AQUEOUS REMEDIATION OF PERSISTENT ORGANIC POLLUTANTS USING MAGNETIC NANO-IRON SORBENT

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Funding: National Science Foundation, Environmental Protection Agency, Toxic Substances Research & Training Program

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A Tale of Two Sorbents

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Cast of Characters

The Pollutants: Persistent Organic Pollutants (POPs)

- Include pesticides and byproducts of industry
- Stay in the environment
- Harmful to human health

The Sorbents:

Activated Carbon

- -The most common sorbent
- -Requires water to be pumped and treated offsite
- -Reusing it has a high energy cost

Magnetic Permanently Confined Micelle Arrays

- -Nano-iron Sorbent
- -Can be used on-site
- -Most of the POP can be recovered after treatment
- -Reusable

Research Goals

- Synthesize iron nanoparticles called magnetic Permanently Confined Micelle Arrays (magPCMA).

- Test magPCMA with different POPs and study its effectiveness as a sorbent compared with the common commercial sorbent activated carbon.

-2 classes of pollutants studied:

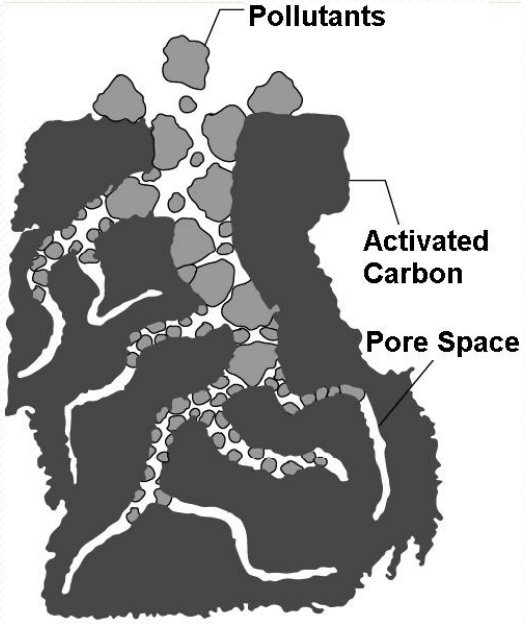
-Polycyclic Aromatic Hydrocarbons (PAHs)

-Chlorinated Hydrocarbons--pesticides

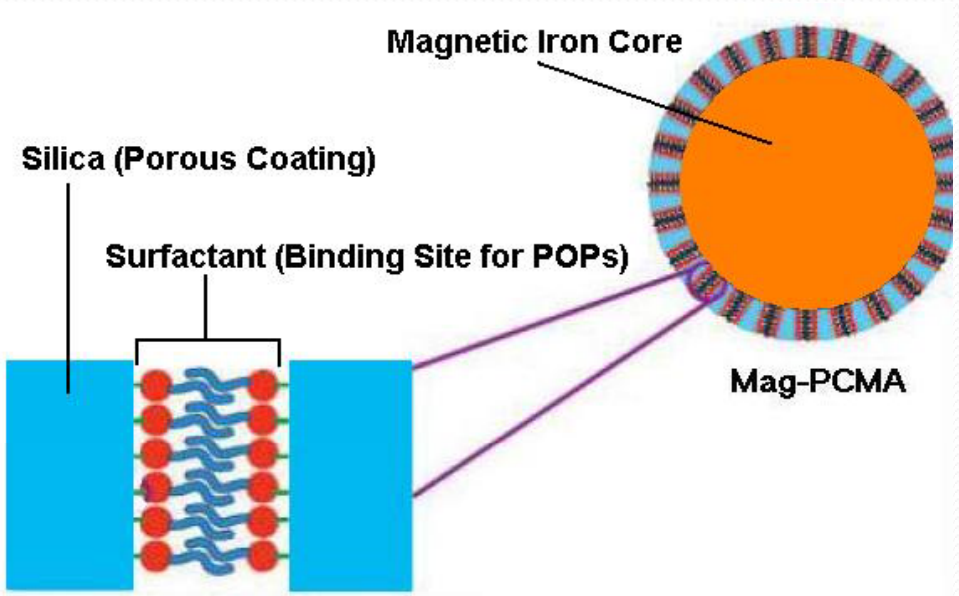
MagPCMA

Activated Carbon

(Image from metalclay.com)



(Adapted from waterprofessionals.com)



(Adapted from Wang et al)

Research Methods

Step 1: Synthesize magPCMA

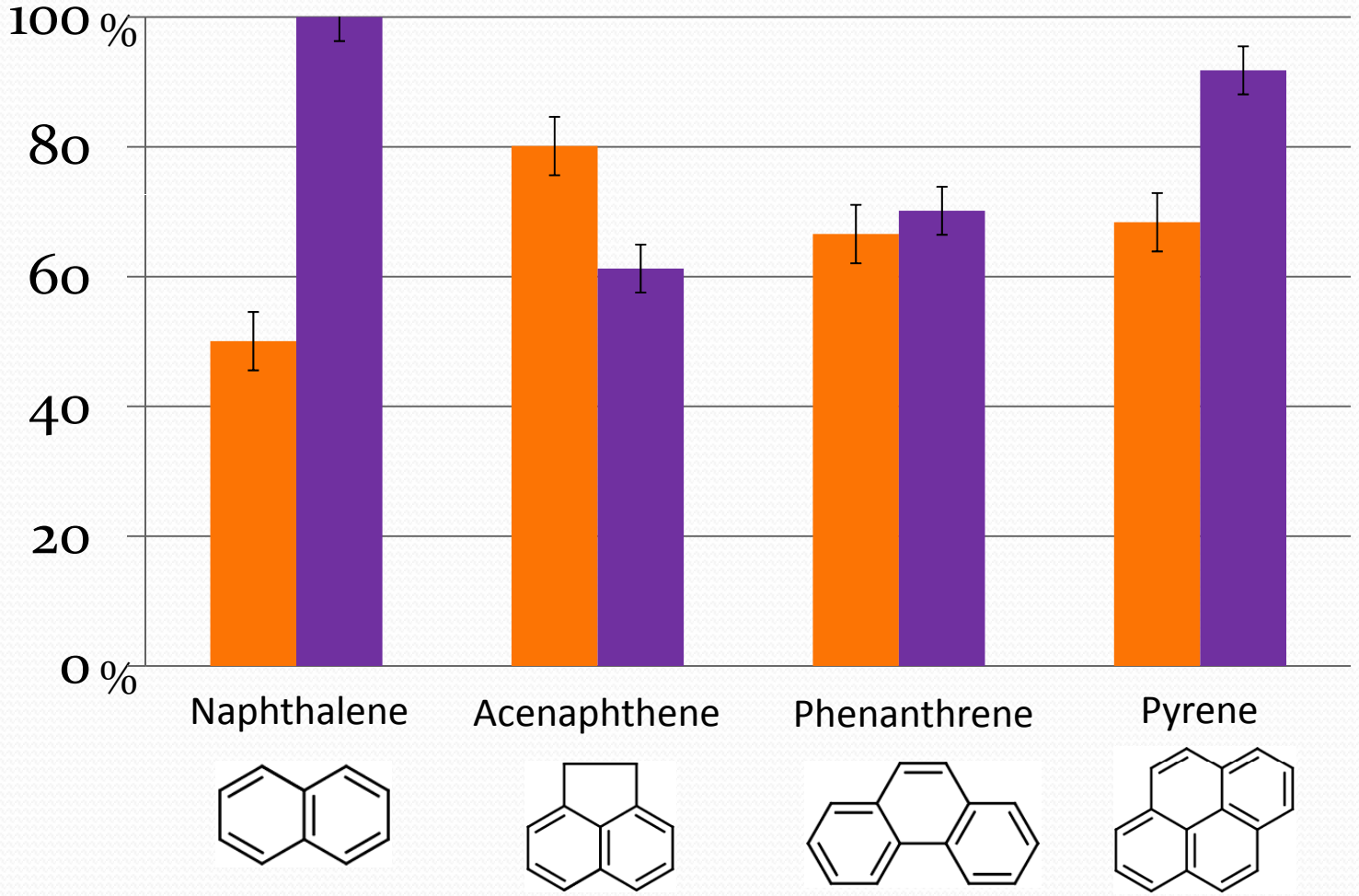
Step 2: Dose samples of magPCMA and activated carbon with POPs and allow to mix for 24 hours

Step 3: Use absorption spectrophotometry, GC-MS, and HPLC to determine how much pollutant was sorbed

Step 4: Run magnetic recovery and reusability experiments

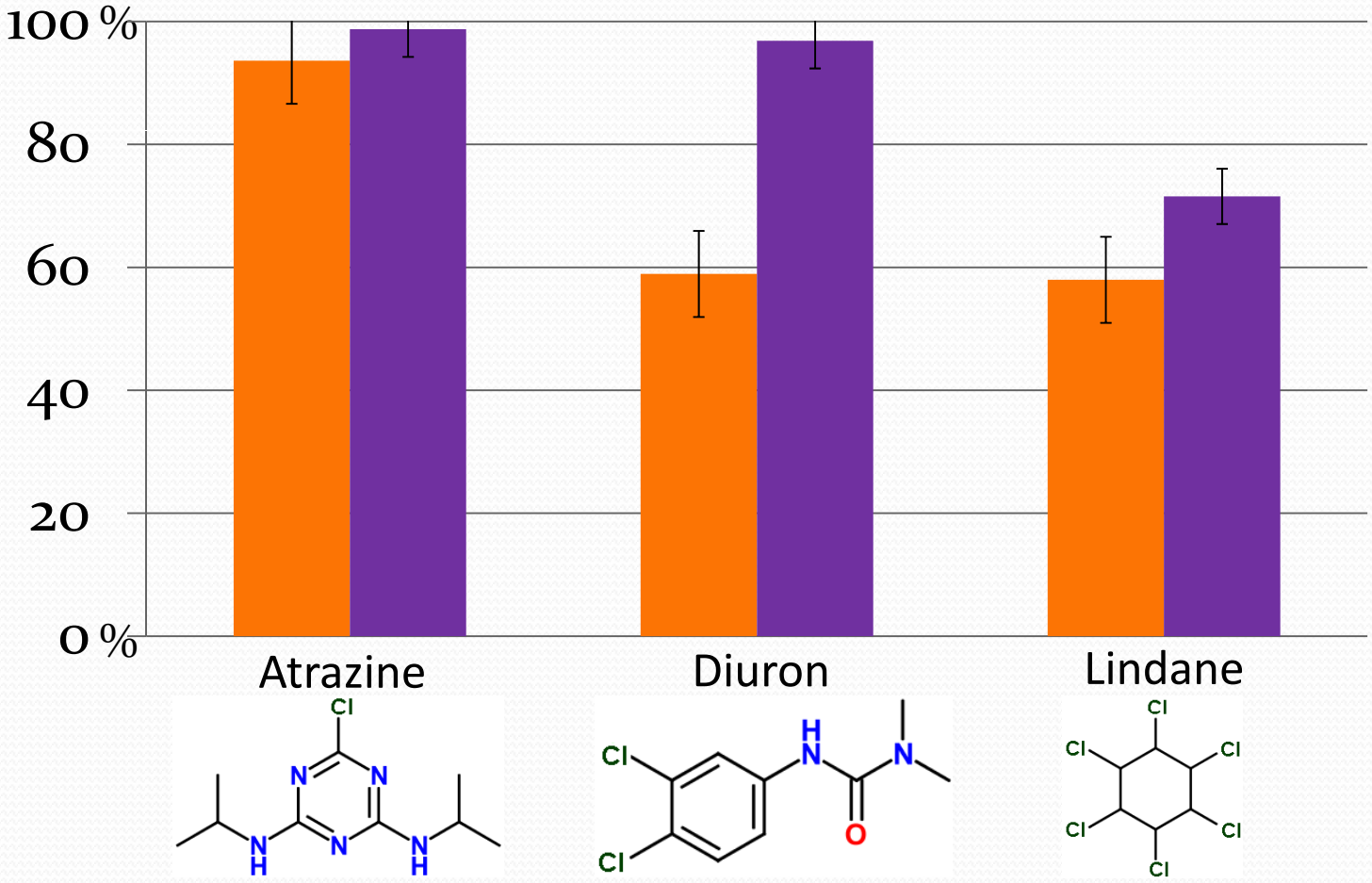
% PAH Sorbed in 24 Hours

MagPCMA vs. Activated Carbon



% Chlorinated Hydrocarbon Sorbed in 24 Hours

MagPCMA vs. Activated Carbon



Summary

-Activated carbon is initially more effective at removing POPs from solution than MagPCMA.

-Activated carbon is cheaper and simpler to produce

<u>However:</u>

-MagPCMA can be used on-site and removed magnetically

-Activated carbon used in this study was of very high quality

-In an acetone extraction, 83.6% of acenaphthene could be removed from MagPCMA

- Preliminary data shows that MagPCMA can be reused multiple times

(Image from cameroncarbon.com)

Acknowledgements

The Keller Lab

Mentors: Kristin Clark & Reginald Thio

PI: Dr. Arturo Keller

Lab Partners: Colin Van-Zandt, Marc Stefanuto, Annabelle Lee

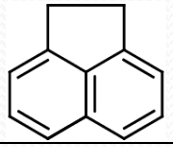
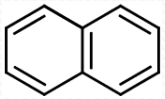
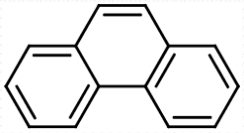
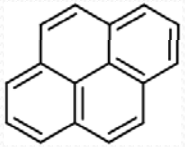
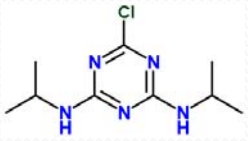
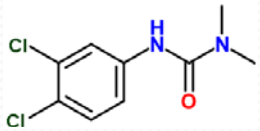
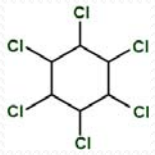
INSET

Jens-Uwe Kuhn, Nick Arnold, Arica Lubin

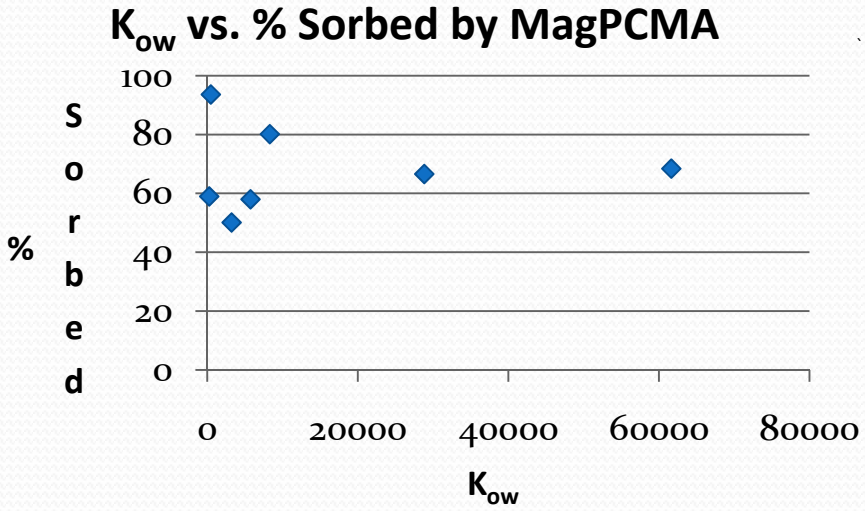
Family, Friends, and Instructors

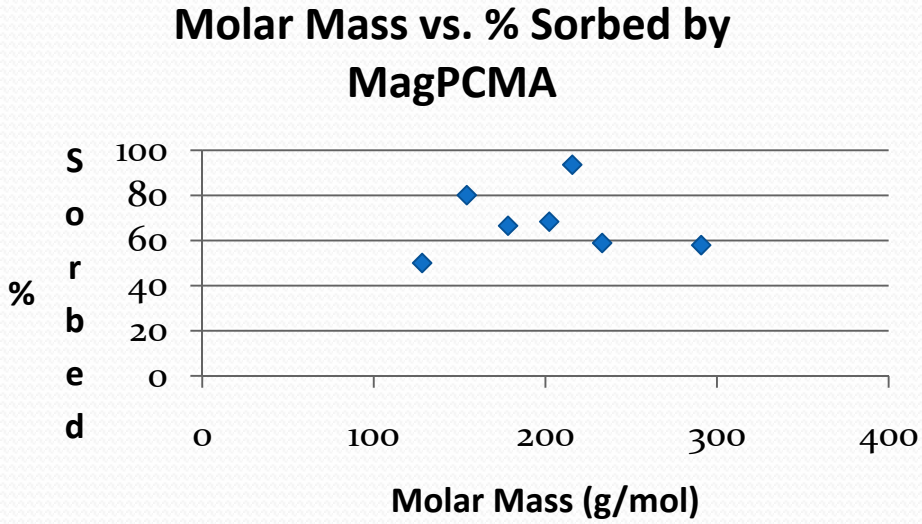
Questions?

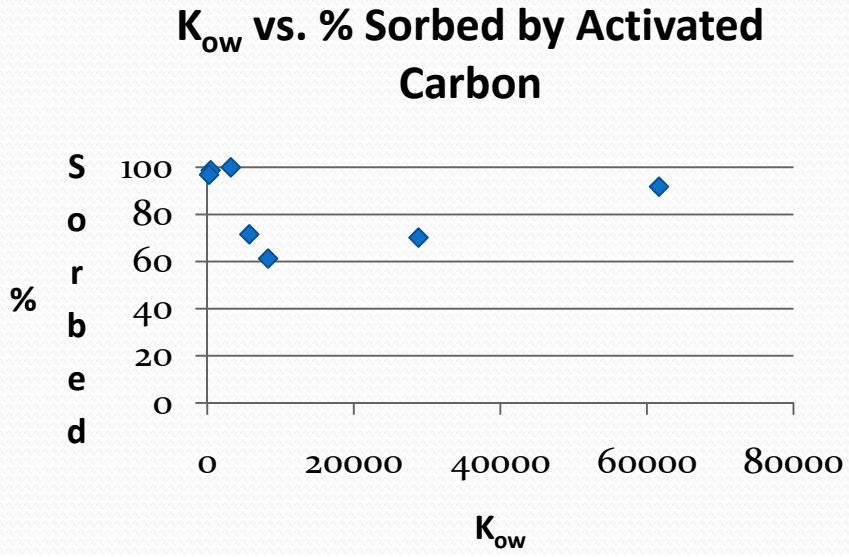
Physical Properties of Some HOCs

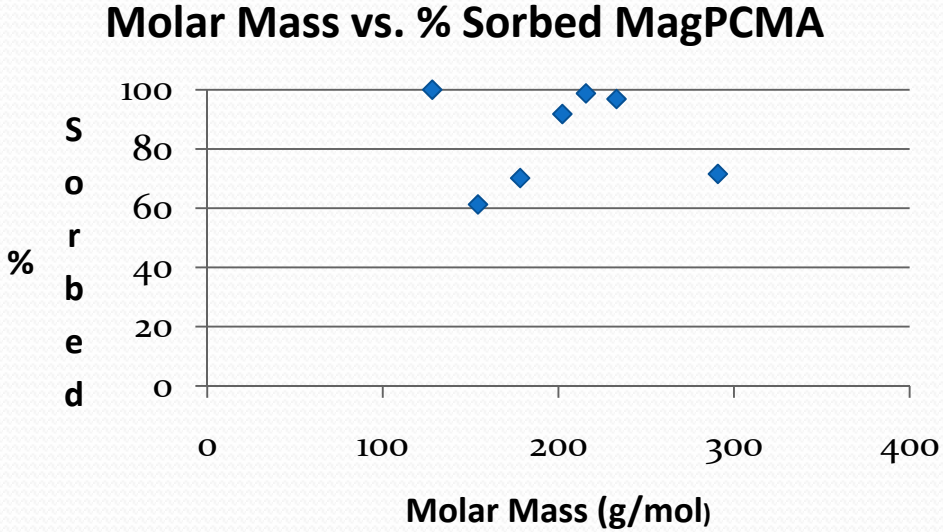
Compound Type	Compound	Structure	Molar Mass (g/mol)	Solubility in H_2O (mg/L)	K_{ow}
Polycyclic Aromatic Hydrocarbons	Acenaphthene		154.211	4	8317.6
	Naphthalene		128.171	31.9	3235.9
	Phenanthrene		178.233	1.28	28840.3
	Pyrene		202.255	0.135	61659.5
Pesticides	Atrazine		215.686	33.0	478.6
	Diuron		233.097	42	263.0
	Lindane		290.832	7.30	5754.4

Correlations (or lack thereof) Between Some Physical Properties of POPs and % Sorbed









Regeneration of Activated Carbon

-Requires an expensive, 3-step process that uses heat to desorb organics

-Up to 900°C

-Process is too expensive for smaller treatment sites, so they ship activated carbon in and out

Health Effects of PAHs and Chlorinated Hydrocarbons

PAHs

-Long-term exposure of PAHs showed an increase in cancer in mice.

-Exposure to PAHs has shown to effect the reproductive health of laboratory mice.

-Other effects may include liver and kidney damage, cataracts, and jaundice.

(Illinois Department of Public Health)

Chlorinated Hydrocarbons

- Many of these are specifically used as poison (i.e. incecticides, herbicides, and rodenticides)

- Acutely toxic (adverse effects take place after a single dose)

- Carcinogenic

(Columbia Environmental Research Center)