The Science and Technology of Dispersants

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Surfactants are amphiphilic molecules containing a hydrophobic head group and a hydrophilic tail.

Lipids are biological surfactants

The packing parameter $p = \frac{v}{a_l}$ is a guide to the prediction of assembly.
The Deepwater Horizon Incident

April 20, 2010 – Sept 19, 2010

4.9 millions barrels of oil

1.84 million gallons of dispersants used

0.77 million gallons dispersant released at the wellhead

Methods of Oil Containment and Oil Removal

- Booms, berms
- Controlled burns
- Skimmers

All figures from Wikipedia
Methods of Applying Dispersants

Boat based spraying

Aerial spraying

Deep Sea Injection

All figures from the internet
The use of dispersants is an important oil spill response strategy.

Dispersant Application

Oil droplets dispersed in water column

Droplet formation and entrainment

Image courtesy Exxon Mobil

Dispersant is a mixture of surfactants and solvents.

Surfactant molecule

Hydrophilic group

Hydrophobic group

oil on water.wmv
**Surface/Interfacial Tension**

\[dW = \gamma \, dA\]

Surface Tension (liquid-gas interface)
Interfacial Tension (interface between two immiscible liquids)

Surfactants reduce the surface/interfacial tension

All figures from the internet
The creation of droplets of oil increases the interfacial area – how is this done with natural turbulence?

The use of dispersants is an important oil spill response strategy.

\[ dW = \gamma \, dA \]

Dispersant is a mixture of surfactants and solvents.

Dispersant Application

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Surfactant molecule

Hydrophilic group

Hydrophobic group
Spinning Drop Interfacial Tensiometer

\[ \gamma = \frac{\Delta \rho \omega^2}{4} R^3 \]

\( \gamma = \) Interfacial tension
\( \Delta \rho = \) difference in densities
\( \omega = \) angular velocity
Role of COREXIT 9500 in Modulating Oil-Water Interfacial Tension

![Graph showing the interfacial tension (IFT) over volume ratio of COREXIT 9500 to crude oil (DOR). The graph compares COREXIT 9500 mixed with water and COREXIT 9500 mixed with oil. The interfacial tension decreases as the volume ratio increases.]
# COREXIT 9500

COMMERCIAL DISPERSANT USED EXTENSIVELY FOR OIL SPILL REMEDIATION
(Corexit 9500 ingredients from Nalco website)

<table>
<thead>
<tr>
<th>INGREDIENT</th>
<th>PROPERTIES</th>
<th>CHEMICAL STRUCTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPAN 80</td>
<td>NON IONIC, OIL SOLUBLE, HLB=4.3</td>
<td><img src="image" alt="Structure" /></td>
</tr>
<tr>
<td>TWEEN 85</td>
<td>NON IONIC, WATER SOLUBLE, HLB=11.0</td>
<td><img src="image" alt="Structure" /></td>
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<tr>
<td>TWEEN 80</td>
<td>NON IONIC, WATER SOLUBLE, HLB=15.0</td>
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<tr>
<td>DIOCTYL SODIUM SULFOSUCCINATE</td>
<td>ANIONIC, OIL SOLUBLE</td>
<td><img src="image" alt="Structure" /></td>
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<tr>
<td>PROPYLENE GLYCOL</td>
<td>AMPHIPHATIC SOLVENT</td>
<td><img src="image" alt="Structure" /></td>
</tr>
<tr>
<td>HYDROCARBON DISTILLATE</td>
<td>HYDROPHOBIC SOLVENT</td>
<td><img src="image" alt="Structure" /></td>
</tr>
</tbody>
</table>
Release Site May 9: Prior to Injection

Courtesy of Ocean Imaging
Winds @ 0850 40° / 16 knots
Avg winds 64° / 16 knots

Wind direction

05/09/2010 8:52am CST
Copyright 2010 Ocean Imaging Corp.

All images from the internet
Release Site May 10: 3 hrs of Injection

Wind direction

Courtesy of Ocean Imaging
Winds @ 0850 40° / 12 knots
Avg winds 91° / 10 knots

All images from the internet
Release Site May 10: 11 hrs of Injection

05/10/2010 - 5:05pm

@ 11 hrs. after start of subsurface dispersant release

Copyright 2010 Ocean Imaging Corp.

All images from the internet
Release Site May 11: 5 hrs after Injection Ended

05/11/2010 - 9:10am CST
Subsurface dispersant release ended 4am
Copyright 2010 Ocean Imaging Corp.

Winds @ 1700 140° / 8 knots
Avg winds 134° / 10 knots

All images from the internet
Release Site May 12: 28 hrs After Injection Ended

05/12/2010 - 8:35am CST

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All images from the internet
Surface Tension Gradient Driven Flows – Marangoni Flows and Chemical Herding

http://iopscience.iop.org/1751-8121/43/24/242001/fulltext/

Using surfactants to thicken surface oil slicks “chemical herding”

http://www.crrel.usace.army.mil/innovations/oil_spill_research/mitigation.html
Continuing research in dispersants

• Improvements in dispersant science (a) minimization of solvents (b) targeted delivery (c) dispersant applicability to deep sea operations, operations in the Arctic, etc.
• New concepts in dispersant science. The use of new materials that act synergistically with existing dispersants. Polymers, buoyant gels, particles, plant based surfactants. Smart delivery of dispersants.
• Understanding dispersants at the molecular level.
• New tools to characterize dispersants and their behavior.
• Scale up from laboratory to field tests.
• It is important to understand dispersants and their effects at concentration (dosage) levels relevant to actual conditions.