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DISPERSANTS AND THEIR ROLE IN OIL SPILL RESPONSE

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A summary of the IPIECA report

Dispersants are one option for reducing damage from oil spills. By breaking up slicks, they can lessen effects from oil coating and smothering, reducing biological damage. However, dispersants are not a panacea. This report considers when they should be used, and when they should not, and how the dispersant option relates to contingency planning.

Dispersants and how they work

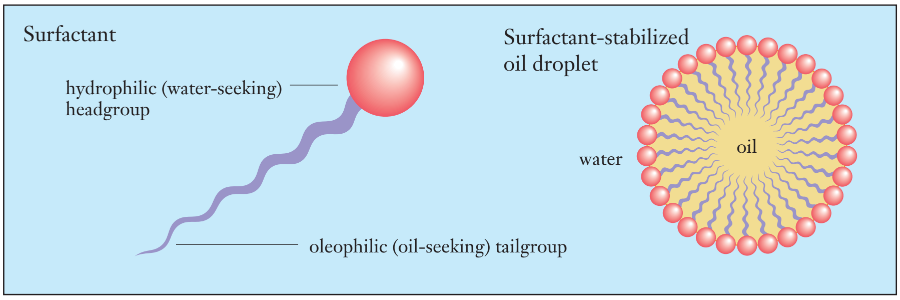
It is common knowledge that oil and water do not mix easily. Spilled oil floats on the sea surface in calm conditions. The mixing action of the waves can cause oil and water to combine in two ways:

Natural dispersion
Waves break up the oil slick, forming oil droplets that become suspended in the water. The majority of these oil droplets will float back to the surface; but a small proportion of tiny droplets with neutral buoyancy will remain dispersed in the water almost indefinitely.

Water-in-oil emulsification
The mixing action of waves can cause water droplets to be incorporated into the oil, forming a water-in-oil emulsion which has a much higher viscosity than the oil from which it is formed. This emulsion is often referred to as 'chocolate mousse' and can increase in volume by up to four times that of the spilled oil.

Dispersants alter the balance between natural dispersion and emulsification, pushing the balance strongly towards dispersion and away from emulsification. By applying dispersant onto the spilled oil, it is possible to inhibit emulsion formation while promoting oil dispersion.

Dispersants — the active ingredients
Dispersants promote the formation of numerous tiny oil droplets, and delay the reformation of slicks because they contain surfactants with hydrophilic heads which associate with water molecules, and oleophilic tails which associate with oil (see diagram). Oil droplets are thus surrounded by surfactant molecules and stabilized. This helps promote rapid dilution by water movements.



Surfactants consist of two parts; a water-seeking hydrophilic headgroup and an oil-seeking oleophilic tailgroup. This allows them to stabilize oil droplets.

The formation of droplets increases the exposure of oil to bacteria and oxygen, favouring biodegradation. However, the distribution of oil into the water column is increased. How to weigh up these advantages and disadvantages is one of the main subjects of this report.

Advantages and disadvantages of dispersants

Dispersion of floating oil into the water column provides a number of advantages, including:

- reducing risk of contamination of marine habitats and wildlife;
- assisting with biodegradation of the oil by increasing exposure to naturally-occurring bacteria and oxygen;
- reducing the amount of surface oil susceptible to drifting with the wind;
- rapid treatment of large areas through application of dispersant from aircraft compared to alternative response methods;
- dispersed oil droplets can become associated with suspended sediment, producing a neutrally buoyant 'aggregate' which is distributed naturally over large areas at very low concentrations.

The main potential disadvantage of dispersion of oil is the localized and temporary increase in oil in water concentration which could effect marine life in the immediate vicinity of the spill.

Subsequent sections of this report consider the importance of weighing up the advantages and disadvantages of dispersant application.

Types of dispersants available

This section of the report looks at the types, effectiveness and means of application of dispersants developed over the years.

Low toxicity dispersants, known as 'Type 1 dispersants' (UK classification) were developed at the beginning of the 1970s. Still available today, they are of relatively low effectiveness and need to be used at very high treatment rates.

More efficient dispersants were produced using a higher surfactant content. The higher viscosity of these dispersants made them difficult to apply using certain existing spraying mechanisms, but this was later overcome by substituting some of the solvent with seawater. Such water-dilutable dispersants became known as 'Type 2' (UK classification) dispersants.

Higher performance dispersants using blends of different surfactant types were developed in 1972 and improvements in formulations continued into the 1990s. Most modern dispersants can be sprayed from aircraft, and from boats and ships.

What dispersants can and cannot do

Dispersants function by enhancing the rate of natural dispersion caused by wave action. The results of field and laboratory tests are described. A table summarizes case histories of effective dispersant use.

When appropriate, and under most circumstances, dispersants can remove more oil than physical methods. However, dispersants do not always work well: dispersant spraying was ineffective on heavy fuel oil spilled from the Vista Bella (Caribbean, 1991).

Properties of spilled oil which affect dispersant effectiveness (e.g. viscosity, wax content, pour point, sea temperature) are discussed. The need to recognize the different types of dispersants and their characteristics is emphasized.

The potential for natural dispersion of light crude oil was spectacularly demonstrated when the Braer *grounded in severe weather on the Shetland Isles, Scotland, in January 1993, losing its entire 85,000-tonne cargo. Some 120 tonnes of dispersant was applied from aircraft, mainly to treat slicks that formed close to the wreck during periods of slightly calmer weather.*

Effectiveness and toxicity testing

Dispersant effectiveness is usually judged visually, although it is difficult to assess concentrations of dispersed oil in the water column through visual analysis alone. Laboratory analysis of water samples indicates that oil levels following dispersion are not high. UVF techniques have been used over the past ten years to confirm that dispersants are having a positive effect.

Laboratory procedures for testing toxicity are also useful but cannot be used to predict environmental effects. Studies have shown that toxicity concerns should be focused on the potential environmental effects of chemically-dispersed oil rather than on dispersants themselves.

To spray or not to spray

Weighing up the advantages and disadvantages of dispersant spraying is of primary importance in the decision-making process. The evidence from spill case histories and experiments is summarized.

Dispersed oil in the water column

Information on concentrations of oil below dispersant-treated slicks comes mainly from field experiments in open water. Measured oil concentrations range from <1 to >60 ppm. How damaging are such exposures to marine life? Information from the US National Research Council, and the Searsport, TROPICS and BIOS experiments is summarized. A case history is included on the Searsport experiment.

Field experiments on chemically dispersed and untreated oil

There is little comparative information for birds and mammals. Direct fouling of birds and fur-insulated mammals is disastrous for them, and it is assumed that dispersion of surface slicks must be beneficial because it reduces the risk of such fouling. However, use of dispersants as 'shampoos' increases the wettability of fur and feathers, which can lead to death by hypothermia. Spraying should be kept as far as possible from birds and mammals.

Economic considerations

Economic factors are important in deciding whether or not to spray dispersants — for example, beaches and marinas may need to be protected by dispersants but industries using saltwater intakes may be adversely affected by dispersants. Economic and biological considerations may coincide; for example, a mangrove swamp may be important both ecologically and economically and so require priority protection.

Dispersants and contingency planning

The 'window of opportunity' for dispersant spraying generally lasts for only two to three days, so it is essential that the dispersant option has pre-approval under certain conditions depending on water depths, currents, wave characteristics and mixing energy, and distance from sensitive resources. Named products have to be approved and stocked. There are also logistical requirements, such as approval in principle for aircraft to operate in certain areas. Details are provided on the pre-approval process.

The pre-approval process involves:

- definition of oil types, scenarios and geographical locations where dispersants are a viable option from the logistical point of view;
- net environmental benefit analysis, i.e. consideration of the advantages and disadvantages of dispersant use compared with those of other response options;
- on the basis of the above, identification of locations and situations where dispersant use can or cannot be pre-approved—any restrictions should be indicated on sensitivity maps.

The dispersant option is then discussed in relation to a number of hypothetical scenarios:

- the open sea, slick moving rapidly towards a fishing ground and islands with important bird colonies;
- a large river;
- nearshore, slick moving through area of shallow water with coral reefs, towards a mangrove area;
- nearshore, slick moving through area of shallow water with coral reefs, towards a sandy shore;
- nearshore, slick moving towards industrial water intakes or harbours;
- nearshore, slick moving through area of shallow water with sub-tidal shellfish, towards tourist resort; and
- rocky shore, with sub-tidal seafood resources (e.g. lobsters) near the shore.

Application options

Ideal spraying systems deliver dispersant uniformly to the slick in a way which maximizes dispersant-oil mixing and minimizes wind drift. The various dispersant application systems—boat based systems, aircraft based systems and helicopter based systems—are summarized.

Dispersant use on shorelines

The use of dispersants on shorelines requires careful consideration of the risks and benefits. The approaches to shoreline clean-up are discussed, and the report notes that specialized shoreline cleaning agents are now available which should be considered in preference to dispersants.

The publication makes a number of conclusions and includes a bibliography.

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Copies of the full report are available from the IPIECA Secretariat, telephone: +44 (0)20 7221 2026; e-mail: info@ipieca.org