Novel Automated Oil Spill Capture and Recovery with Aerogels

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Introduction

The heavy reliance on oil for manufacturing, transportation and electricity generation among other reasons is spread worldwide and has created an expansive oil industry. With this emphasized need for a constant oil supply and a third of this oil coming from underwater reservoirs, the extraction, storage, and distribution of the oil has caused numerous oil spill events and leaks (Ivshina et.al, 2015). While major oil spill events, such as the Deepwater Horizon oil spill, have allowed for advances in dispersant and bioremediation technologies, there is a general lack of innovation for oil spill management methods from past to more recent events. Many methods focus on introducing chemicals to the marine environment or using absorbent materials that collect both the oil and water, reducing the efficiency of capturing all the spilled oil.

The goal for this research was to expand on the existing methods and utilize a material called aerogel, which is known for its extremely low densities due to the high porosity of the material. In terms of trying to increase the efficiency of collecting oil, the two aerogels, Thermal Wrap and Spaceloft, were chosen due to their hydrophobic qualities. The purpose of choosing these aerogels was to provide an alternative material that is able to collect only the oil spilled, reducing the number of resources and time spent cleaning up oil spills from marine environments. The other focus of this research was to go one step further and try to recover the oil collected in hopes of reusing it. An oil recovery device utilizing a roller was created and used with the aerogel to determine the effectiveness and future alterations needed to make this a viable clean up method.

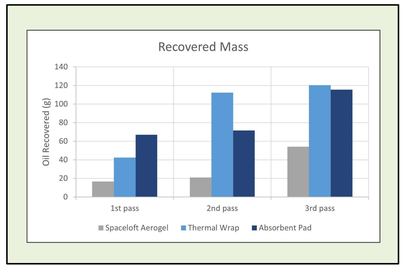
Methods and Materials

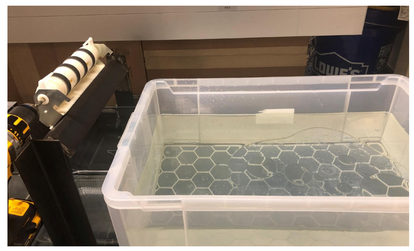
- The oil recovery device was constructed by welding steel pieces and attaching the roller to the top portion at an angle, to allow the oil to drip into the container.
- A storage container was prepared with water and canola oil and set up next to the oil recovery device. A smaller container was setup to hold the aerogel after passing through the device. A tray was placed underneath the recovery device to collect the extracted oil.
- A piece of the Spaceloft Aerogel, measuring 63.6 cm long by 17.8 cm wide, was weighed for the initial weight and then laid on the surface of the oil and water within the storage container. The aerogel was left to absorb the oil for 2 minutes.
- After the 2 minutes, the aerogel was passed through the recovery device and deposited into the smaller container, that was then weighed to find the mass of the aerogel and oil absorbed. The mass of the tray with the extracted oil was measured and recorded as the mass of oil recovered.
- This process was repeated two more times, with the number of passes through the roller device increasing to 3 and then 5 passes. These are referred as the first, second and third pass, respectively.
- These steps were repeated for the Thermal Wrap Aerogel and absorbent pad.

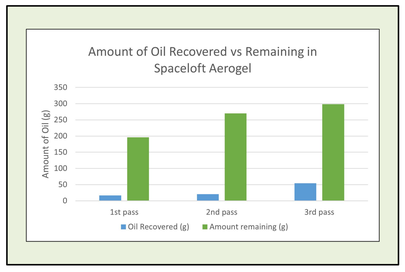
Abstract

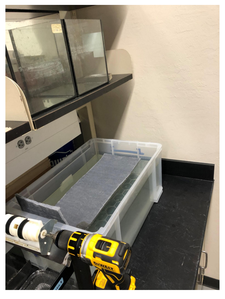
The heavy reliance on oil for manufacturing, transportation and electricity generation among other reasons is spread worldwide and has created an expansive oil industry. As a result, there has been numerous oil spill events across Earth's oceans that have resulted in detrimental effects to the environment and human health. While some of these oil spills have allowed for advancements in dispersant and bioremediation technologies, there is a general lack of innovation for oil spill management methods from past to more recent events. Therefore, the focus of this project was to include new technology, a material known as Aerogel, which exhibits hydrophobic qualities allowing it to effectively collect oil spilled in water. The aerogel could then be passed through an oil recovery device that was built to extract the oil collected in hopes of reusing the oil. This device was designed as a roller system that the Aerogel could be passed through, thus pressing the collected oil from the Aerogel into a collection container. The purpose of the Aerogel was to use a material that would target only the oil spilled while avoiding the use of any additional chemicals to decrease the effects on the marine environments. Data was collected for the mass of oil recovered for the Thermal Wrap aerogel, Spaceloft aerogel, and the absorbent pad to determine the efficiency of oil absorption and extraction. The results indicate alterations need to be made to the process of collecting the oil with the aerogel and to the device to increase the amount of oil recovered.

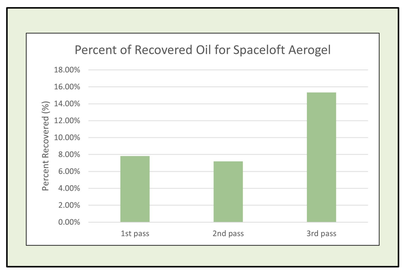
Results

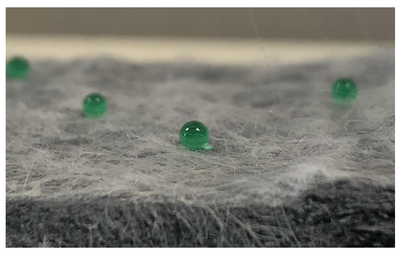












Discussion

- Based on the results of the oil extraction using the oil recovery device, the Thermal Wrap aerogel allowed for a greater mass of oil to be extracted whereas the Spaceloft aerogel retained between 85% and 95% of the oil after passing through the oil recovery device, resulting in a low extraction efficiency.
- In terms of the durability of the aerogels passing through the oil recovery device, the Spaceloft aerogel experienced a lot of wear from passing through the roller, including fraying on the edges and tearing on the surface. The Thermal Wrap aerogel did show noticeable signs of wear from passing through the device.
- For future consideration in terms of the design of the recovery device, the roller used to extract the oil should have a unform surface all the way around. The roller used for this device had sections of flat surfaces that were able to apply pressure to effectively extract more oil. However, the other sections were slightly raised and therefore, were not able to effectively squeeze the aerogel.
- To increase the amount of recovered oil from the aerogels, future alterations should be made to the amount of pressure applied by the roller to the material.
- For the results shown, the aerogels were placed on the surface of the water and oil for a total of two minutes, based on data collected for mass uptake for 4 cm by 3 cm aerogel pieces. For future replications, it is advisable that mass uptake data be collected for larger aerogel pieces, as the oil did not absorb completely throughout the entire piece within the two minutes.

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