Science MATTERS!
... IN CONNECTICUT

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NIE ACTIVITY

Economical and Eco-Friendly OIL SPILL RECOVERY

Autumn Kim, Senior, Greenwich High School

Annually, ~1.3 million gallons of crude oil spill into the ocean, leading to devastating economical, environmental, and health effects -- killing as many as 25,900 marine animals per year. Traditional methods of oil-spill cleanup are costly and harmful to the environment, typically focusing on the excess oil spilled into the ocean, leaving persistent, soluble nonvisible oil to continue to harm the environment.

Polyurethane, a cheap, recyclable material that is commonly disposed into landfills, has a high porosity and low density. Moreover, bentonite, a low cost (~100 per ton), is a natural absorbent of oil and because of graphite's hydrophobic interactions, attracts oil. Iron-oxide nanoparticles (Fe3O4) are versatile and are low cost (~$1-2/kg). And their biocompatibility and superparamagnetic nature help with oil maneuverability.

In my research, I took bentonite, Fe3O4, and graphite and embedded them into a polyurethane sponge to create an oil-in-water **remediation** tool that can remove and recover high levels (insoluble/visible) of oil contamination in water, as well as soluble, undetectable contaminants.

One of the first questions I encountered was how I could model oil contamination in water? Because of the high **quantum yield** of the hydrocarbons in oil, I was able to use **fluorescence** as a way to determine the sponge's oil remediation and recovery in different oil-spill conditions.

The Fe3O4/Bentonite/Graphite-Coated Polyurethane (FBG) sponge was made by first creating the Fe3O4 nanoparticles through a coprecipitation process. Once dried, the nanoparticles were combined with bentonite and graphite to form a slurry. Polyurethane cubes were soaked in the slurry for an hour and then dried for another hour.

To test the FBG sponge's capabilities in the heavy, visible, excess oil, I first placed the FBG sponge atop a simulated, contaminated solution of floating, insoluble oil. After 10 minutes, the soaked FBG-sponge was removed and squeezed for ~100% oil recovery (determined using the fluorescence) and successfully remediated insoluble oil from the water that can then be used for its original, intended use.

In the soluble oil experiment, I placed a second, new FBG-sponge into the now soluble (nonvisible) oil-in-water, and I placed samples on a shaker -- to mimic wave movement. Analyzing the fluorescence data over a few days, the solutions with a plain sponge and a non-coated polyurethane sponge, the FBG sponge significantly remediated more oil than the control and non-coated sponge and was able to recover soluble oil as well.

In conclusion, the FBG sponge can successfully remediate and recover both insoluble, excess oil and nonvisible, soluble oil in an economical and environmentally friendly way.

Meet the Scientist

As a kid, I was always interested in science, but it wasn't until my father was in the hospital that I fostered my love for medicine. The interdisciplinary field has helped families and patients in ways we never thought possible, with modern technology and advancements in scientific research. My love for STEM comes from individuals from different fields working together to help people around the world. In the future, I would like to be a pediatric surgeon that helps children with limited resources. In my free time, I am on the fencing team and tutor local elementary school students in STEM.

Autumn Kim is the Connecticut Science and Engineering Fair's Physical Science-Senior Division Winner. For this accomplishment she also was awarded by the Connecticut Academy of Science and Engineering a 2021 H. Joseph Gerber Medal of Excellence.

Skills & Kowledge

The interdisciplinary nature of this project allowed me to dive into chemistry, environmental science, and engineering. I needed to understand the chemical interactions between each of the ingredients and the oil to determine the best ratio for the slurry. Moreover, understanding the interaction of light and the electrons that make fluorescence work was vital for the measurements throughout my experiment.

Words To Know

Remediation: the removal of a toxic compound from water or soil, or the containment of a spill so that the area that is contaminated does not increase. Spill remediation refers to the response to an environmental spill that occurs in freshwater and marine water, and on land.

Quantum Yield: the efficiency of converting absorbed light into emitted light, which can be in the form of fluorescence.

Fluorescence: emission of electromagnetic radiation, usually visible light, caused by excitation of atoms in a material

hyperlinks

https://oceanservice.noaa.gov/facts/oilimpacts.html

https://ocean.si.edu/conservation/gulf-oil-spill/gulf-mexico-oil-spill-interactive

For Students and Teachers Making Curriculum Connections, see the following:

Connecticut State Department of Education (CSDE) - Common Core State Standards (CCSS): Mathematics

- CCSS.Math.Practice.MP1 Make sense of problems and persevere in solving them
- CCSS.Math.Practice.MP3 Construct viable arguments and critique the reasoning of others
- CCSS.Math.Practice.MP5 Use appropriate tools strategically

CSDE - Next Generation Science Standards: Scientific and Engineering Practices

- Asking questions and defining problems; developing and using models; planning and carrying out investigations; analyzing and interpreting data; using Mathematics and computational thinking; constructing explanations and designing solutions; engaging in argument from evidence; and obtaining, evaluating, and communicating information.

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