SpillPrevention.org

FATE OF **OIL AND WEATHERING**

Things You **Should Know**

After oil is spilled in the environment, it immediately begins to undergo a wide variety of physical, chemical, and biological processes that begin to transform the oil.

Oil weathering can have a significant impact on the properties of a slick and affect dispersant performance.

Oil in the water column will appear anywhere from milky-white to red-brown to orange after being treated with dispersant.

If some dispersant lands near a slick in open water, it rapidly dilutes below acute toxic thresholds and begins to biodegrade.

Overview

Dispersants are products used in oil spill response to enhance natural microbial degradation, a naturally occurring process where microorganisms remove oil from the environment. All environments contain naturally occurring microbes that feed on and break down crude oil. Dispersants aid the microbial degradation by forming tiny oil droplets, typically less than the size of a period on this page (<100 microns), making them more available for microbial degradation. Wind, current, wave action, or other forms of turbulence help both this process and the rapid dilution of the dispersed oil. The increased surface area of these very small oil droplets in relation to their volume makes the oil much easier for the petroleum-degrading microorganisms to consume (See **Fact Sheet #1 — Introduction to Dispersants**).

Dispersants can be used under a wide variety of conditions since they are generally not subject to the same operational and sea state limitations as the other two main response tools — mechanical recovery and burning in place (also known as in-situ burning). While mechanical recovery may be the best option for small, near-shore spills, which are by far the majority, it has only recovered a small fraction of large offshore spills in the past and requires calm sea state conditions that are not needed for dispersant application. When used appropriately, dispersants have low environmental and human health risk and contain ingredients that are used safely in a variety of consumer products, such as skin creams, cosmetics, and mouthwash (Fingas et al., 1991; 1995).

This fact sheet summarizes the primary weathering processes that affect and change the oil as it remains in the environment. A good working knowledge of the likely behavior of the oil as it weathers is required to accurately predict and address the changing spill response needs over time. Monitoring weathered oil properties during a spill response is key to ensure that dispersants are used most effectively, especially as their usefulness may decrease after the first few days following a spill.

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Introduction

What Happens to Sprayed Dispersants?

When dispersants are applied to a slick they mix with the oil, where they will remain and biodegrade along with the resulting dispersed oil droplets. During aerial application, aircraft typically fly at an altitude of approximately 75 feet (25 meters) above the sea surface. At this altitude the sprayed dispersant droplet sizes ensure that most will encounter the targeted oil slick. In the case where some of the dispersant may miss the slick and land in open water, the dispersant ingredients rapidly dilute and are biodegraded by microscopic organisms already present in the water column (Davies et al., 2001). This colonization process begins as soon as the dispersant enters the marine environment, but it may take a few days for rapid biodegradation to commence. Using vessels for dispersant application can result in even more effective slick targeting, but vessel application is unable to match the size of the treated area made possible by the use of aircraft (See **Fact Sheet #1 — Introduction to Dispersants** for more information).

Oil and Dispersant Appearance

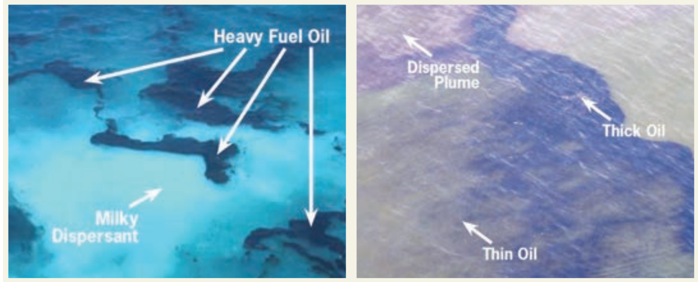
Before dispersants are applied, an oil slick may display different colors depending on oil type, thickness, weather conditions, and other factors. It may display a rainbow-like appearance, have a metallic look, or appear as a dark brown or black slick on the water surface depending on its thickness (**Table 1**) (NOAA, 2007a).

TABLE 1. Oil color, appearance and approximate thickness. Developed from NOAA, 2007a.

Description of Appearance	Approx. Thickness (μm)
Sheen	0.04 to 0.30
Rainbow	0.30 to 5.0
Metallic	5.0 to 50.0
Discontinuous true oil color (heavy oil)	50 to 200
Continuous true oil color (heavy oil)	>200

When dispersants are initially sprayed, they may exhibit a white, milky color. If they miss the oil during application or do not mix with the oil, they may form a milky cloud beneath the surface (**Figure 1 [*Left*]**). When applied appropriately to surface oil, the dispersed oil will generally form a cloud that is typically brown to a milky brown color. It is often described as having the appearance of café au lait (**Figure 1 [*Right*]**).

FIGURE 1. *Left:* example of initial dispersant application with the milky-white color that indicates that the dispersant did not mix with the oil; *Right:* example of an effective dispersant application with a café au lait dispersion. From: NOAA, 2007b.



Different Oil Types and Dispersants

Petroleum oils come in many different compositions and the type of oil being treated can influence the effectiveness of the dispersant.

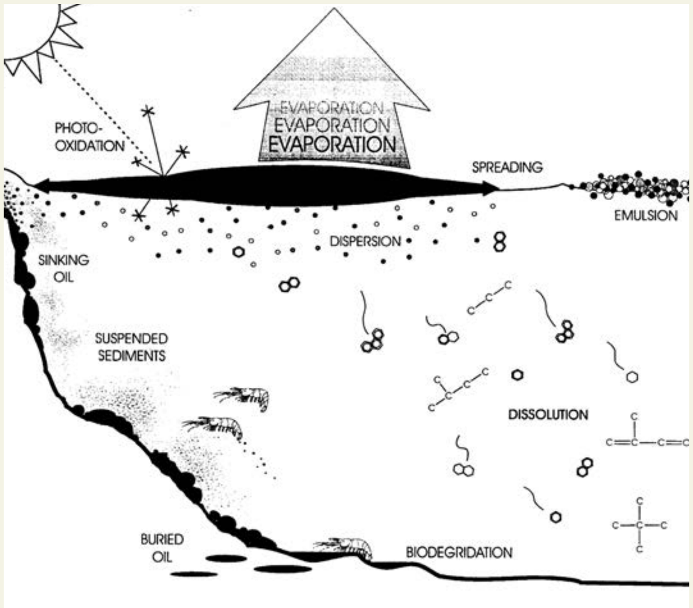
Oils are not made up of just one type of molecule, but are made up of a wide range of components. This results in a variety oil classes — from light refined products like gasoline to heavier materials that are more like asphalt (Etkin, 2003). The very light oils tend to evaporate on their own, leaving little residue, while the very heavy oils do not evaporate nearly as much and may be less likely to disperse completely. For those products in between very light and very heavy oils, the use of dispersants may be the best response option.

Oil Weathering and Dispersants

The “weathering” process refers to the changes that occur to oil as it spends time in the environment. After oil is released, it undergoes a wide variety of physical, chemical, and biological processes that begin to transform the oil almost immediately. This process is affected by the spill location, surrounding air and water temperatures, wave activity, wind, and other factors, such as the presence of particulates or sediment in the water. Each weathering process has the potential to influence the effectiveness of a dispersant application (ITOPF online, 2012). **Figure 2** summarizes the major weathering processes and a brief summary of the five dominant processes and how they affect dispersant applications is provided below.

Spreading: The movement of oil on the water’s surface. For example, if a small amount of oil is poured into a pool of water, a circle of oil, that gets thinner and thinner, will grow over time due to spreading. When oil spreads it creates a larger surface area presented to both the air and the water underneath. This serves to increase the effectiveness when dispersants are

FIGURE 2. Summary of the major oil weathering processes for oil spilled into the environment (API, 1999).



applied, since the thinner, larger area is more rapidly diluted into the water. However, because this process enlarges the surface slick, more area needs to be covered during dispersant operations and more equipment may be needed for an effective response.

Evaporation: The preferential loss of the lighter weight, volatile organic components of the oil into the atmosphere. This process may increase the density and viscosity of the oil, and in some cases, make it more difficult to disperse.

Emulsification: The incorporation of water in the oil, ultimately leading to thickening and an increase in the total volume remaining. At the same time, emulsification can reduce the other natural weathering processes. Different emulsions react differently with dispersants and some recent experiments have shown that it is possible to disperse a wide range of emulsified oil (SINTEF, 2010-2011).

Natural Dispersion: Occurs when wave action causes a surface slick to break into oil drops which mix and spread within the water column. These naturally dispersed droplets are larger than those observed when dispersants are used and they may float back to the surface where they recombine to form another slick. Some natural dispersion occurs with all oils, especially light oils. In rough seas, light oils may even be completely dispersed by this process.

When a dispersant is applied to surface oil, it facilitates the formation of much smaller droplets that do not rise back to the surface very quickly. Instead, they have the time to dilute in the water column rather than recombining to form a new slick.

Sedimentation: The association of oil with heavier solids suspended in the water column, generally close to shore. Over time, these suspended solids may settle on the sea floor to form sediments. If dispersants are applied before sedimentation has the potential to occur, they can serve to prevent this process by dispersing the oil offshore, thereby preventing it from coming into shallow shoreline areas, where it may encounter abundant sediment. The dispersed oil droplets remain buoyant and do not sink.

Biodegradation: The process where naturally occurring bacteria and fungi consume hydrocarbons to use as an energy source. These bacteria are common and are present in waters around the world (Arctic/Antarctic to the equator). The process of dispersing the oil into the water column to enhance natural biodegradation is the ultimate goal of dispersant use. Research has shown that the petroleum-degrading microbes in the water column more rapidly colonize dispersed oil droplets than oil droplets without dispersant (Venosa and Holder, 2007; Davies et al., 2001; Varadaraj et al., 1995).

Why It Matters

When an oil spill occurs, the decision-makers involved with response efforts conduct a rapid Net Environmental Benefit Analysis (NEBA) when considering the various options available to them. A prompt decision-making process is important since oil changes properties as it weathers and the efficiency of dispersants may decrease with time. This leads to a distinct window of opportunity and prompt decision-making is key. The NEBA approach analyzes the potential trade-offs of the various response options to determine ways to minimize any impact to resources or the environment. The decision to use dispersants involves evaluating the risk from oil on the water's surface to that of its presence in the water column. The goal is to choose the approach that offers the best outcome, taking all the environmental factors into consideration. For more information on the NEBA process refer to **Fact Sheet #6 — Assessing Dispersant Use Trade-offs**.

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