Diamondoids
New Tools to Solve Environmental Oil Spill Mysteries

The Problem
Oil spills can kill fish, marine mammals and birds, and destroy plant life. Even small amounts can damage the ecological balance and cause long-term harm to aquatic ecosystems and wildlife.

Identifying the exact source of petroleum spills is hard to do – but essential for successful investigation and enforcement.

When a spill of oil or other contaminant occurs, difficult questions are asked. Who caused the contamination? How much did different parties contribute? What exactly is the contamination? How extensive is it? Have there been any attempts to cover it up? What levels of contamination have people been exposed to?

Although scientists have developed tools to help in environmental forensic investigations, spills of petroleum products are difficult to identify conclusively. Biomarkers, unique chemical compounds that can indicate biological involvement in the formation of petroleum, are abundant in crude oils and are one of the most important hydrocarbon groups used for chemical fingerprinting. Unfortunately, the most commonly-used biomarkers for this purpose are removed during the refining process.

 Seeking Solutions through S&T
Smaller biomarkers called diamondoids are concentrated in many crude oils and petroleum products, including refined products. Diamondoids are a group of three-dimensional chemical compounds with a diamond-like structure. In the past they were difficult to identify reliably, particularly in light to midrange distillates such as jet and diesel fuels. Weathering also changes the composition of the products over time, making it difficult to conduct effective analyses.

The Emergencies Science and Technology Division of the Environmental Science and Technology Centre (Ottawa) conducts research into potential technologies to address environmental problems, as mandated under the Canadian Environmental Protection Act (1999). Recently, scientists developed a new tool for characterizing and quantifying diamondoids. With this new analytical method using gas chromatography-mass spectroscopy (GC-MS), they studied the distribution of
diamondoids in over 100 oils and various refined products. They evaluated weathering effects on diamondoids, and developed and tested a number of source indicators.

In 2004, they successfully used this method for source identification in a spilled fuel incident. Partners from Sweden visiting the Environmental Science and Technology Centre brought three oil samples collected from a harbour spill in The Netherlands. Several labs had analyzed the samples but had been unable to determine the source of a thick layer of oil found between a bunker boat and a quay next to a bunker centre. Using the new technique, Environment Canada scientists were able to correlate the spill oil to the suspected source candidate, the bunker boat.

Diamondoid detection:
Diamondoids can neither be destroyed nor created, and as such are considered a naturally occurring internal standard by which oil can be identified.

The diamond-like structure of diamondoids gives these molecules high kinetic and thermodynamic stability, causing them to be increasingly concentrated and conserved in residual oil or condensate produced during petroleum refining processes.

In recent years, the petroleum industry has been increasing the use of diamondoids in petroleum exploration and refining. However, there have been few reports of the use of these compounds for forensic oil spill investigations. Until Environment Canada scientists developed new test methods, there were almost no quantitative data on concentrations and distribution of diamondoids in oil and refined products.

Transforming Knowledge into Action

Who can use these results?

With this new diagnostic tool, experts can pinpoint the exact sources of light oil and fuel spills and “fingerprint” the polluter. Environmental enforcement regulations can then be applied to those responsible – so the polluter pays.

Environment Canada uses environmental forensic tools to support relevant legislation. Bill C-15, which received Royal Assent in 2005, amended the Canadian Environmental Protection Act (1999), allowing for more effective enforcement against marine polluters under Canadian jurisdiction. The Act has clarified enforcement powers, increasing fines and enabling enforcement officers to take action to protect wildlife and marine waters.

Under Bill C-15, shipping companies and their ships’ officers will be held accountable for any illegal dumping of bilge oil in Canadian waters. Any vessel of more than 5,000 tonnes found guilty would face a minimum fine of $100,000 for a summary conviction and $500,000 for an indictable offence.
Benefits to Canadians

Canadian taxpayers benefit from a speedy resolution of legal proceedings in environmental pollution cases when polluters cannot falsely argue their innocence. Improved chemical fingerprinting techniques are valuable for prosecuting polluters and also for allocating clean-up costs to those responsible for the spill.

As well as economic benefits, Canadians enjoy a reduction in risks to health and the environment when the source and nature of contamination are found quickly and protective countermeasures are taken promptly.

For more information:

Environmental Science and Technology Centre’s Emergencies Science and Technology Division
www.etc-cte.ec.gc.ca/organization/estd/estd_summary_e.html

Emergencies Science and Technology Division’s Spills Technology Oil Properties Database
www.etc-cte.ec.gc.ca/databases/spills/oil_prop_e.html

Proclamation of Bill C-15
www.ec.gc.ca/press/2005/050625_b_e.htm


