

2021 Emerging Contaminants in the Environment Conference

OHM SPONGE

An Oil Spill Remediation Platform

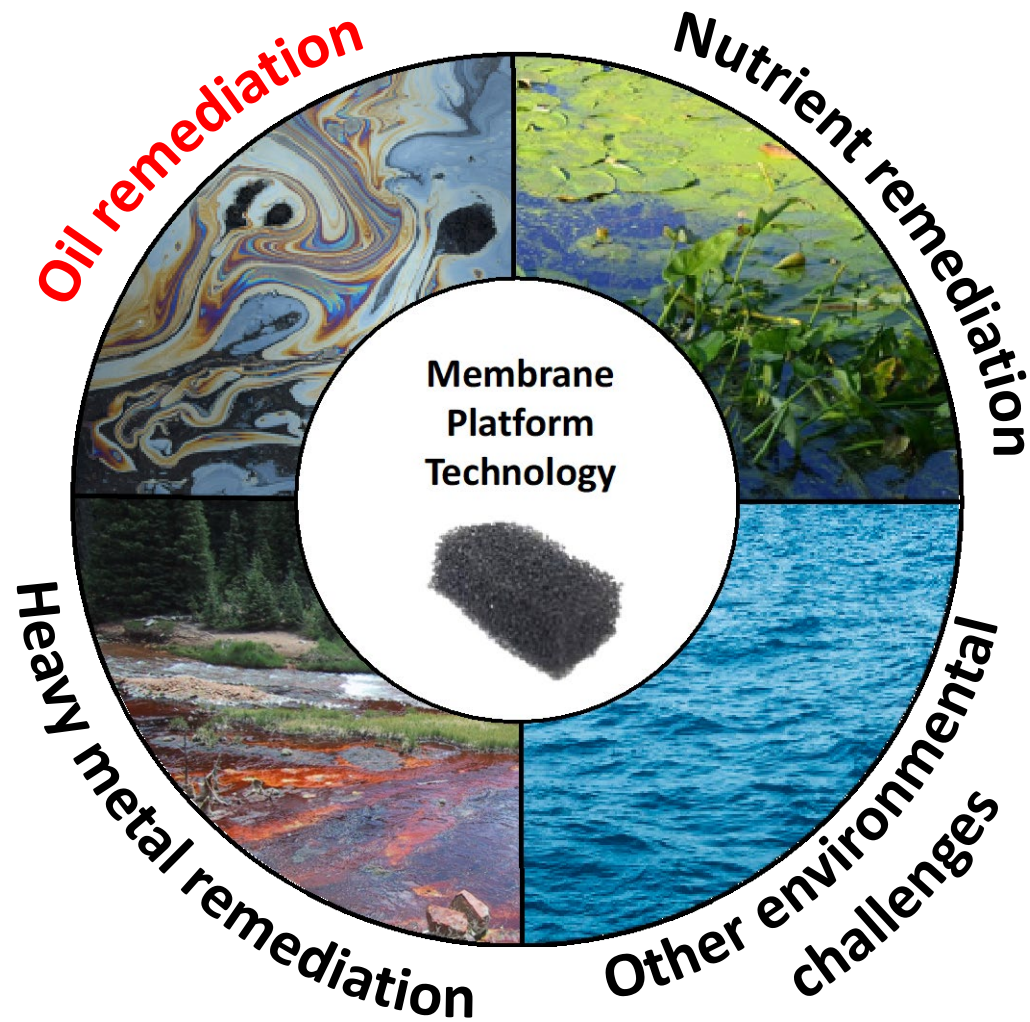
Dr. Vikas Nandwana

Prof. Vinayak Dravid

Northwestern University



Research Philosophy: *Nano-scale Approach to Giga-ton Problems*



*Prof. Vinayak Dravid,
Abraham Harris Professor*



*Dr. Vikas Nandwana,
Research Associate*



*Dr. Roberto dos Reis,
Scientific Officer*



*Stephanie Ribet,
PhD Student*



*Benjamin Shindel,
PhD Student*



*Jack Hegarty,
PhD Student*

- **Selective:** nanocomposite tailored to pollutant
- **Scalable:** synthesis uses earth abundant elements and water-based techniques
- **Reusable:** membrane is used for multiple cycles

Oil Spills and Their Effects



Human Health



Marine life



Aquatic Ecosystem



Fishing/Tourism industry

Sources: ITOPF, USCG, NOAA, CNN, National Geographic, Elpais, Microbewiki, Greenliving, Grand View Research



Current Methods – Oil Spill Response



Fast

Toxic for Marine Life



Fast

Carbon Emission

Needs for an Ideal Solution

- ✓ Cost effective
- ✓ Fast
- ✓ Selective
- ✓ Oil Recovery
- ✓ Eco-friendly



Partial Oil Recovery

Slow, Inefficient



Efficient, Selective

Expensive, Physical Waste

OHM Sponge

Economic

- *Made of cost-effective materials*
- *Reusable*

Efficient

- *Selectively removes/recovers oil*

Eco-friendly

- *Protect marine life*
- *No carbon emission*
- *Made from safe materials/methods*

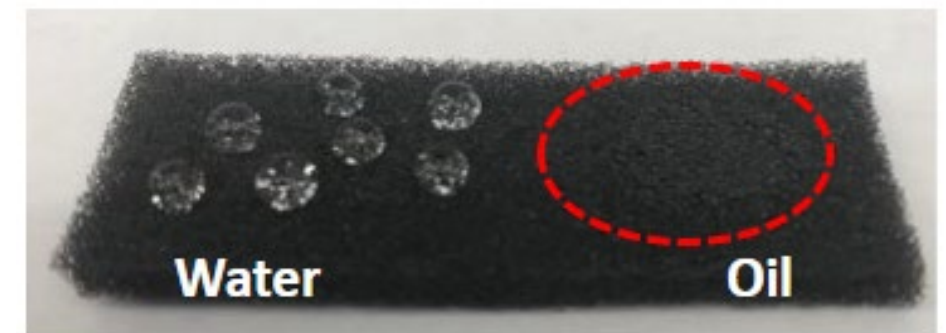
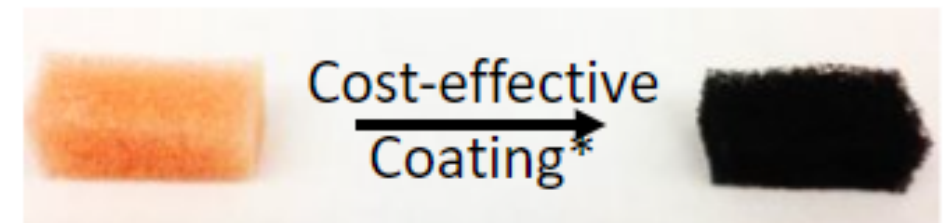
O = Oleophilic,

H = Hydrophobic

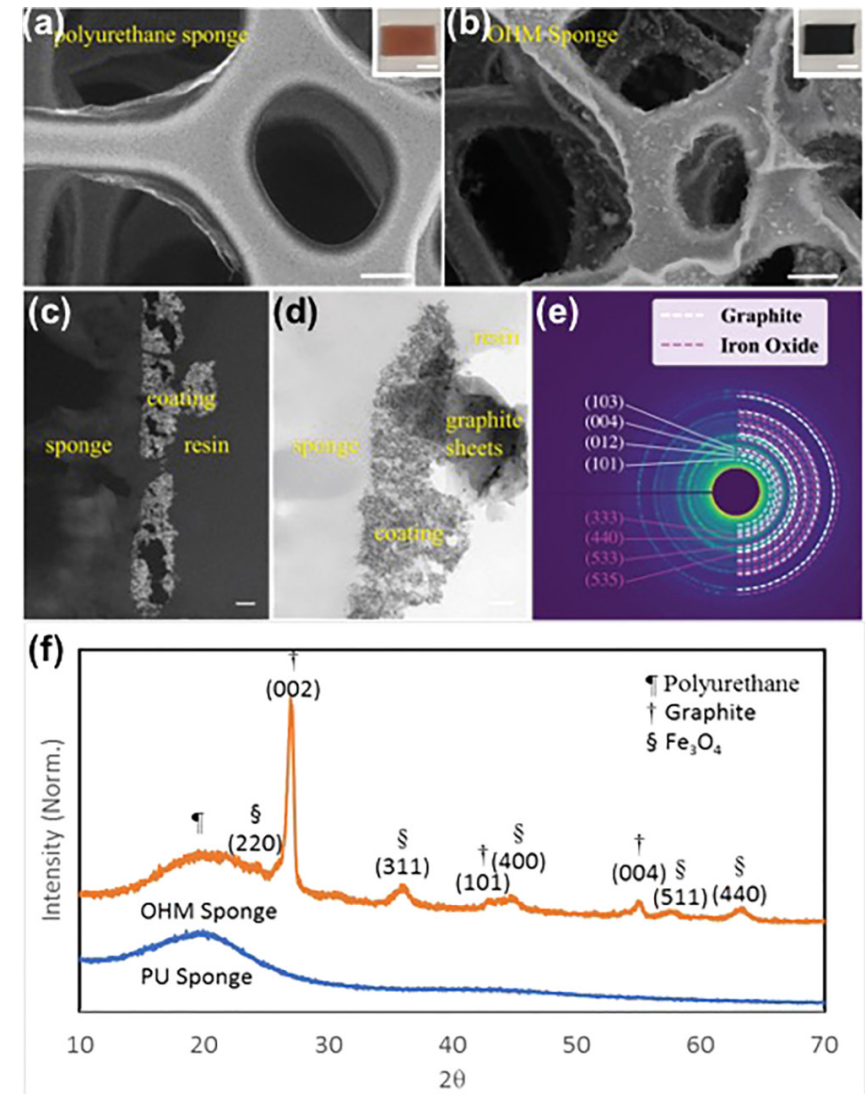
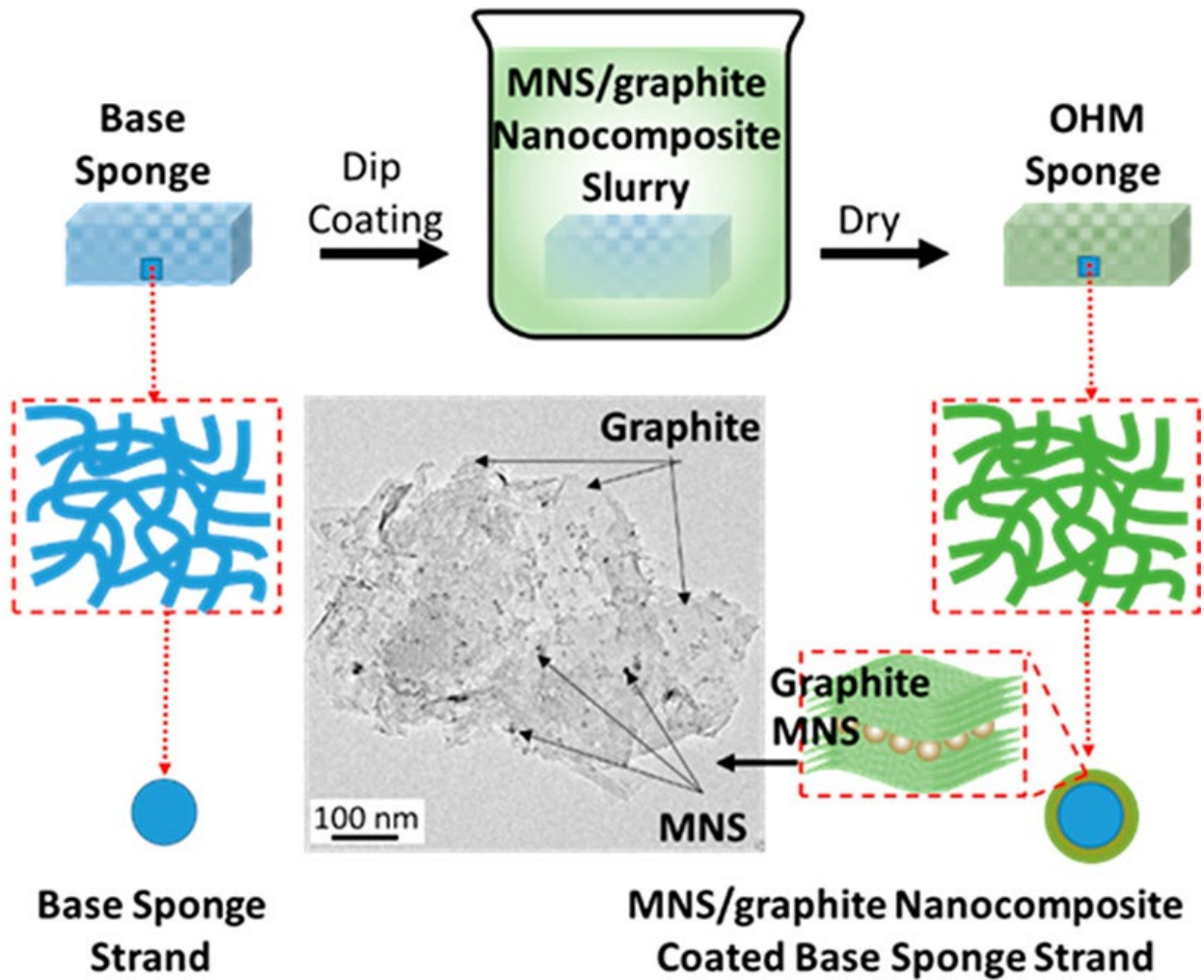
M = Multi-functional

Commercially
Available Sponge

OHM
Sponge

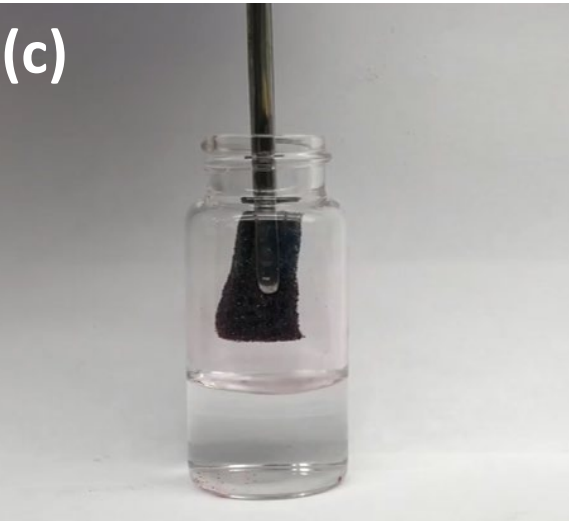
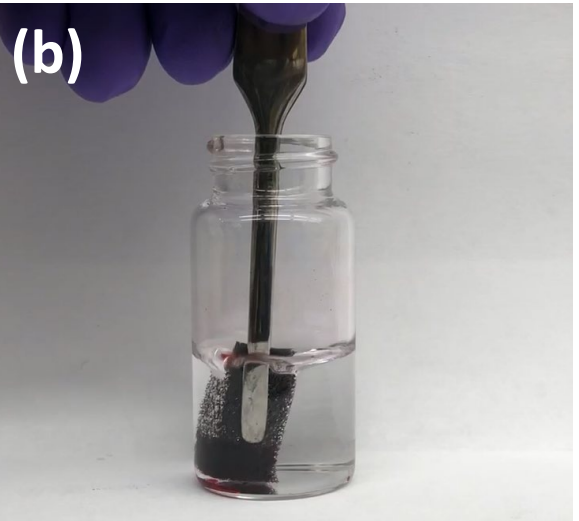
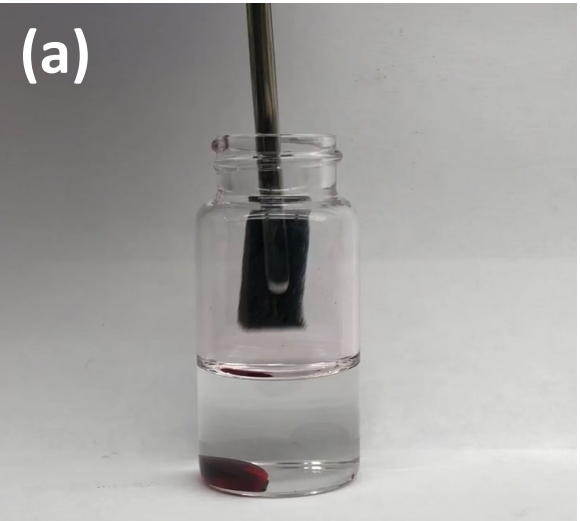
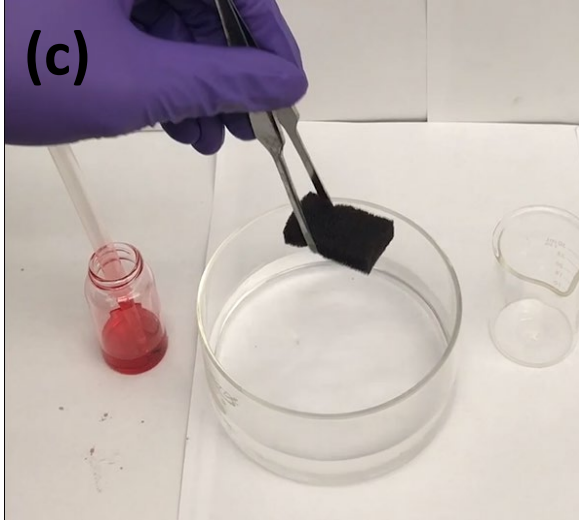
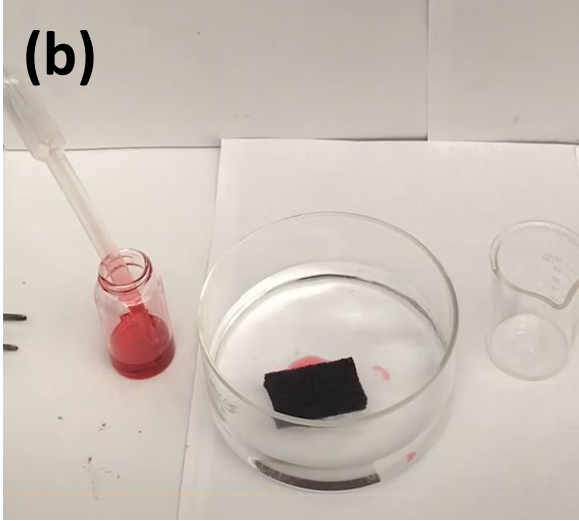
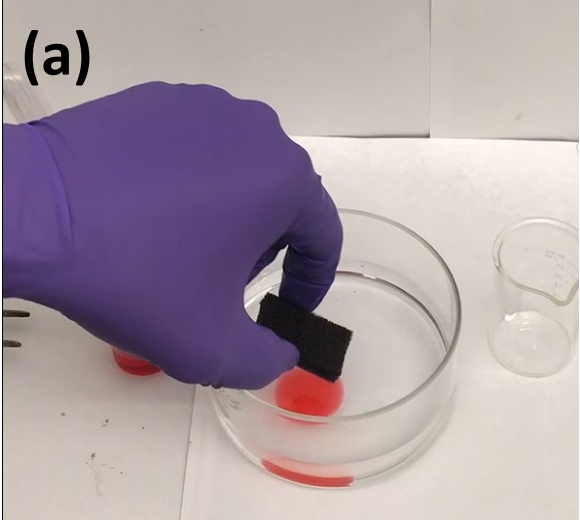


OHM Sponge – Synthesis and Characterization



OHM Sponge in Action

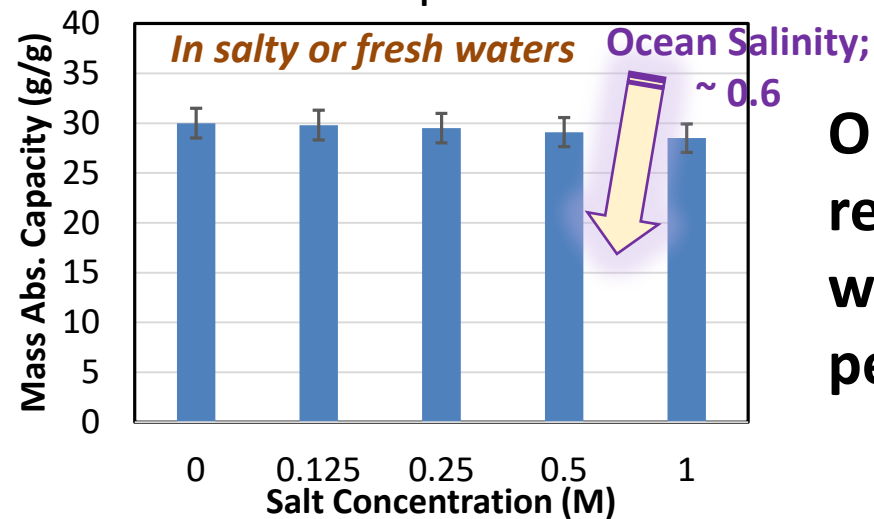
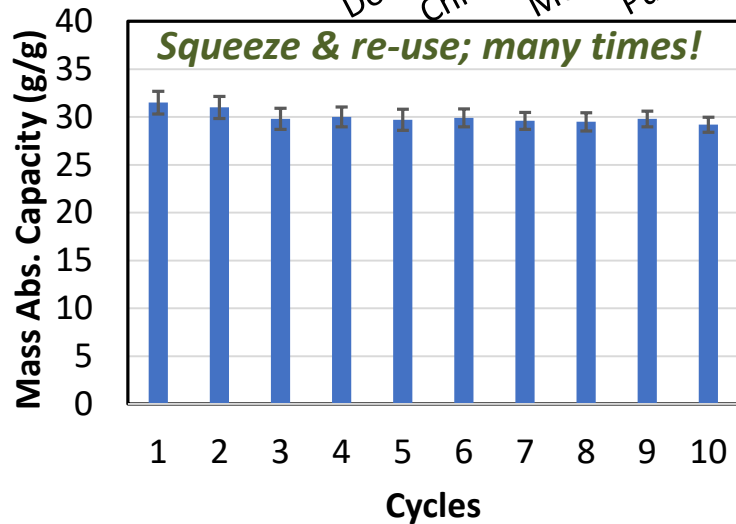
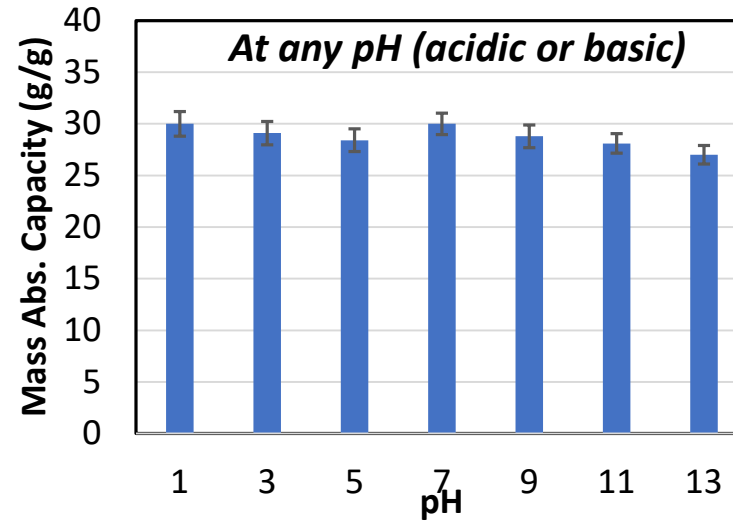
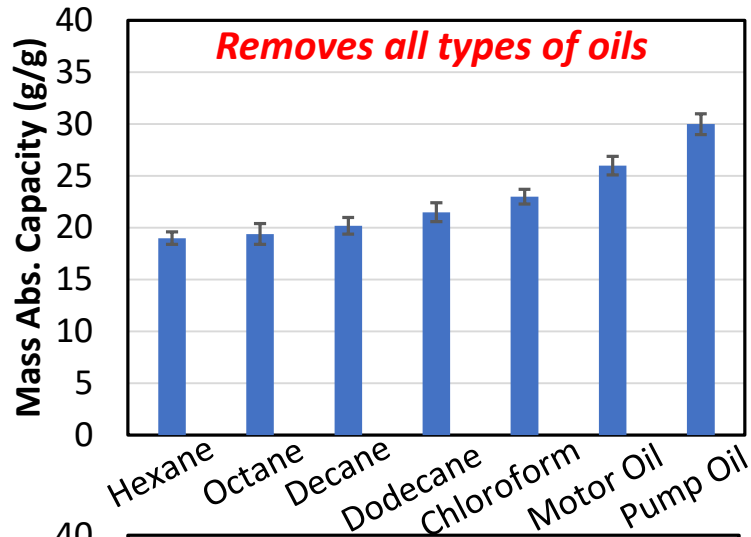
OHM Sponge can selectively remove oil from oil/water mix, regardless oil is present on the water surface OR below it.



*Nandwana, David et al, Ind. Eng. Chem. Res. 2020, 59, 23
US Patent 62/788,347*



Oil Absorption – Selectivity and Reusability

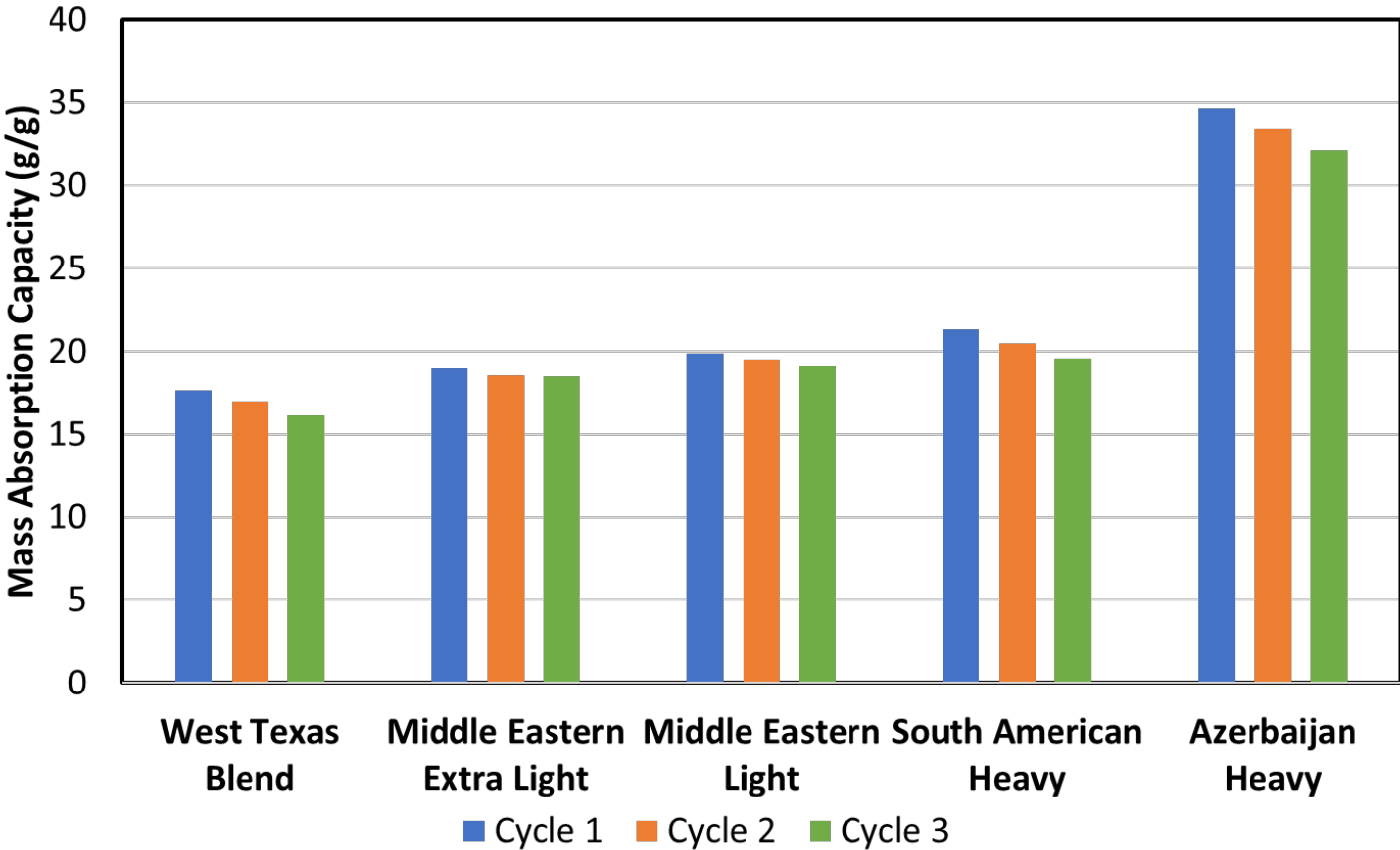


Absorption capacity of OHM Sponge is not affected due to pH, salinity, or various oil types.

OHM Sponge can be reused dozens of times without any change in performance.

Mass absorption capacity is based on American Standard Test Method (ASTM) 726-06 using Fisherbrand™ 19 Mechanical Pump Oil (unless otherwise specified).

Commercial Crude Oil Removal with OHM Sponge

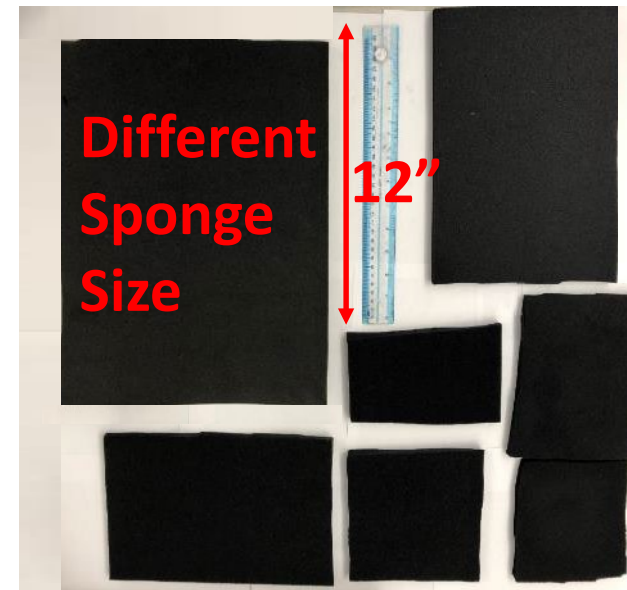
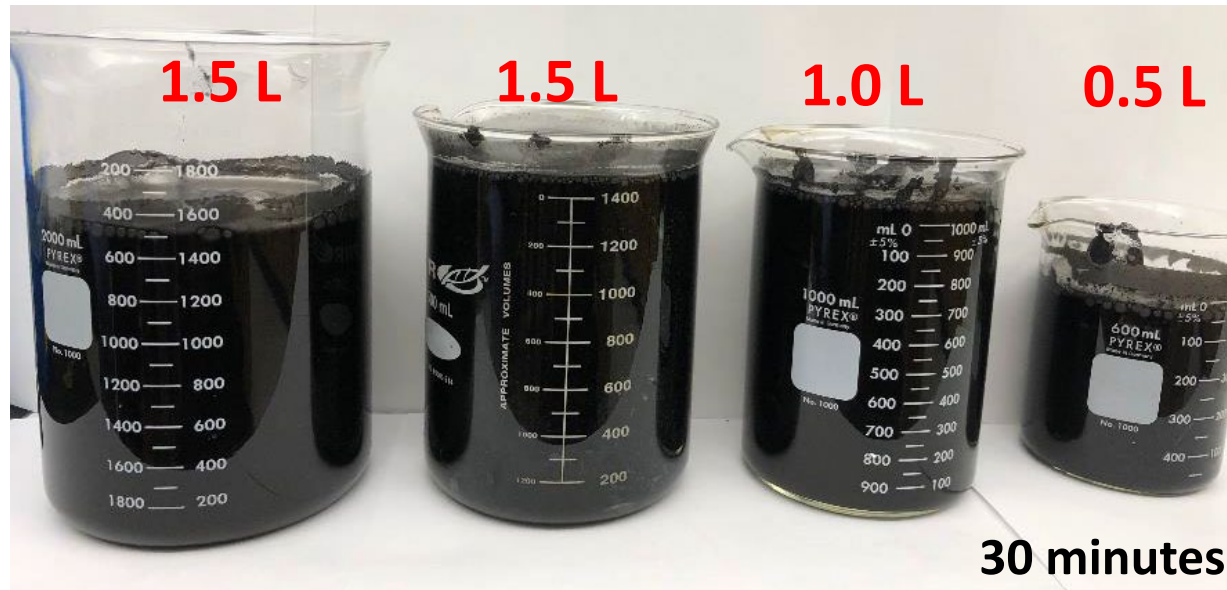


OHM Sponge can absorb various crude oils regardless of their density or viscosity.

Middle Eastern and South American Crude Oil Samples were kindly provided by Chevron
West Texas and Azerbaijan samples were bought from onta.com.
Mass absorption capacity is based on American Standard Test Method (ASTM) 726-06.

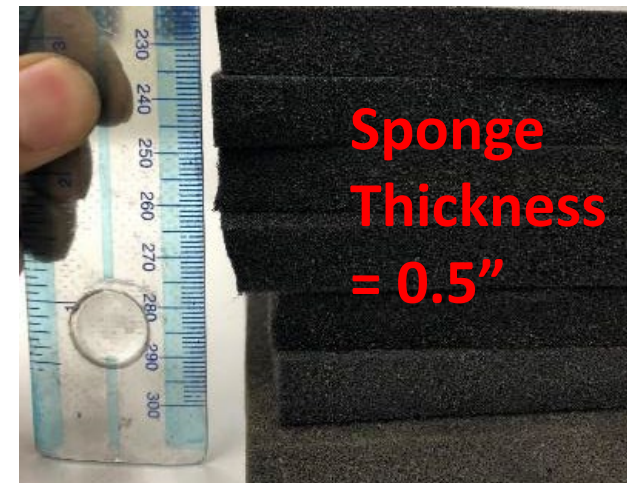


Large Scale Production Capability



Lab Scale (per hour production)

- 9L (70g) of slurry
- 40 OHM sponge sheets (1'x1'x0.5")
- ~500 L of oil absorption



External Validation – OHMSETT Facility (managed by BSEE under DoI)

- Validated at a largest oil spill response testing facility in North America
- Tested 50 sheets of 1'x1'x0.5" of OHM sponge under various conditions
 - Oil with different viscosity
 - Stationary and moving water
 - Oil Sheen

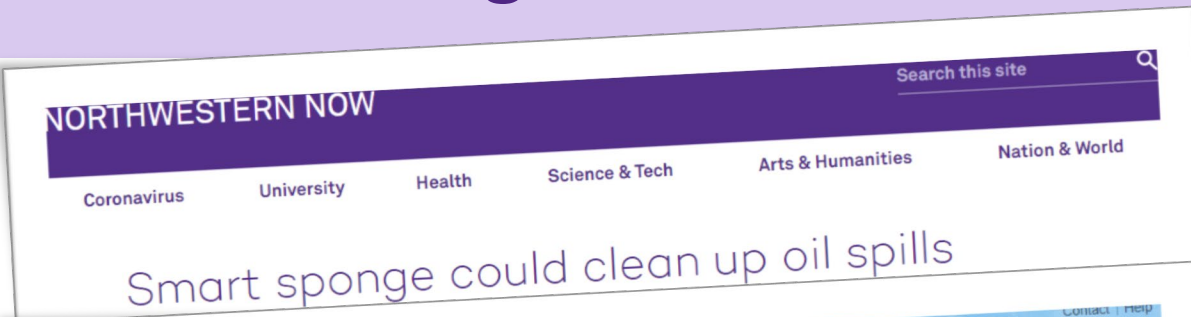


OHM Sponge results obtained at OHMSETT were similar or better than that of laboratory conditions.

Source: OHMSETT



Media Coverage



NORTHWESTERN NOW Search this site

Coronavirus University Health Science & Tech Arts & Humanities Nation & World

Smart sponge could clean up oil spills

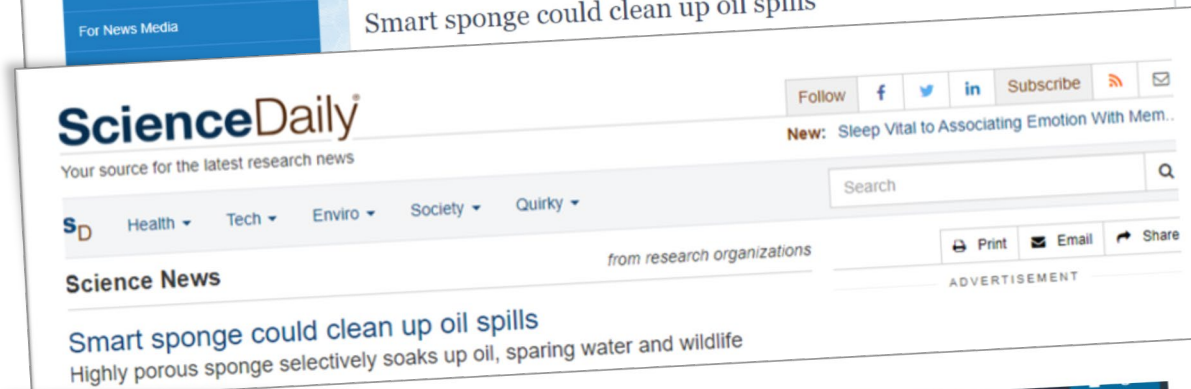


National Science Foundation WHERE DISCOVERIES BEGIN

Research Areas Funding Awards Document Library News About NSF

Home > News

Smart sponge could clean up oil spills

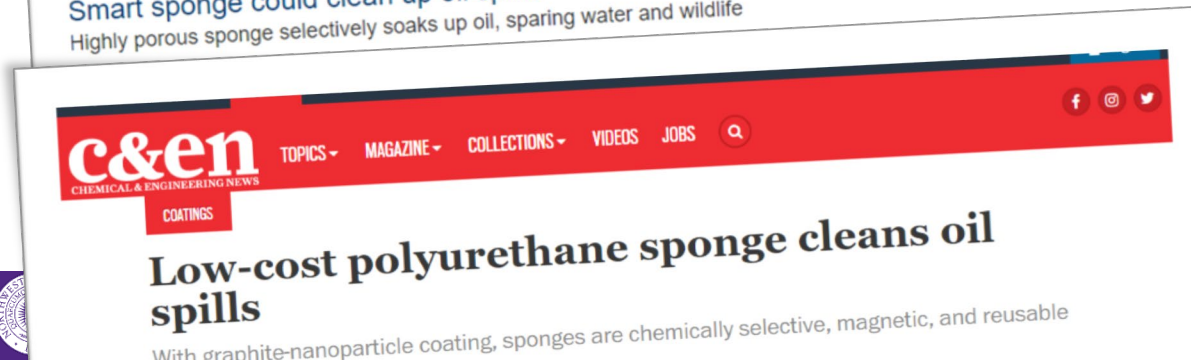


ScienceDaily Your source for the latest research news

Health Tech Enviro Society Quirky

Smart sponge could clean up oil spills

Highly porous sponge selectively soaks up oil, sparing water and wildlife




c&en CHEMICAL & ENGINEERING NEWS

COATINGS

Low-cost polyurethane sponge cleans oil spills

With graphite-nanoparticle coating, sponges are chemically selective, magnetic, and reusable



Forbes Subscribe | Sign In

Jun 21, 2020, 03:12pm EDT | 3,239 views

Game-Changing New Smart Sponge Soaks Up Oil Spills, Saving Water And Wildlife



The Guardian

Oil spills

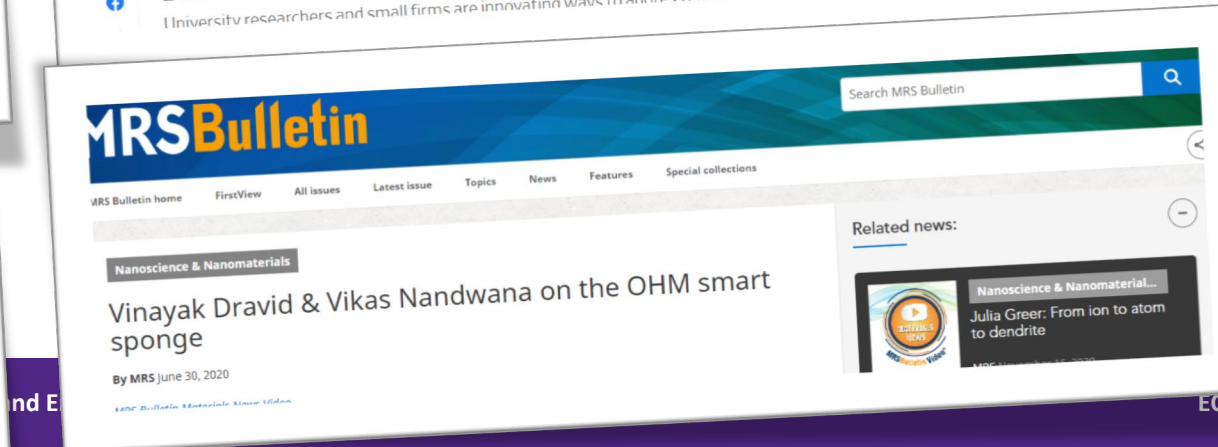
Robots and magnetic soap: scientists rethink oil spill clean-ups



THE WALL STREET JOURNAL

Home World U.S. Politics Economy Business Tech Markets Opinion Life & Arts Real Estate WSJ Magazine

Future of Cleaning Oil Spills Looks to Robots, Wood Chips and Sponges

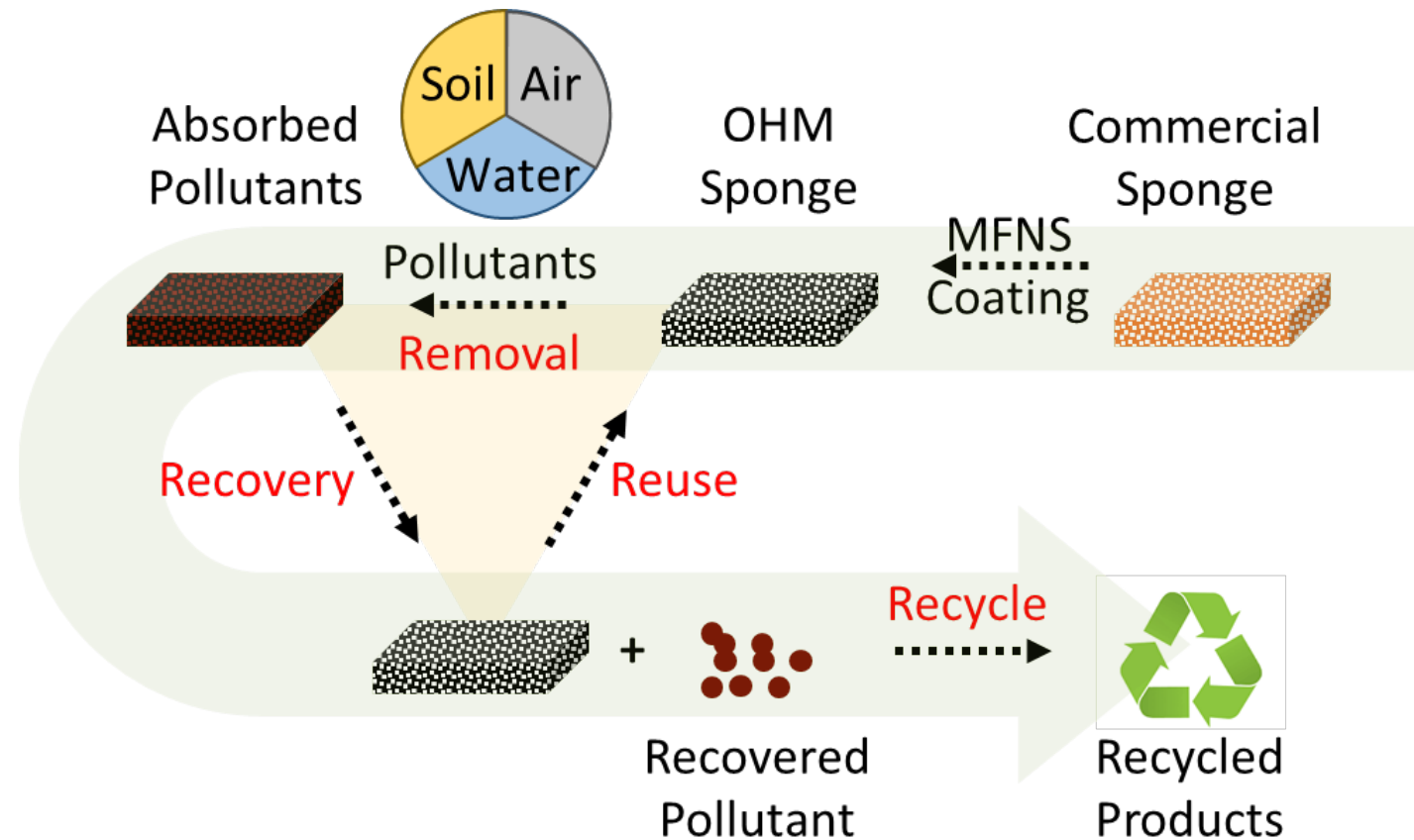


MRS Bulletin

Nanoscience & Nanomaterials

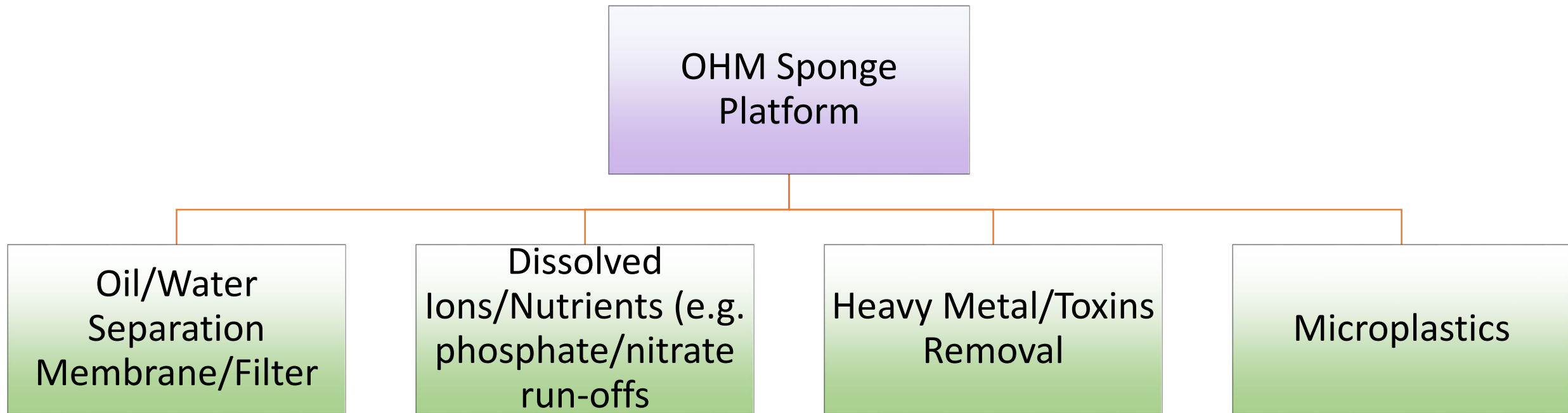
Vinayak Dravid & Vikas Nandwana on the OHM smart sponge

OHM Sponge: An Environmental Remediation Platform



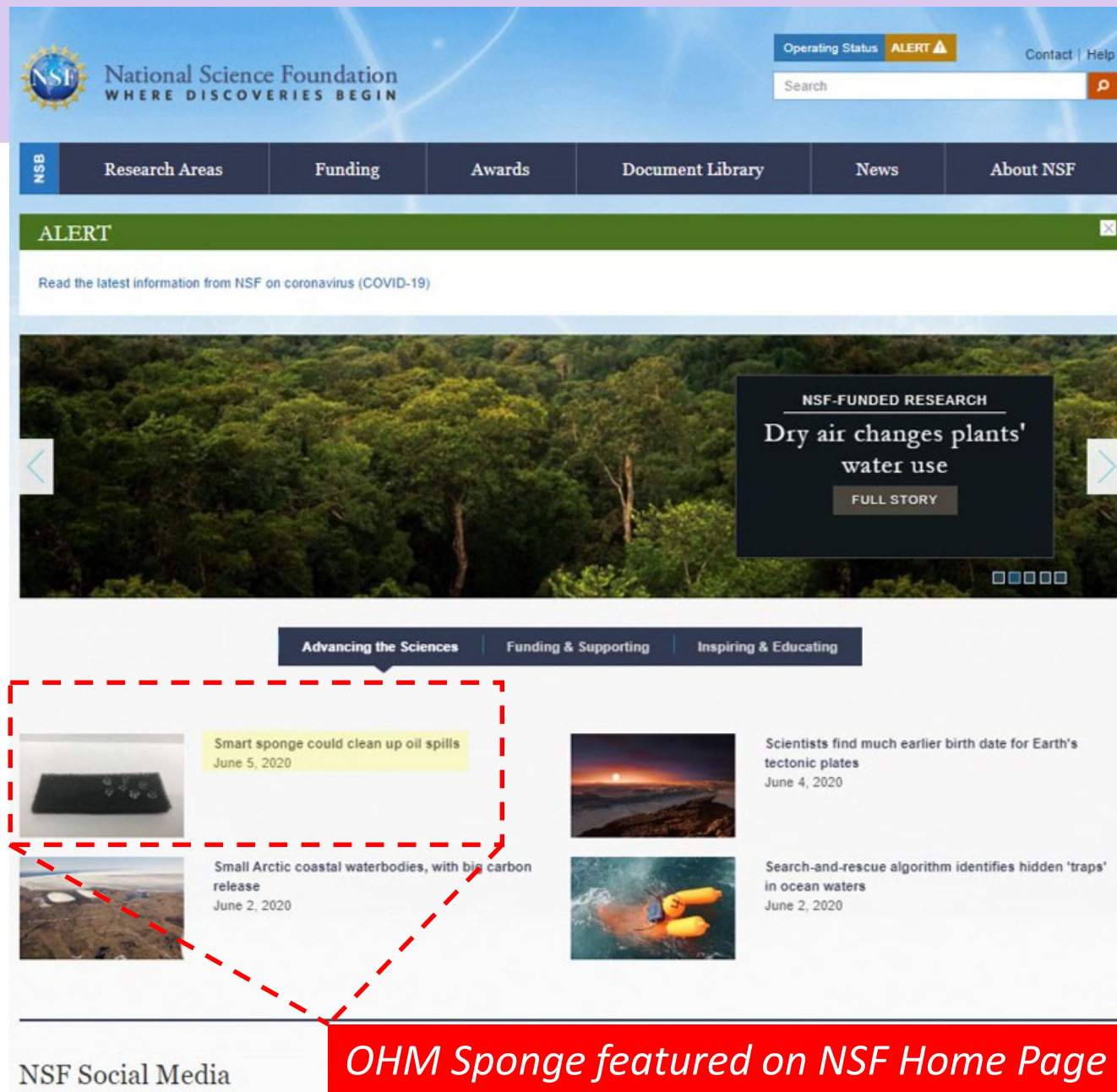
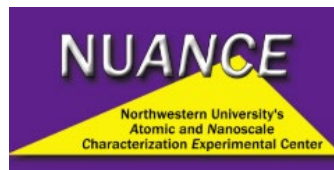
Reusable sponges will clean the environment and recycle pollutants into useful products

Environmental Remediation Platform



Acknowledgements

- Prof. Vinayak P. Dravid
- Dr. Roberto Dos Reis
- Stephanie Ribet
- Ben Shindel
- Yash More
- Other VPD Group Members



NSF Social Media

OHM Sponge featured on NSF Home Page

Conclusion

- ❖ OHM sponge: a revolutionary oil spill solution.
- ❖ Economic (high through-put, cheap raw material, cost-effective)
- ❖ Efficient (selective absorption of oil, > 150-200 times self-weight)
- ❖ Eco-friendly (green chemistry, reusable, no waste, bio-compatible)

**Beyond
OHM Sponge**



Toxin and heavy metal removal

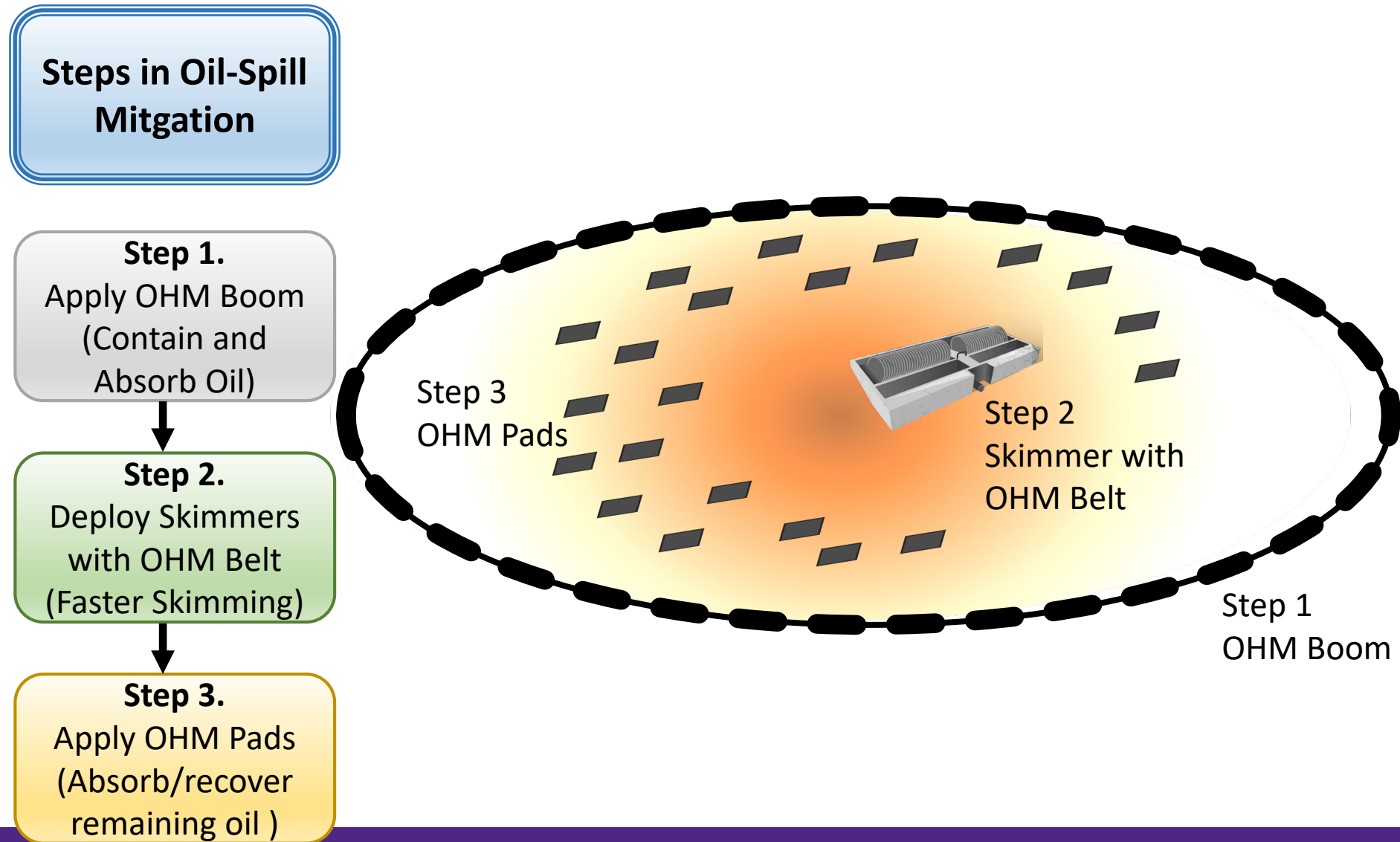
Dissolved Ions/Nutrients

Microplastics

Back-up



Oil Spill Response using OHM sponge



Modes of Deployment

Skimmer Belts



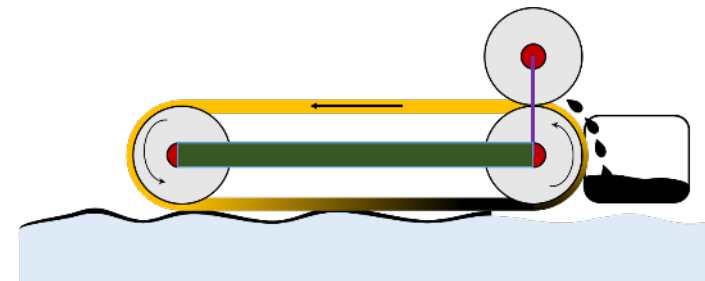
Reusable Sorbent Pads



Air-drop



Autonomous Boats



Competition and Competitive Advantages




Solution	Skimmer	Dispersant (Corexit)	In situ Burning	Sorbent	OHM Sponge	
Cost	No	Yes	Yes	No	Yes	} Economic
Speed	No	Yes	Yes	No	Yes	
Reusable	No	No	No	No	Yes	
Recovery	Yes	No	No	No	Yes	} Efficient
Selective	No	No	Yes	Yes	Yes	
C Emission	Yes	Yes	No	Yes	Yes	} Eco-friendly
Marine Life	Yes	No	No	Yes	Yes	

OHM Sponge is more Economic, Efficient, and Eco-friendly than currently deployed oil spill removal solutions.

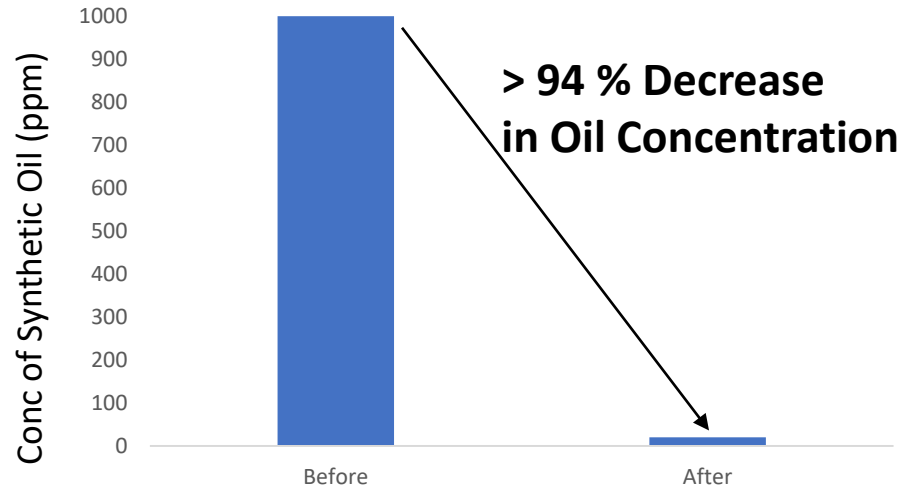


Comparison with Other Sorbents

Category	Product	Physical Waste Generated	Type of oils	Breadth of Use Cases	Cost	Recovery of Sorbent	Scalable	Recovery of Oil
	OHM Sponge	Best in category	Best in category	Best in category	\$	Best in category	Best in category	Best in category
<i>Direct Competitor</i>	Organic Sorbents	Worst in category	Worst in category	Worst in category	\$	Worst in category	Best in category	Worst in category
	Inorganic Sorbents	Worst in category	Worst in category	Worst in category	\$	Worst in category	Best in category	Worst in category
	Synthetic Sorbents	Middle in category	Middle in category	Middle in category	\$	Worst in category	Best in category	Middle in category
	Continuous Boom Sorbents	Worst in category	Worst in category	Worst in category	\$	Middle in category	Best in category	Worst in category
	Loose Fiber Synthetic Sorbents	Middle in category	Middle in category	Middle in category	\$	Middle in category	Best in category	Worst in category
<i>Emerging Competitor</i>	Argonne Labs OLEO Sponge	Best in category	Best in category	Best in category	\$\$\$	Best in category	Worst in category	Best in category
	Carbon Nanotubes	Best in category	Best in category	Best in category	\$\$\$	Best in category	Worst in category	Best in category

 Best in category
  Middle in category
  Worst in category

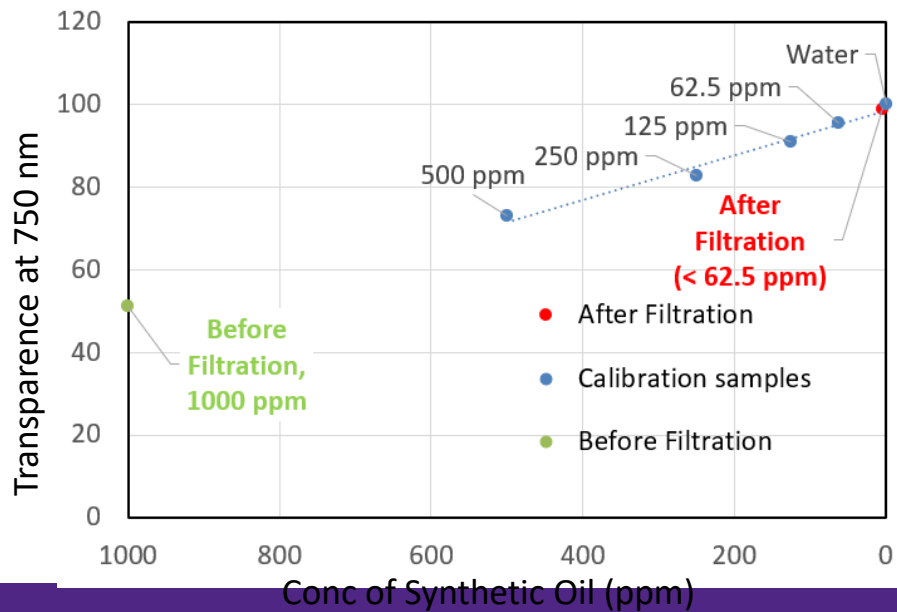
Results



Crude Oil Emulsion

→

OHM Membrane



Our Solution - OHM Membrane

- Hydrophilic substrates with oleophilic coating
- **Efficient**
 - *Selectively remove oil from oil/water emulsion down to <5 ppm.*
- **Economic**
 - *Made of cost-effective materials*
 - *Reusable*
- **Eco-friendly**
 - *Made from safe materials/methods*

