Sustainable Amphiphilic Herders For Efficient Oil Spill Treatment

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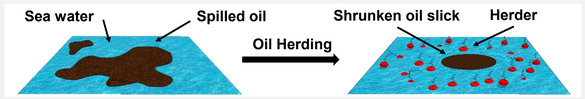
Motivation

Oil spills caused by damaged oil rigs, ruptured pipelines, and tankers can cause immediate and long-term detrimental effects on marine systems and aquatic life. Herein we further developed the an oil spill recovery technique called **oil herding**.

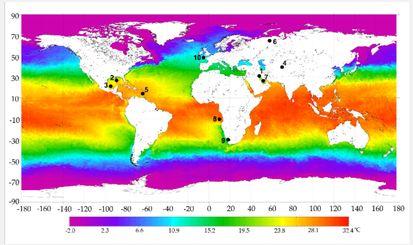
Oil herder is **an amphiphilic oil-collecting surfactant** which is applied to spray around the oil spill areas and is able to retract oil slicks, transforming them from **a large thin layer to a small thick bulk**. This herding treatment greatly simplifies further in-situ burning and the recycle process.

The natural konjac glucomannan (KGM) material could be functionalized and examined here as an oil herder, which has the great advantage of nontoxicity, biocompatibility, and adaptability. Moreover, functionalized KGM is a non-ionic surfactant with no obvious **Krafft temperature**. The absence of Krafft temperature gives KGM surfactants the unique ability to retain surfactant ability at temperatures nearing 0 ° C. It offers a new direction for efficient oil herders within a wide range of water temperatures in the offshore safety control, especially for oil spills treatment in Arctic area.



Oil Spill Challenge

World Map of 10 Largest Oil Spills in History and Sea Surface Temperature

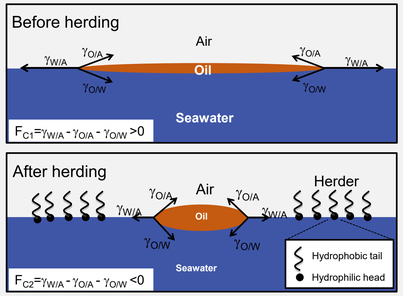


large-scale oil spills resulted in huge socio-economic impacts and attracted negative media and public attention.

Besides of larger oil spills, more than half of the oil spills incidents are smaller in magnitude and are commonly existing, which often evade attention and more difficult to clean up.

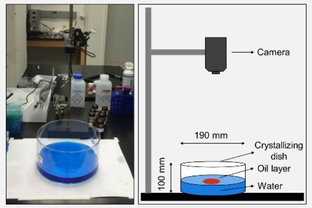
Global Oil Spill Ranking	Date	Cause	Location	Source	Spill volume (million gallons)
1	1991.01.23	Gulf War	Persian Gulf	Oil rig	400
2	2010.04.20	Rig explosion	Gulf of Mexico	Deepwater Horizon oil rig	210
3	1979.06.03	Well blowout	Gulf of Mexico	Ixtoc 1 Oil Well	140
4	1992.03.02	Well blowout	Fergana Valley, Uzbekistan	Oil well	88
5	1979.07.19	Tanker collision	Trinidad & Tobago	Atlantic Aegean Captain Oil Tanker	87
6	1994.09.08	Dam burst	Kharyaga, Russia	Oil reservoir	84
7	1983.02.04	Collision	Persian Gulf, Iran	Nowruz Fields Platform	80
8	1991.05.28	Explosion	Angola Offshore	ABT oil tanker	79
9	1983.08.06	Fire on tanker	Cape Town, South Africa	Castillo de Bellver oil tanker	78
10	1978.03.16	Tanker sinking	Coast of Brittany, France	Amoco Cadiz oil tanker	69

Herding Mechanism

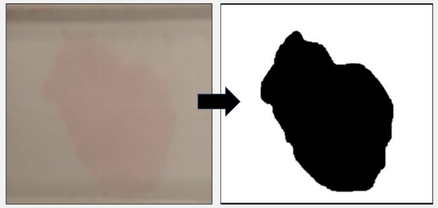


Before herding surfactant was applied, oil on water surface system experienced with three forces, the oil-water surface tension ($\gamma_{O/W}$), the oil-air surface tension ($\gamma_{O/A}$) and the air-water surface tension ($\gamma_{A/W}$). Water is a highly polar solvent and has high surface tension ($\gamma_{A/W}$ =72.5 mN/m). The $\gamma_{O/W}$ and $\gamma_{O/A}$ majorly depend on oil and water properties and the net sum value ($\gamma_{O/W}$ +$\gamma_{O/A}$) is around 25 mN/m. Higher $\gamma_{A/W}$ made the oil slick quickly spread outside from center until $\gamma_{A/W}$ and ($\gamma_{O/W}$ +$\gamma_{O/A}$) value are the same. At this moment, the oil slick became a very thin layer and reached the equilibrium state.

Experiment Analysis



Experimental setup for oil herding process

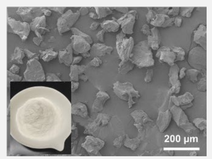


Oil area analysis and pixel conversion

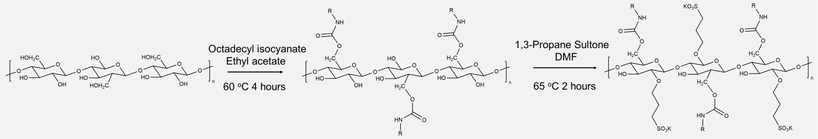
KGM Surfactant

Konjac Stem

Konjac Food

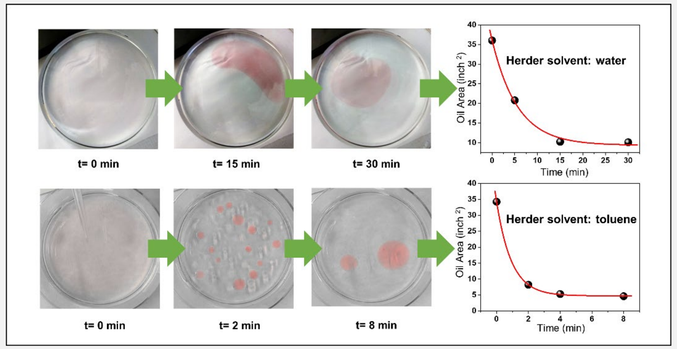


Konjac Powder (KGM) EM Image

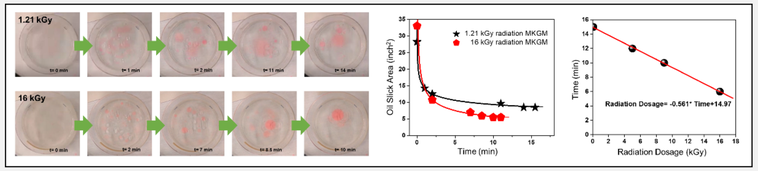


KGM Synthesis Route

KGM Herding

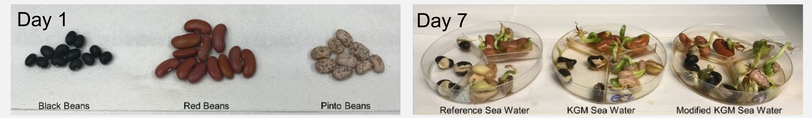


Oil herding of MKGM with various solvent in low temperature (1°C)



Oil herding of MKGM with various radiation dosage in low temperature water (1°C)

Biocompatible Test



Biocompatible sprouting test for MKGM herding surfactant

References

Huang, D., Sebastian, R., Zhang, L., Xu, H., Lei, S., Chen, M., ... & Cheng, Z. (2019). Biocompatible Herder for rapid oil spill treatment over a wide temperature range. *Journal of Loss Prevention in the Process Industries*, *62*, 103948.

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