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CEE 697z
*Organic Compounds in Water and
Wastewater*

Oil Spill Cleanup and Surfactant Use

Kristie Stauch-White: Lecture #14

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Oil Spill Clean Up

- 
1. Containment
 2. Recovery
 1. Burning
 1. Dispersants
 2. Biodegradation

CONTAINMENT:



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http://www.federallabs.org/flc/sandlg/state_profile/?state_id=127



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Recovery

Skimmers and Sorbent materials:

- polyester Fiber Mats
- Super-Hydrophobic Absorbents
 - polyethylene mop-like pads
- Hair Mats
- Hay
- Pine Shavings



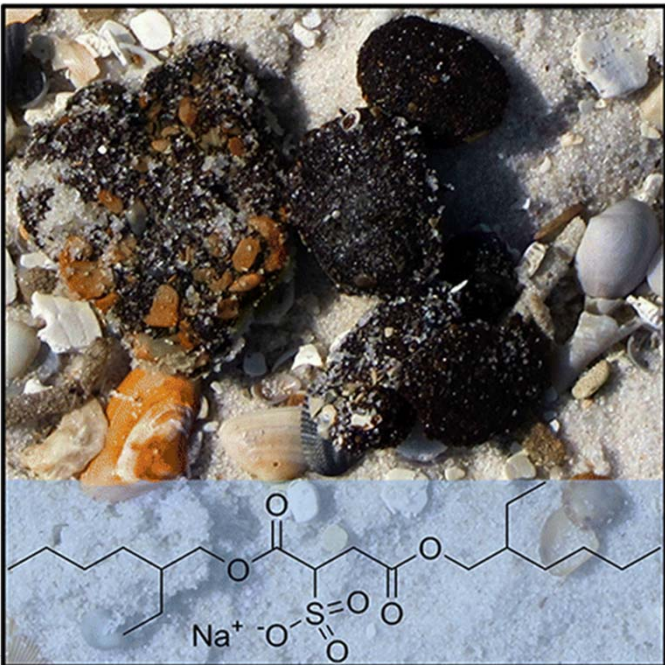
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Burning



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Department of Defense



The image shows a close-up of a beach with dark, oily residue and a chemical structure of a surfactant overlaid on the bottom half. The chemical structure is a sodium salt of a sulfonate surfactant, specifically sodium dodecyl sulfonate, with a long hydrophobic alkyl chain and a hydrophilic sulfonate head group. The structure is shown as a skeletal formula with a sodium ion (Na⁺) and a sulfonate group (SO₃⁻) attached to a long alkyl chain.

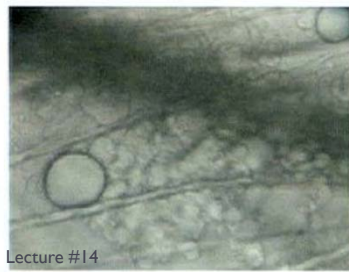
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Helen K. White, 2014, Dept. of Chemistry, Haverford College

Oil Spill Clean Up

- 
- The image shows a photograph of an oil spill on the water surface, with a list of cleanup methods overlaid. The oil is dark and viscous, forming a thick layer on the water. The list includes:
1. Containment
 2. Recovery
 1. Burning
 1. Dispersants
 2. Biodegradation

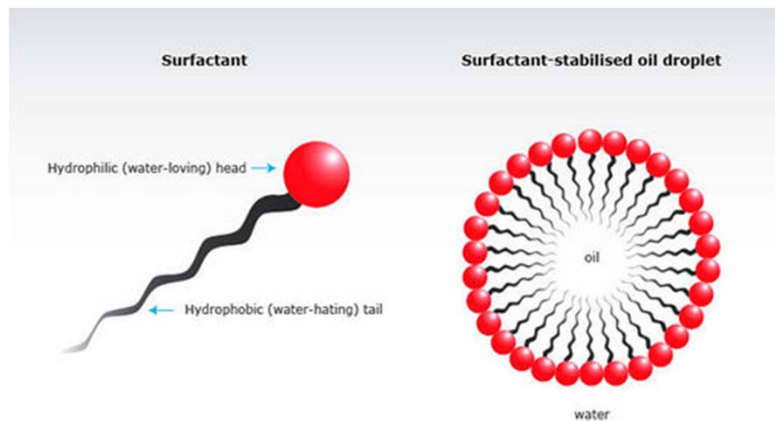
Dispersants

- ▶ Solvents – decrease viscosity
- ▶ Surfactants – surround and emulsify oil
 - ▶ Encourages oil to sink and come into contact with bacteria in the water column
 - ▶ Also encourages oil droplets to spread into fur and feathers of marine animals



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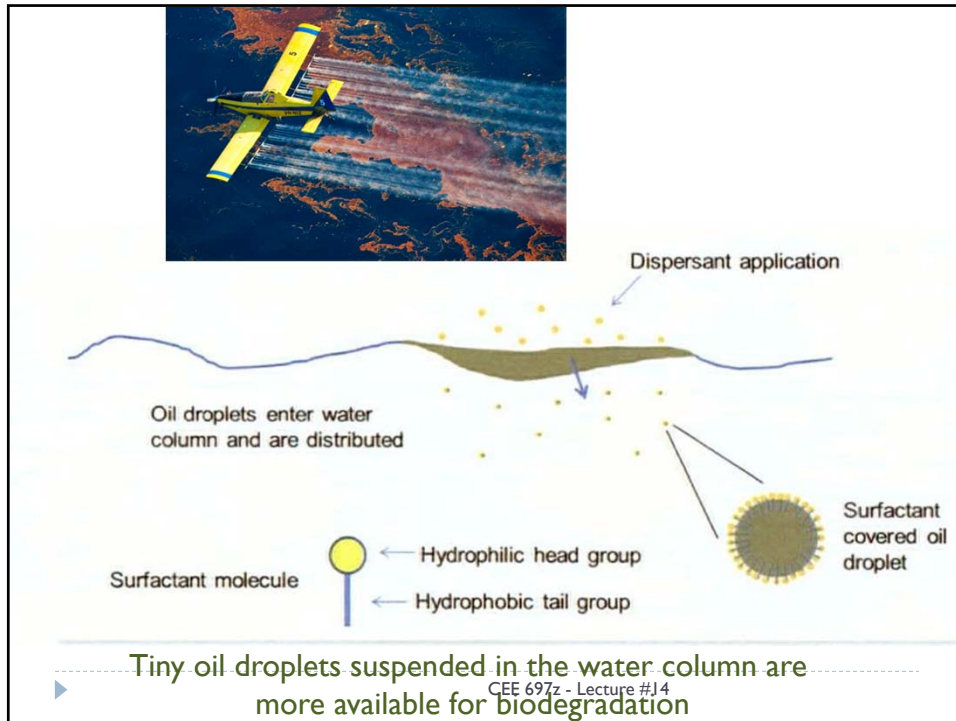
Surfactants



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amphipathic

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Biodegradation

Direct Interfacial Uptake of Oil/Surfactant Emulsion Droplets

Oil Degrading Bacteria:

- Alcanivorax borkumensis
- Pseudomonas

Symbiotic Bacteria:

- Azotobacter – provides fixed nitrogen
- Cyanobacteria – provides fixed nitrogen and oxygen

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ants

- ▶ 1.8 million gallons of Corexit 9500 applied at Deep Water Horizon Oil Spill in 2010

Active Ingredients:

dioctyl sodium sulfosuccinate (DOSS)

- Reported to be quickly biodegradable (>90% in 12-19 days)
- Found in Coral Beds 6 months after application
- Found on Coastline 4 years later
- Toxic to Marine Life
- Toxicity increased when mixed with Oil



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Helen K. White, Haverford College & Woods Hole Oceanographic Institute

Clearly, more research is needed to find less toxic and more biodegradable surfactants for Oil Spill Remediation

- Commercial Lecithin & Cellulose Polymer based surfactant – mixture of natural phospholipids in oil

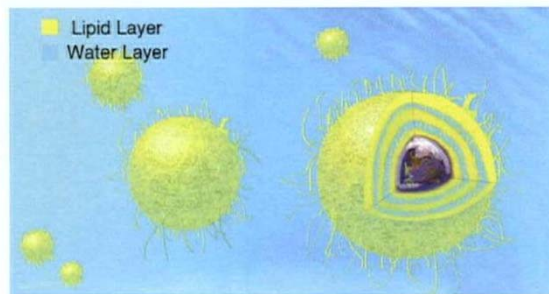


Figure 15—Illustration of the method of encapsulation for antideposition treatment of oil droplets. The lecithin bilayers form around the oil droplet and anchor the cellulosic polymer in the d-spacing of the bilayers. (Note: illustration not to scale)



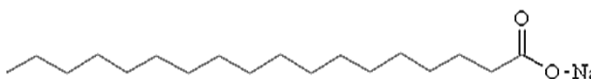
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Lisa Kemp, University of Mississippi

Commonly Used Surfactants

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Commonly Used Surfactants



Sodium Stearate

- Soaps
- Detergents
- Household Cleaners
- Foaming Agents
(sodium lauryl sulfate in toothpaste and shampoo)

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Soap – 1st Widely used Surfactant

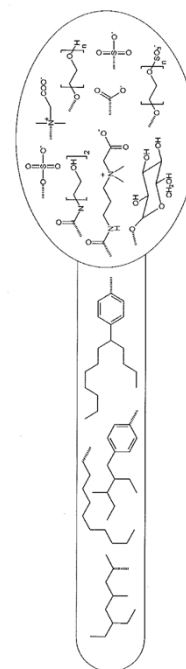
ABS – Alkylbenzene sulfonates used in laundry products*

- left calcium and magnesium salt precipitates
 - foaming in sewage water, treated sewage and river water
 - led to ban in Germany and voluntary bans in the U.S.

LAS – Linear alkylbenzene sulfonates

- introduced in 1960s
 - improved biodegradability
 - less foaming

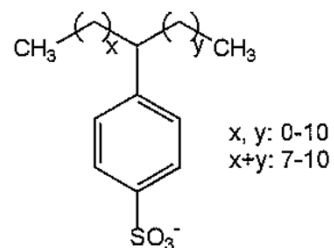
▶ - levels of surfactants in ocean



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 Thomas P. Knepper and Peter Eichhorn

Classes of Surfactants

- ▶ Anionic
- ▶ Cationic
- ▶ Non-ionic

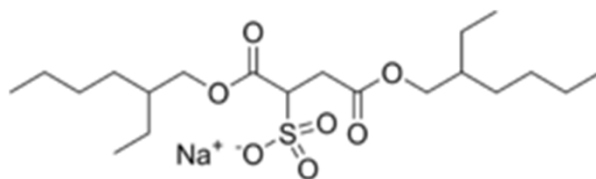


General Structure of LAS
 (linear alkylbenzene sulfonate)

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Knepper & Eichhorn, 2006

Diocetyl Sodium Sulfosuccinate



Anionic Surfactant

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Biodegradation of Surfactants

Primary Biodegradation

- minor alterations in chemical structure of surfactant molecule
- may result in loss of surface-active properties, lowering toxicity

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Knepper & Eichhorn, 2006

Testing for Surfactants

- ▶ Anionic Surfactants are methylene blue-active substances (MBAS)
- ▶ Non-ionic surfactants are bismuth iodide-active substances (BiAS)

Additional testing required to determine the fate of surfactant molecules after primary degradation

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Biodegradation of Surfactants

Organization of Economic Co-Operation and Development (OECD)

- developed International Standard Methodologies for testing the biodegradability of surfactants
 - **Ready Biodegradability** – real environmental conditions (60% CO₂ formation or 70% DOC removal within 28 days)
*likely to be degraded
 - **Inherent Biodegradability** – ideal conditions
*potential to be degraded
 - **Simulation Biodegradability** – WWTP conditions

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What happens to Surfactants from household and industrial use?

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The majority reach Wastewater Treatment Plants where they are effectively eliminated.

Some persistent compounds and their metabolites are found in raw water that is treated for drinking water.

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Additional Research is needed to better understand the fate of these compounds and their metabolites.

Thank you

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