UNITED STATES COAST GUARD ACADEMY

Science Lecture Series

Sunburnt oil: Quantifying the effect of photochemistry for future oil spills

Dr. Danielle Haas Freeman

Assistant Professor, Chemical & Environmental Sciences, USCGA

Oil spilled at sea is transformed by sunlight-driven photochemical reactions. The transformed oil has different properties and behavior in the environment compared to the fresh oil, resulting in different fates and effects. The goal of this work was to put numbers on these changes to better predict where oil will go and how it will behave in future spills. First, we focused on how sunlight generates water-soluble compounds from oil, which can lead to the dissolution of oil-derived compounds in seawater (photo-dissolution). To find out whether photo-dissolution could be an important fate process during an oil spill, we used a combination of experiments and photochemical rate modeling to calculate photo-dissolution rates for the 2010 Deepwater Horizon spill (DwH). We found that photo-dissolution likely converted ~8% of the floating surface oil to dissolved organic carbon during DwH, a fraction similar in magnitude to other well-recognized fate processes. Moving beyond DwH, we evaluated the sensitivity of oil photo-dissolution to temperature. We found that if a spill like DwH had occurred in 5° C water rather than the exceptionally warm 30° C water, 7x less oil could have dissolved via photo-dissolution. The net result is that more oil would stay at the sea surface in a cold-water spill. Finally, we determined photo-dissolution rates for diverse oil products beyond the light crude that spilled during DwH. We found that oil photo-reactivity could be predicted from oil chemical composition. We also found that photo-dissolution likely affects oil mass balance in spills of light oils forming thin slicks but not in spills of light or heavy oils forming thick slicks. Overall, this work advances our understanding of how oil changes in the environment upon sunlight exposure.

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2000 -2100

Dimick Auditorium, U.S. Coast Guard Academy

Danielle Haas Freeman is an environmental chemist with a focus on the chemistry of oil spilled in the ocean. She grew up in NYC and first learned about environmental chemistry through local waterfront programs that shared the history of PCBs in the Hudson River. She studied Chemistry at Bowdoin College and completed her PhD with Dr. Collin Ward at the Woods Hole Oceanographic Institution. Most recently, she worked with Dr. Penny Vlahos at UConn Avery Point and is now excited to the join the Chemical and Environmental Sciences Department at the USCGA.

If you have any questions regarding the event, please contact Dr. Kanani K. M. Lee (kanani.km.lee@uscga.edu) for more information.