Investigating polycyclic aromatic hydrocarbon transport in natural systems

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Polycyclic aromatic hydrocarbons (PAHs)

- Organic compounds
- Ubiquitous pollutant
- Low solubility in water
Environmental Research Relevance – Engineering
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Polycyclic aromatic hydrocarbons

- Image of smoke-emitting volcanic eruption
- Image of water flowing from pipes
- Chemical structures of polycyclic aromatic hydrocarbons
- Images of Earth and Mars

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Research Relevance – Astrobiology

Curiosity Mars Rover

Mission
Understanding the past and present habitability of the martian environment

What?

Where?

Biosignature

“an object, substance, and/or pattern whose origin specifically requires a biological agent.”


Research Relevance – Astrobiology

What compounds are we seeing?
Where do they come from?

Image credits: Eigenbrode et al., 2018

Polycyclic aromatic hydrocarbons

Origin of organic matter harder to discern
Research Objective:

Investigate geochemical conditions that affect polycyclic aromatic hydrocarbon mobility in hydrothermal systems using a continuous flow reactor.
Continuous Flow Chemistry

- Simulate hydrothermal fluids flowing through mineral bed
- Automated and consistent fluid flow throughout the experiment
Packed Bed

Mars Global Simulant Coarse (MGS-1 Coarse)

• Basaltic regolith on Mars
• Similar mineral composition to Earth’s basalt
Ultra Pure MilliQ water
• pH = 6.5 – 7.5
• Standard pressure/temperature

Hydrothermal Fluid (HTF)
• Synthetic, non-heated
  • 4 mM NaCl
  • 0.3 mM CaSO$_4$
  • 100 mM NaSiSO$_4$
• pH = 11.8
• Standard pressure/temperature
Organics – PAHs

- Structural isomers (MW: 178.23 g/mol)
- Common in hydrothermal systems
- Highly studied in PAH removal techniques
Organic Mixtures – 10 mM in system

**Packed Bed**
- Phenanthrene
- Anthracene
- Phenanthroline

**Fluid Solution**
- Phenanthroline
Experiment Schematic

- **0 minutes**
- **15 minutes**
- **30 minutes**
- **60 minutes**
- **90 minutes**

**Phases**
- Packed Bed with approx. 7.5 g of MGS-1 coarse

**Materials**
- Phenanthroline
- Anthracene
- Phenanthrene
- Mars Global Simulant

**Equipment**
- Auto syringe pump
  - Flow rate: 0.2 mL/min
Fluid Analysis – Phenanthrene

**MilliQ-Water**

A) Water + Mars Global Simulant + Phenanthrene, t=0 mins

B) Water + Mars Global Simulant + Phenanthrene, t=15 mins

**Hydrothermal Fluid**

A) Hydrothermal fluid + Mars Global Simulant + Phenanthrene, t=0 mins

B) Hydrothermal fluid + Mars Global Simulant + Phenanthrene, t=15 mins

*aromatics*  
*aliphatics*
Fluid Analysis – Phenanthrene

**MilliQ-Water**

A) H₂O + MGS-1 Coarse + PHE, time = 0 mins
B) H₂O + MGS-1 Coarse + PHE, time = 15 mins
C) H₂O + MGS-1 Coarse + PHE, time = 30 mins
D) H₂O + MGS-1 Coarse + PHE, time = 60 mins
E) H₂O + MGS-1 Coarse + PHE, time = 90 mins

**Hydrothermal Fluid**

A) HTF + MGS-1 Coarse + PHE, time = 0 mins
B) HTF + MGS-1 Coarse + PHE, time = 15 mins
C) HTF + MGS-1 Coarse + PHE, time = 30 mins
D) HTF + MGS-1 Coarse + PHE, time = 60 mins
E) HTF + MGS-1 Coarse + PHE, time = 90 mins
Fluid Analysis – Anthracene

• No aromatic peaks at any timepoint
Conclusions – Environmental Engineering

• At baseline conditions, we’re seeing some phenanthrene decomposition with the continuous flow set up.

• We still have phenanthrene and anthracene left with the organics.

We know phenanthrene decomposition products is likely to be present in contaminated water streams.
Implications – Astrobiology

• Phenanthrene decomposition products could potentially overlap with biomarkers.
  • Need other biosignatures to help confirm biomarkers

We know a set of geochemical conditions that PAH mobility can affect Martian organic analyses.
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