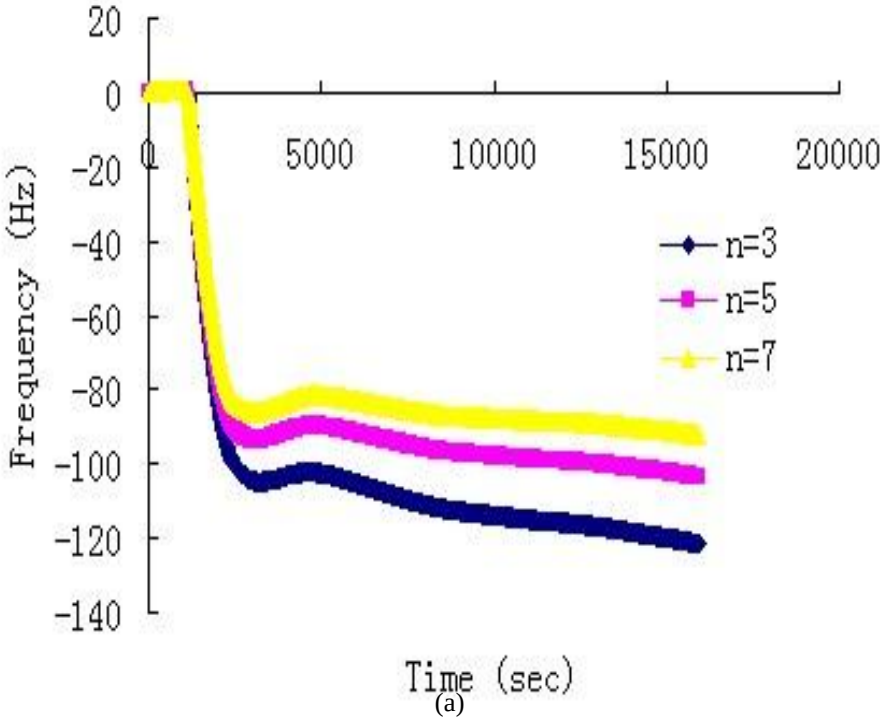


Oil droplets formed using traditional dispersants

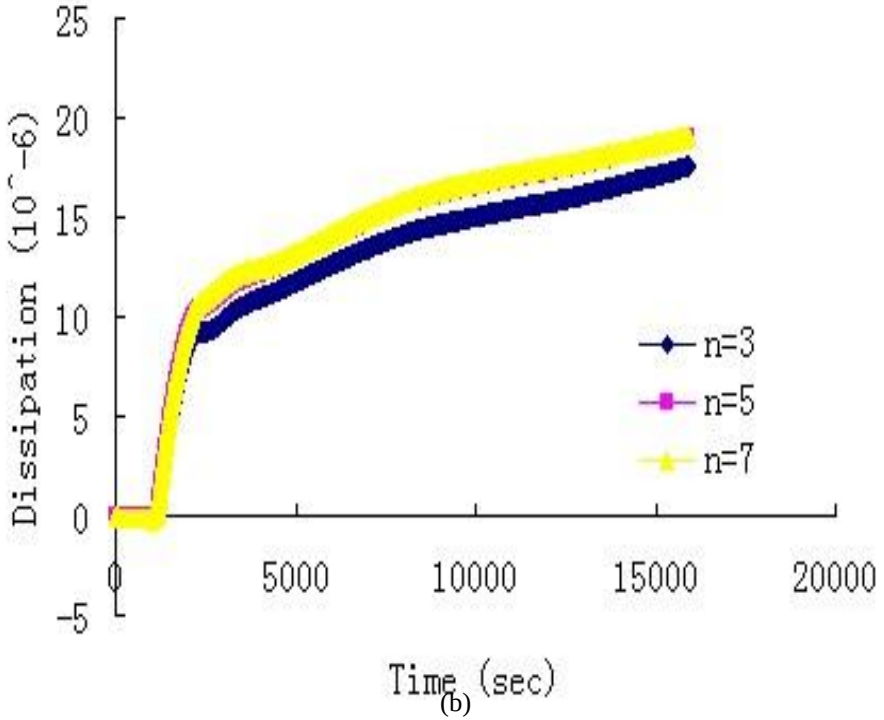


Oil droplets using our anti-deposition agent

# Quartz Crystal Microbalance Studies of Adsorption of Oil and Lecithin

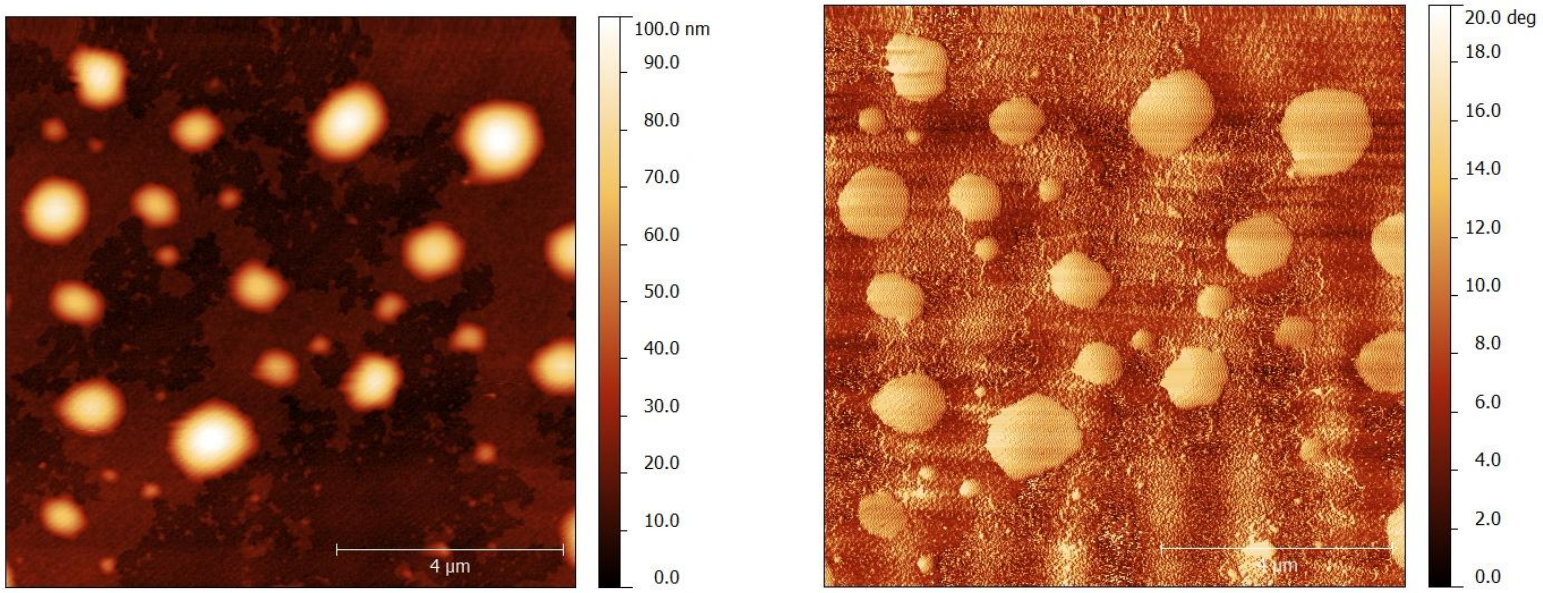



(a)



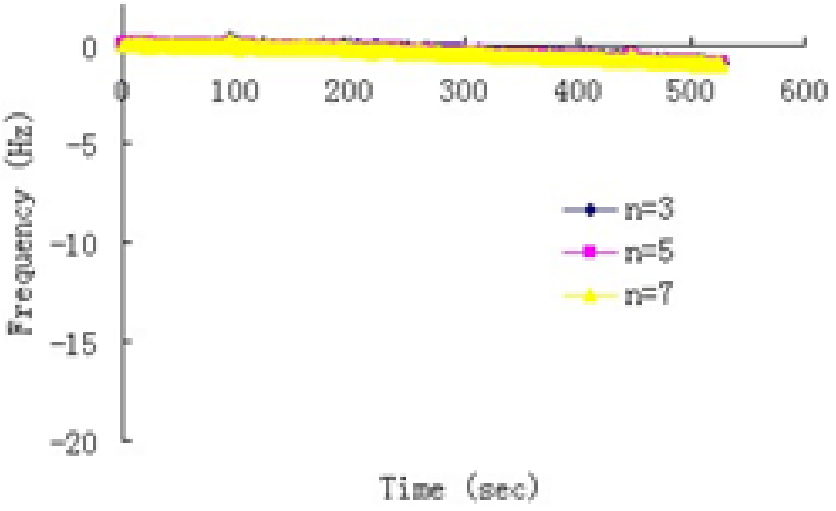

(b)

# AFM – Oil and Lecithin

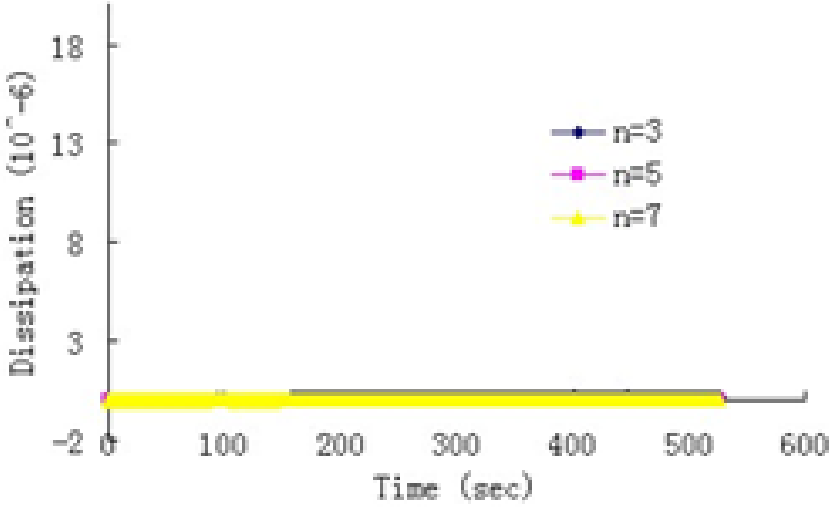



AFM images of oil and lecithin on the QCM sensor in height mode (left) and phase mode (right)

# QCM - Oil and Cellulose

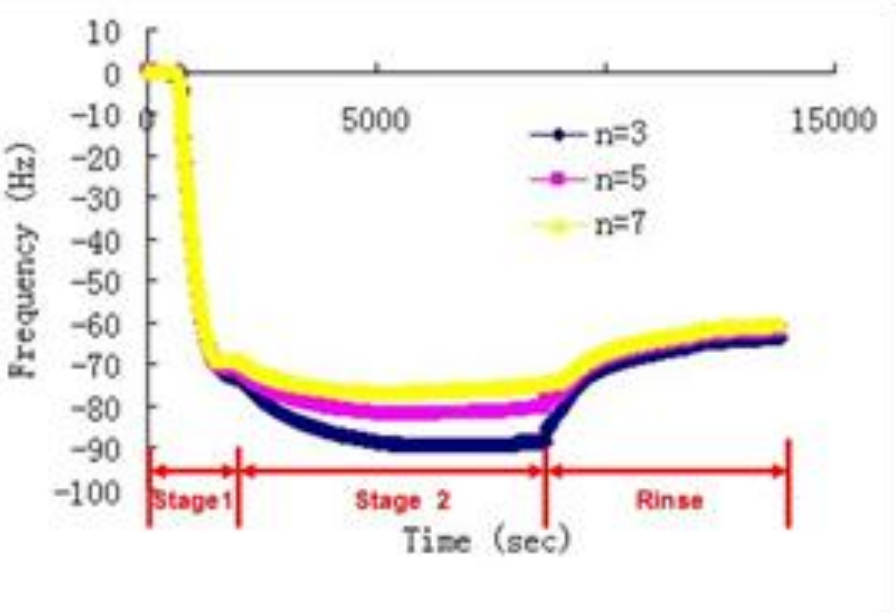



(a)

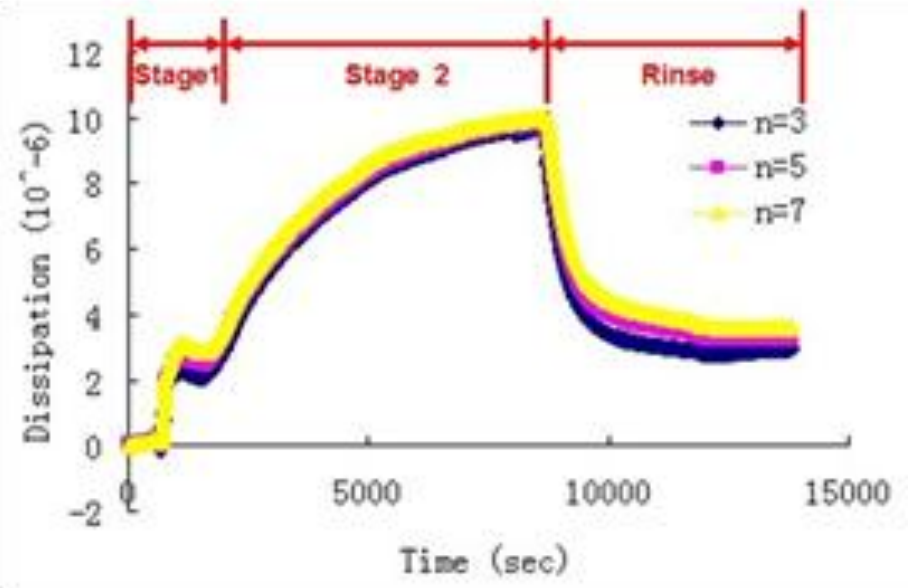



(b)

# QCM – Oil, Lecithin, and Cellulose

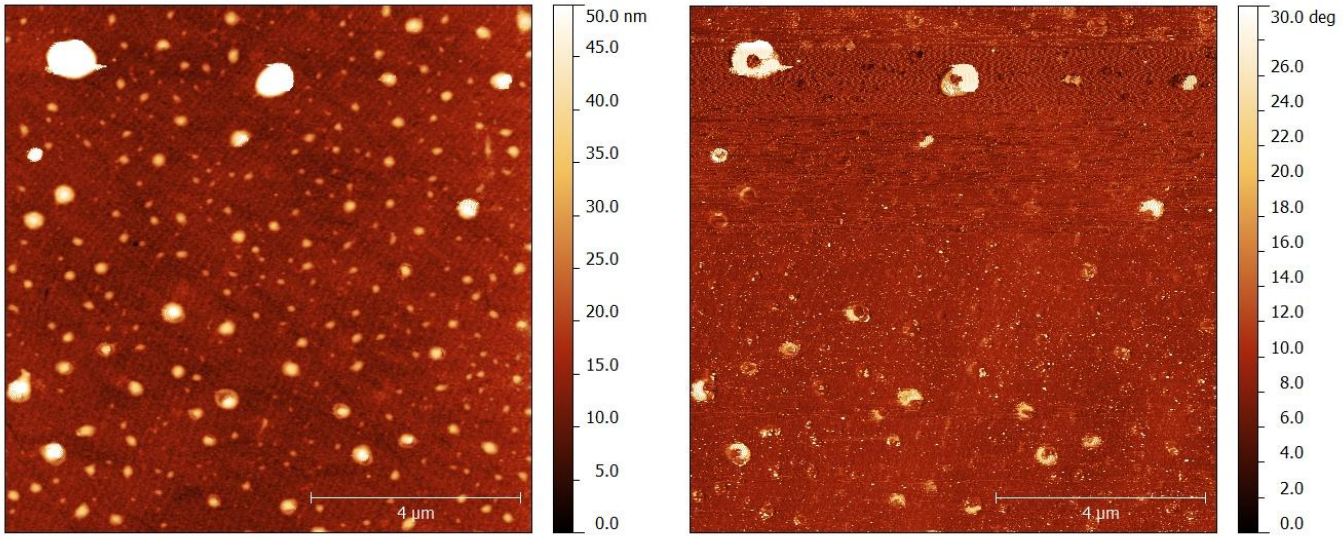



(a)

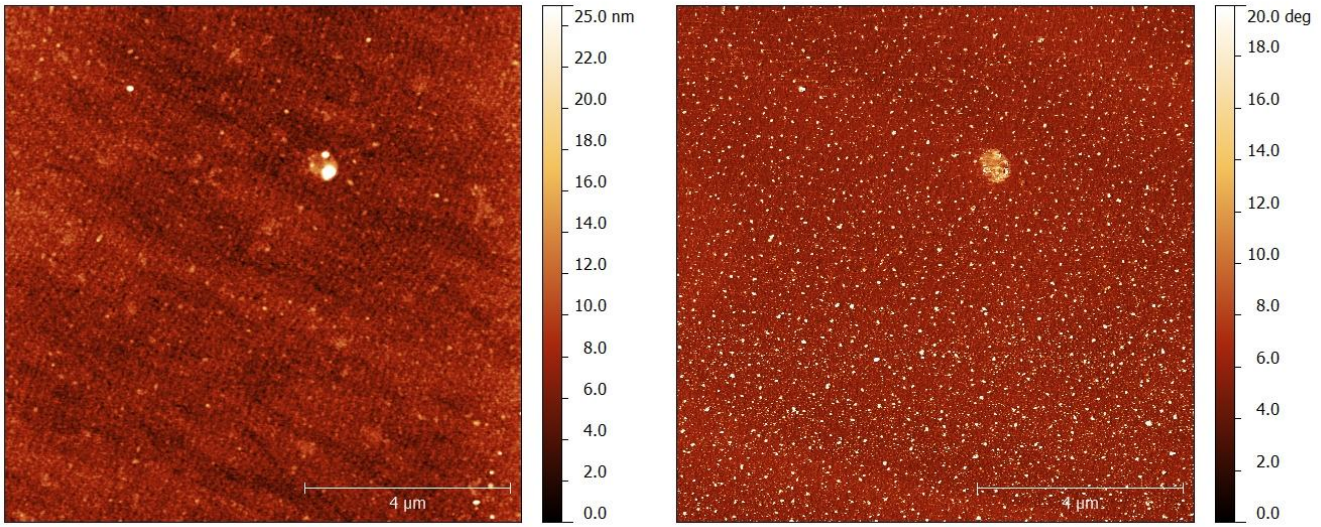



(b)

# AFM – Oil, Lecithin, Cellulose

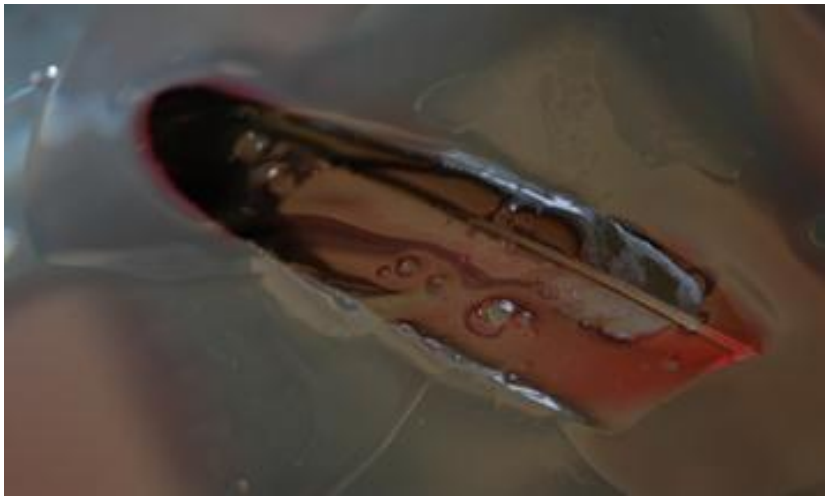


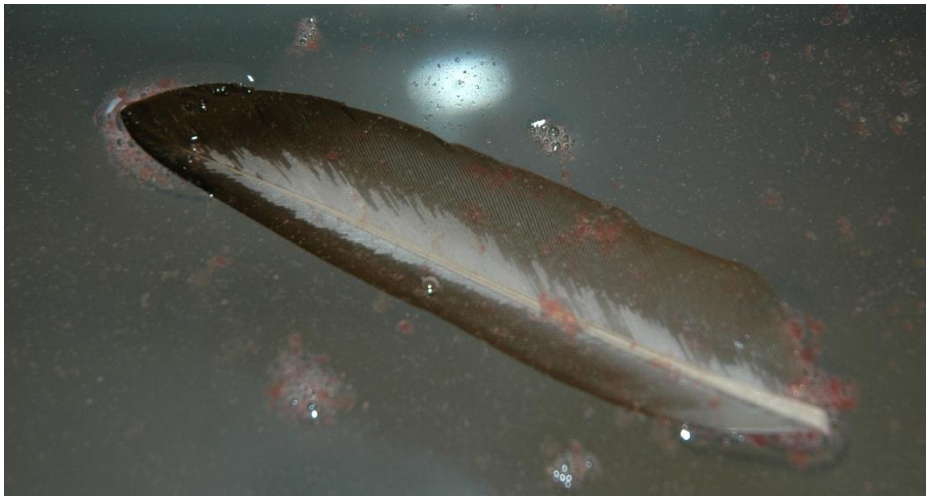

After rinse

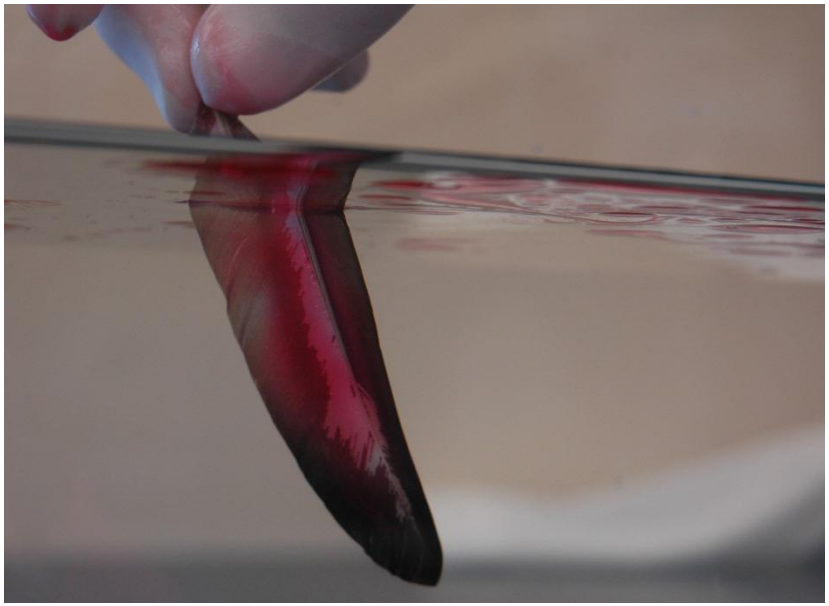


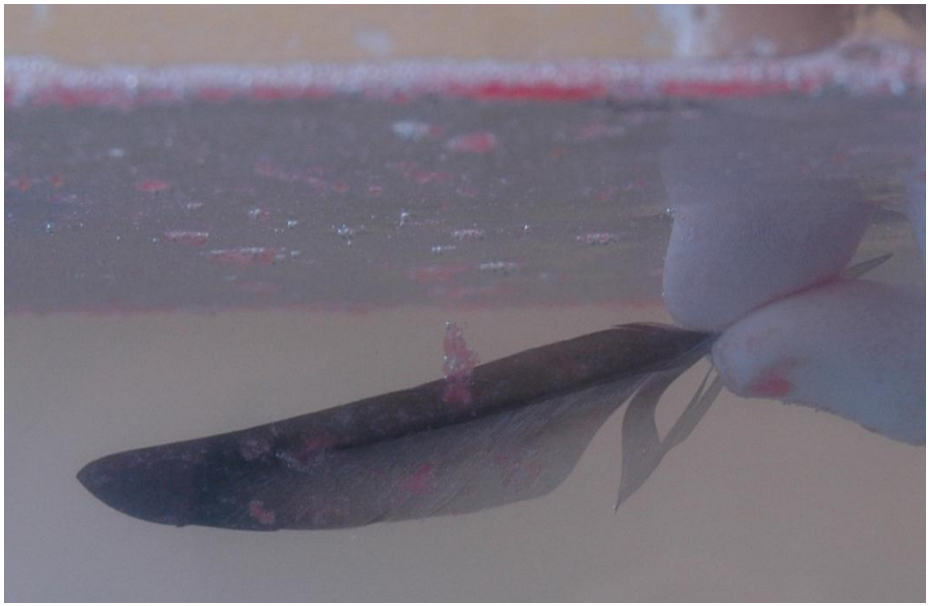
# Readily Scalable

# Lab Tests with Duck Feathers









# Remaining Objectives

- EPA toxicity testing
- Listing on the NCP Product Schedule
- Liquid complement to current product
- Larger scale testing
  - Small field test
  - Ohmsett Wave Tank

# Acknowledgements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