Removal of arsenate and ammonia from water by molecularly imprinted polymers.

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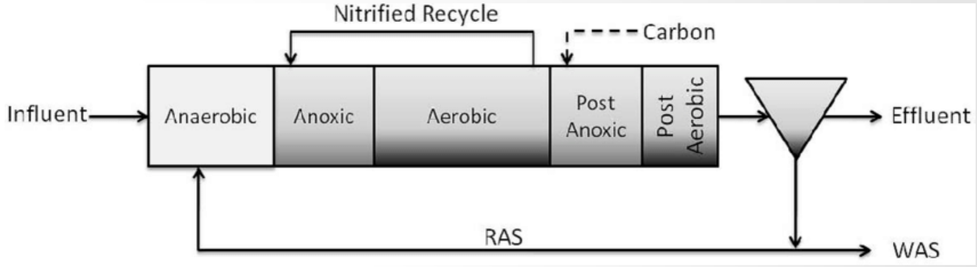
Background

- U.S military personnel are at risk of arsenate and ammonia exposure through drinking and wastewater when deployed in remote areas.

- Limited water purification in the field.



Conventional methods in the field

- Lack selectivity
- Are only partially effective in removing arsenate and ammonia
- Can be difficult to operate in remote locations

Project relevance

- Clean water needed in the field.
- New technology to meet drinking water regulations.
- Develop proof of concept for commercialization.

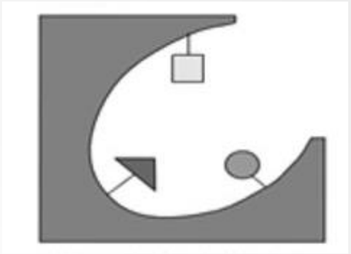
Technical approach

- Molecular imprinting makes polymeric materials selective.

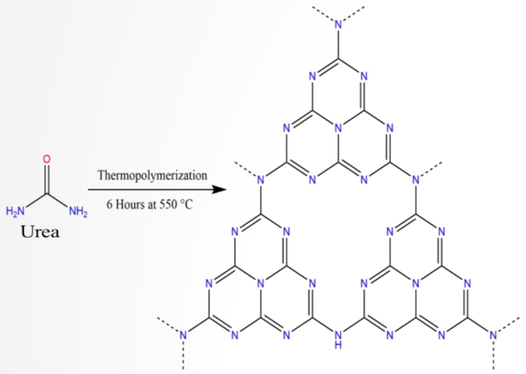
Template molecule

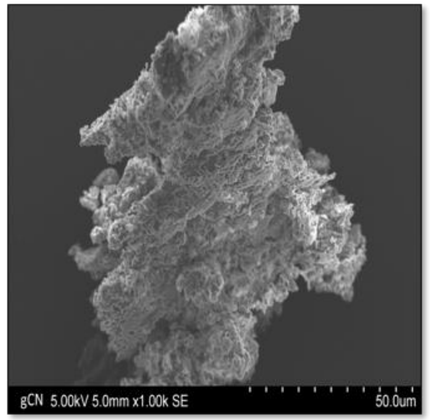
Polymer with template molecule

Polymer with molecular imprint



- Graphitic carbon nitride (g-C_3N_4) improves properties of imprinted material.

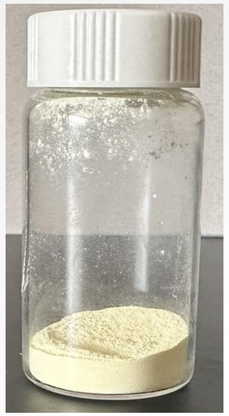


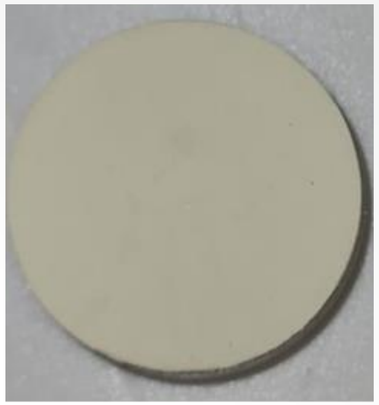


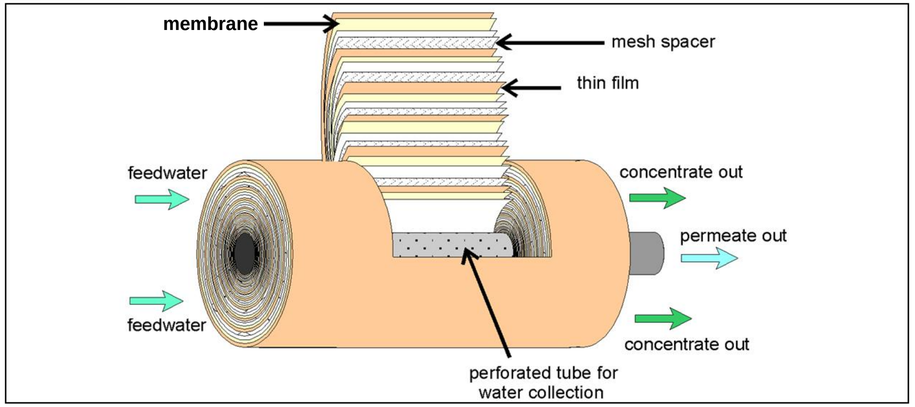
- Stable
- High intrinsic porosity
- Chemical versatility
- Robust mechanical properties
- High surface area
- High strength

Technical approach

- Implemented as filter resins and membranes.







Objectives

1. To prepare g-C_3N_4 functionalized, highly specific, imprinted polymers with arsenate and ammonia as resins and membranes.

2. To evaluate the performance of the resins and membranes in removing arsenate and ammonia from water.

Methods and Experiments

Radical Polymerization

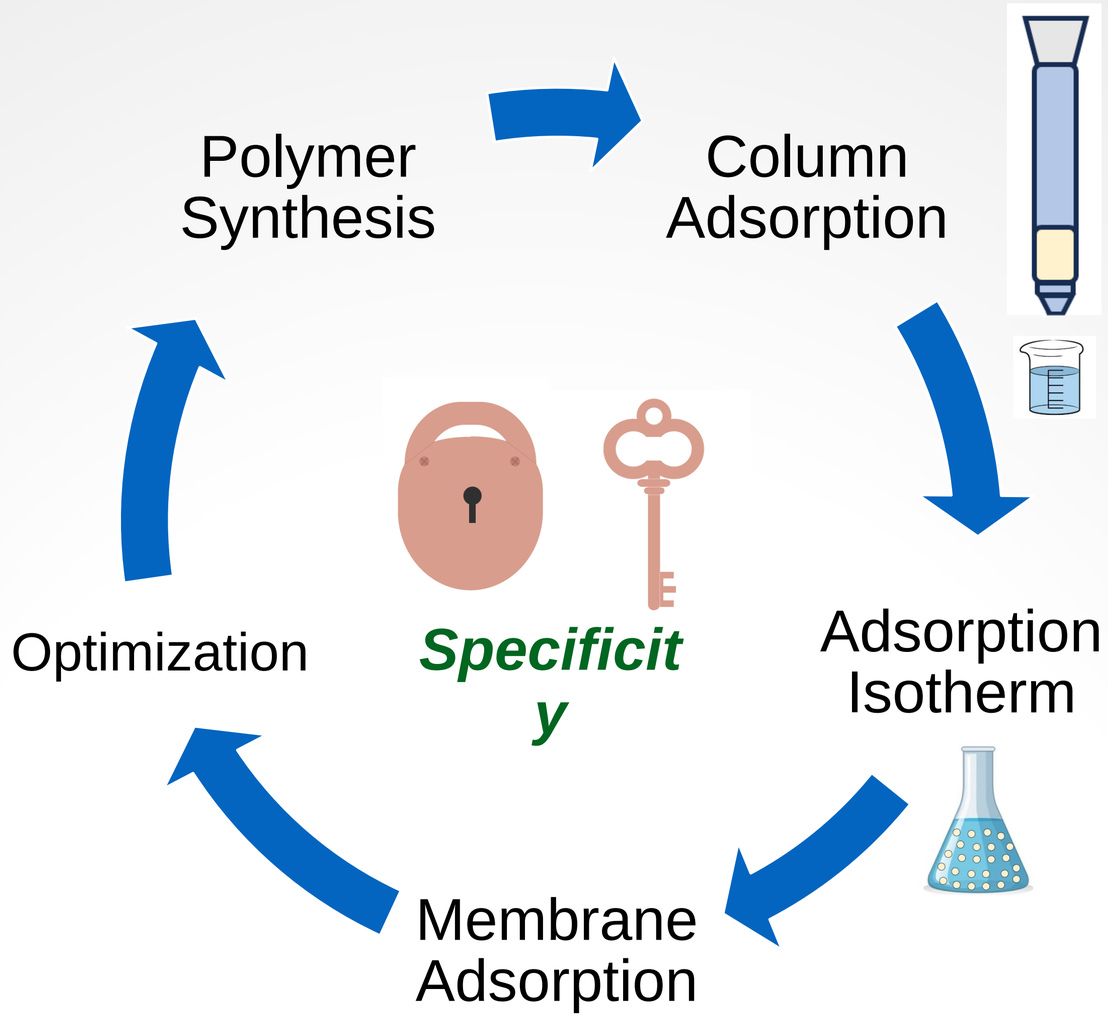
Methylacrylic acid

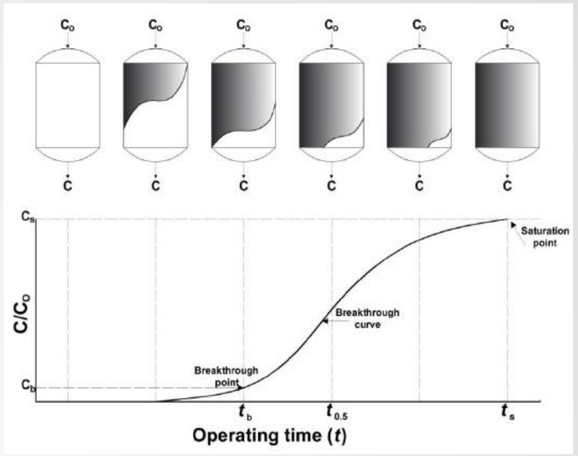
+

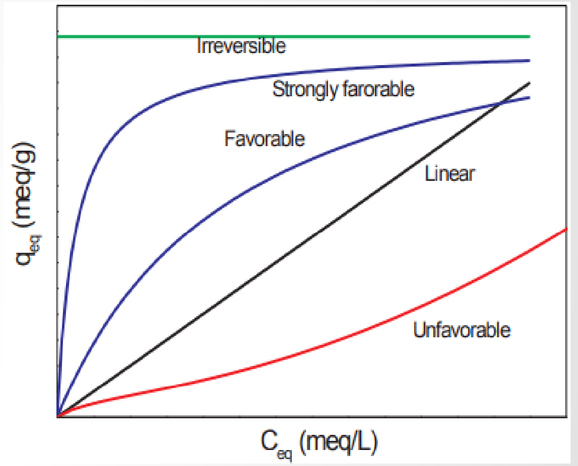
methylacrylamide

+

g-C_3N_4







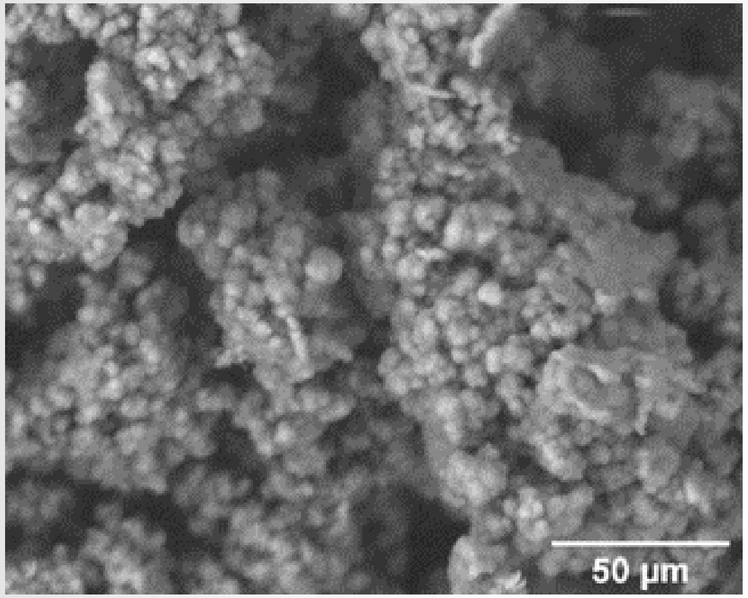
Competition experiments

	Arsenate	Ammonia
Competing Ion	Chloride in NaCl	Calcium in $CaCl_2$
Concentration (percentage)	50%	50%
Volume	20 mL	20 mL
Type of experiment	Column	Column

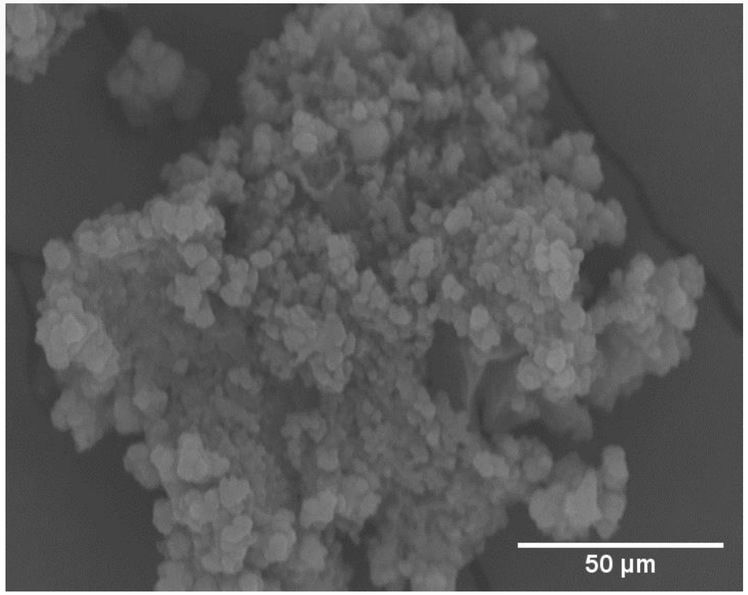
Characterization of Materials

Scanning Electron Microscopy

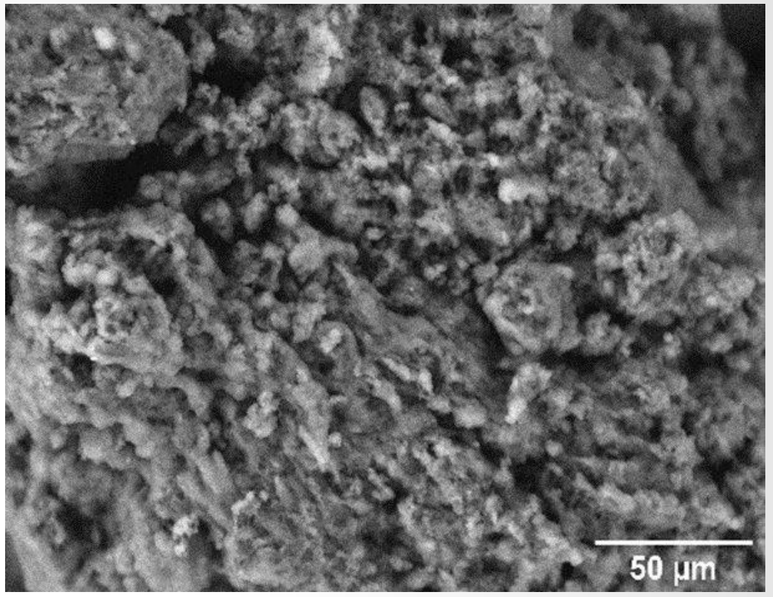
Non-imprinted Polymer Resin



Arsenate – Imprinted Polymer Resin



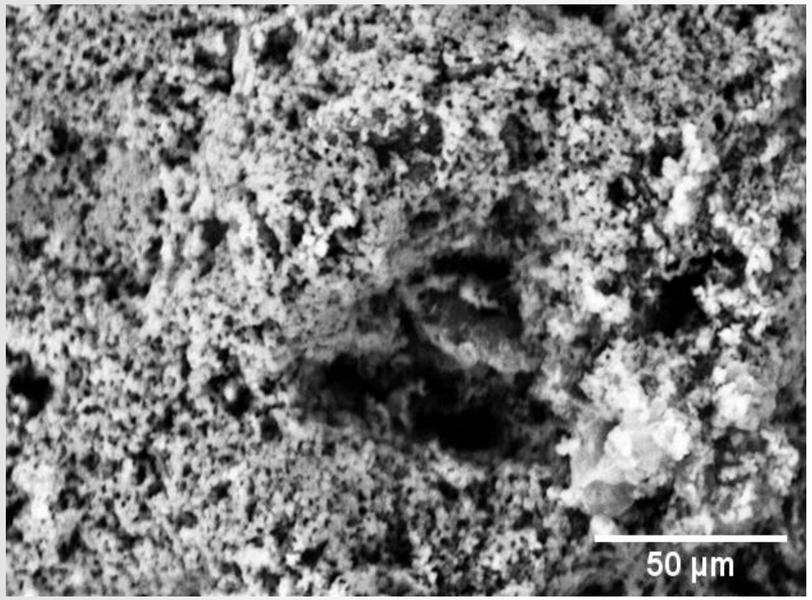
Ammonia – Imprinted Polymer Resin



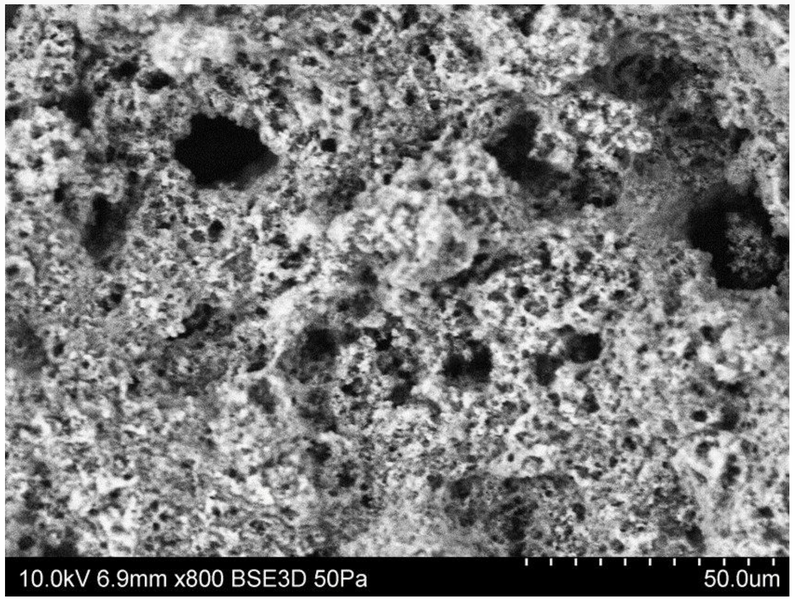
Characterization of Materials

Scanning Electron Microscopy

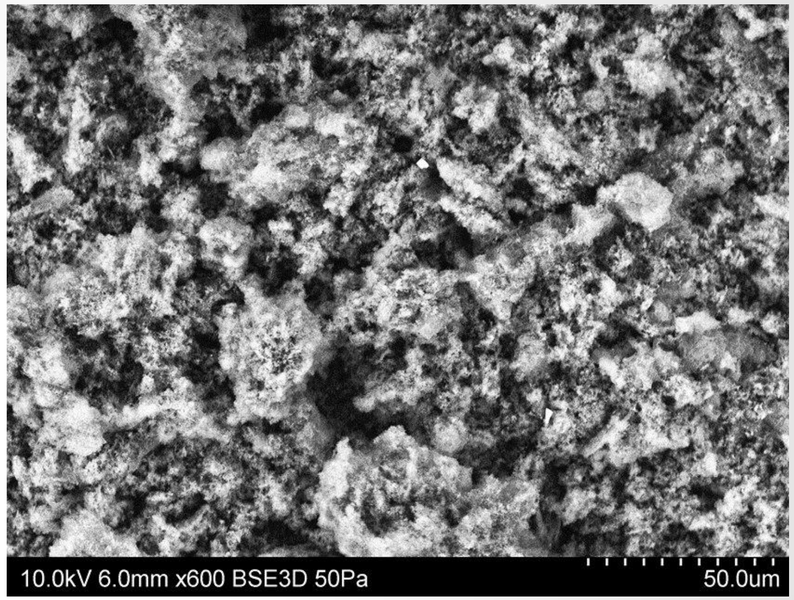
Non-imprinted Membrane



Arsenate – Imprinted Membrane



Ammonia – Imprinted Membrane



Characterization of Materials

Porosimetry

Arsenate - Porosity of Polymer Resin

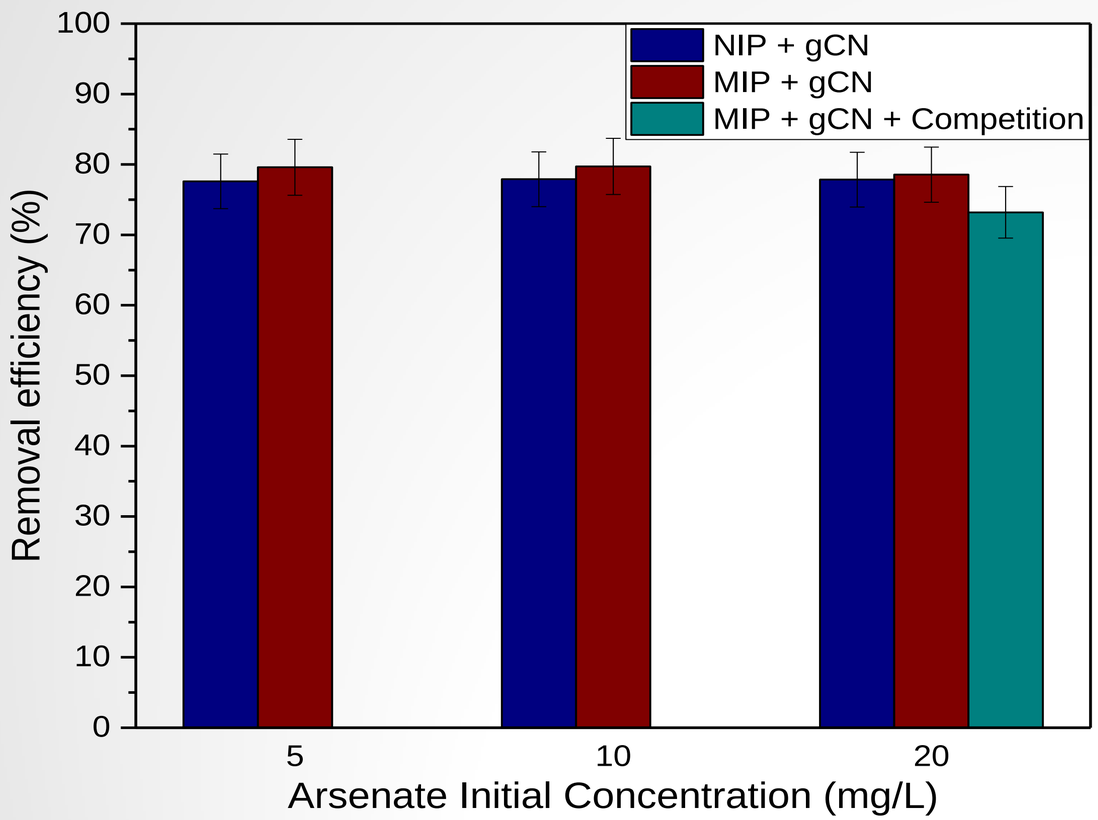
Arsenate	S_{BET} (m^2/g)	Pore size (nm)	Pore volume (cc/g)
g-C_3N_4	162.1	3.062	0.182
NIP	82.5	3.851	0.038
MIP	77.8	3.070	0.033

Ammonia - Porosity of Polymer Resin

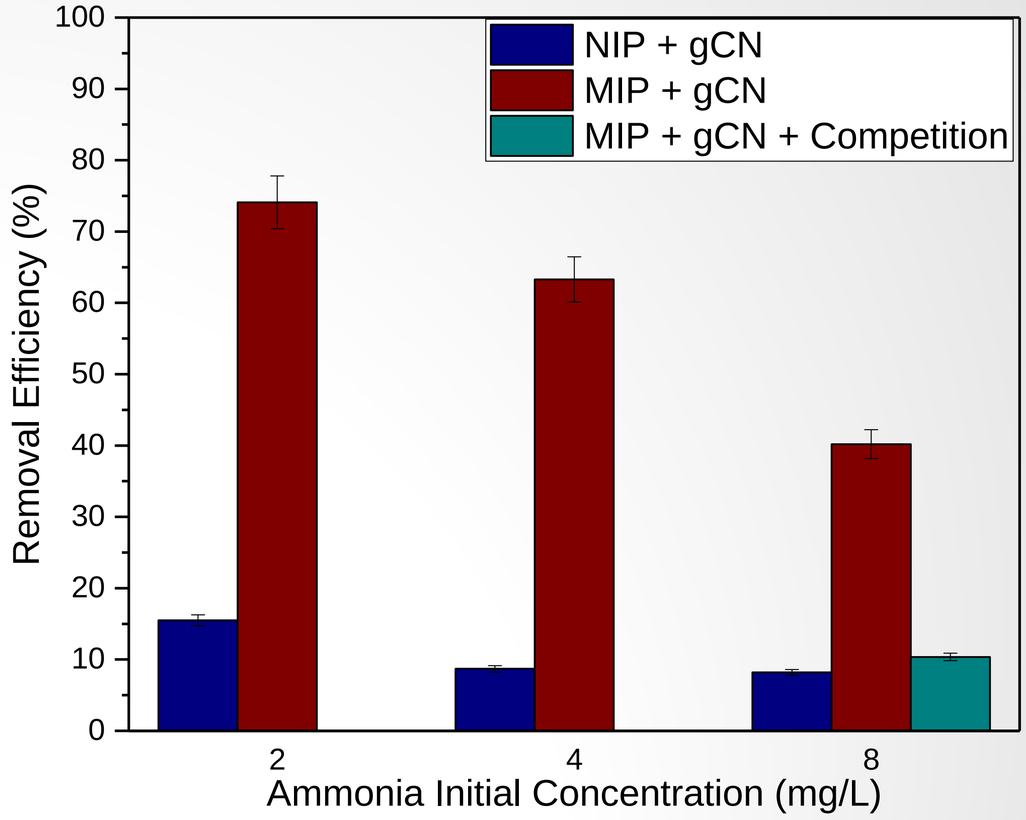
Ammonia	S_{BET} (m^2/g)	Pore size (nm)	Pore volume (cc/g)
g-C_3N_4	162.1	3.062	0.182
NIP	117.2	3.068	0.034
MIP	92.6	3.069	0.015

Performance of Resins

Arsenate Resin

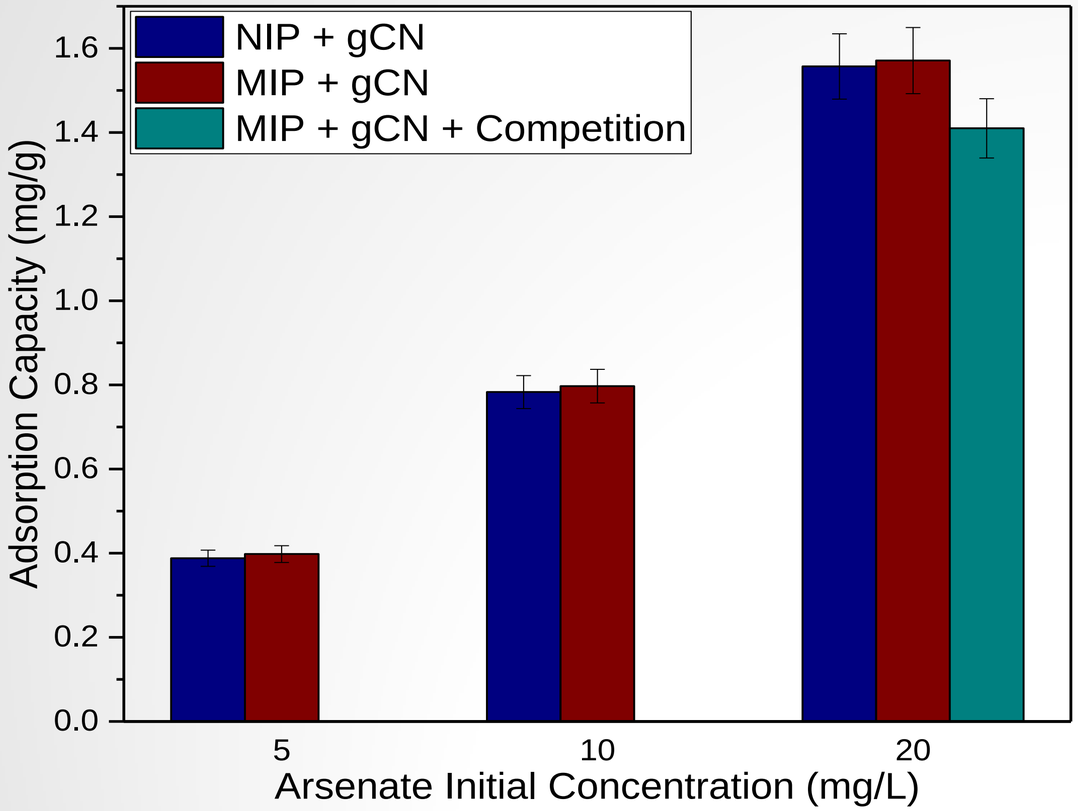


Ammonia Resin

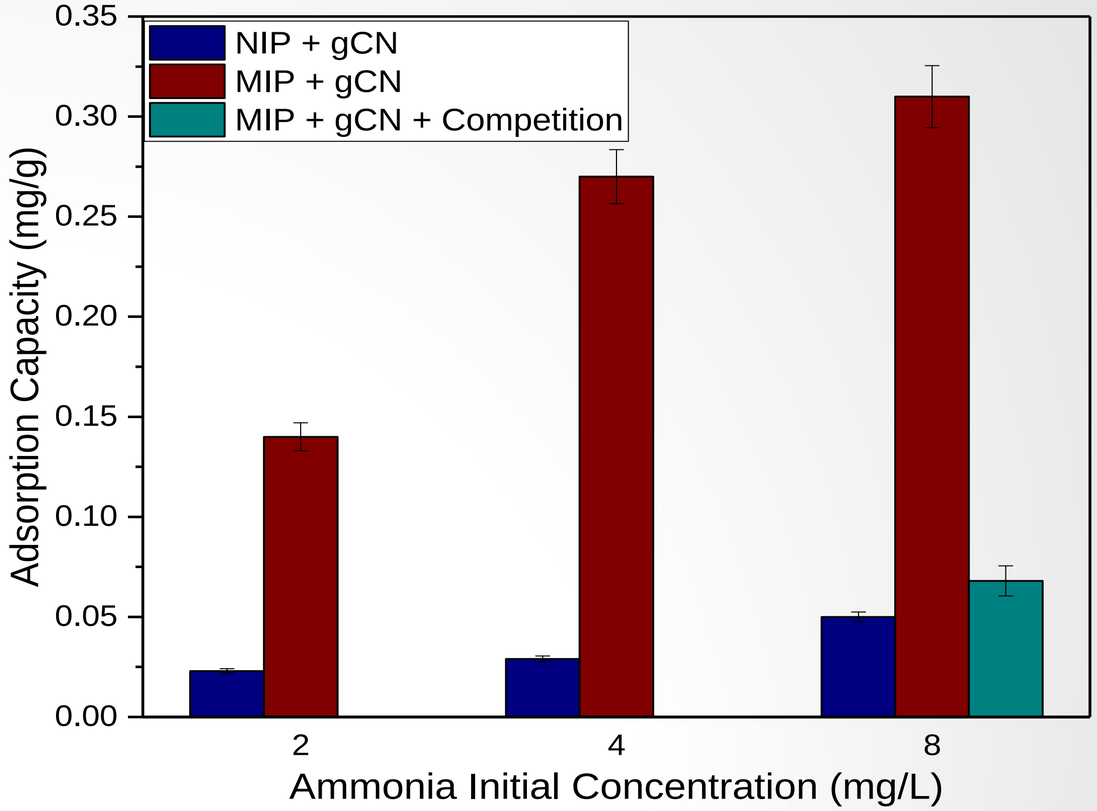


Performance of Resins

Arsenate Resin

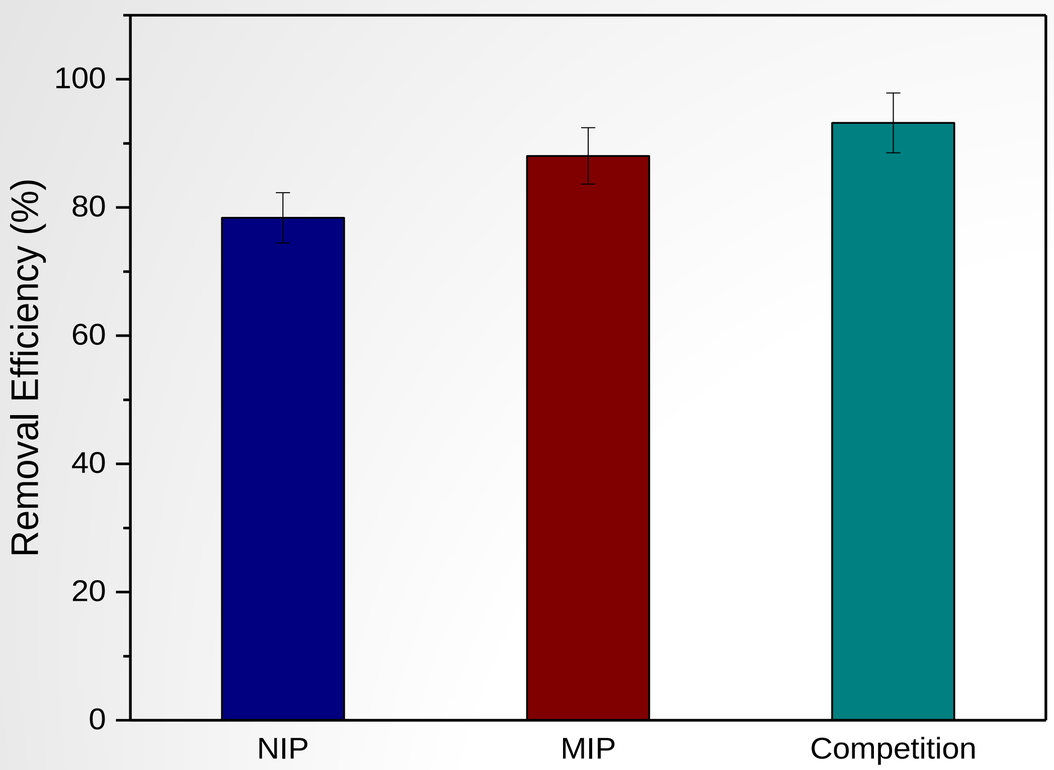


Ammonia Resin



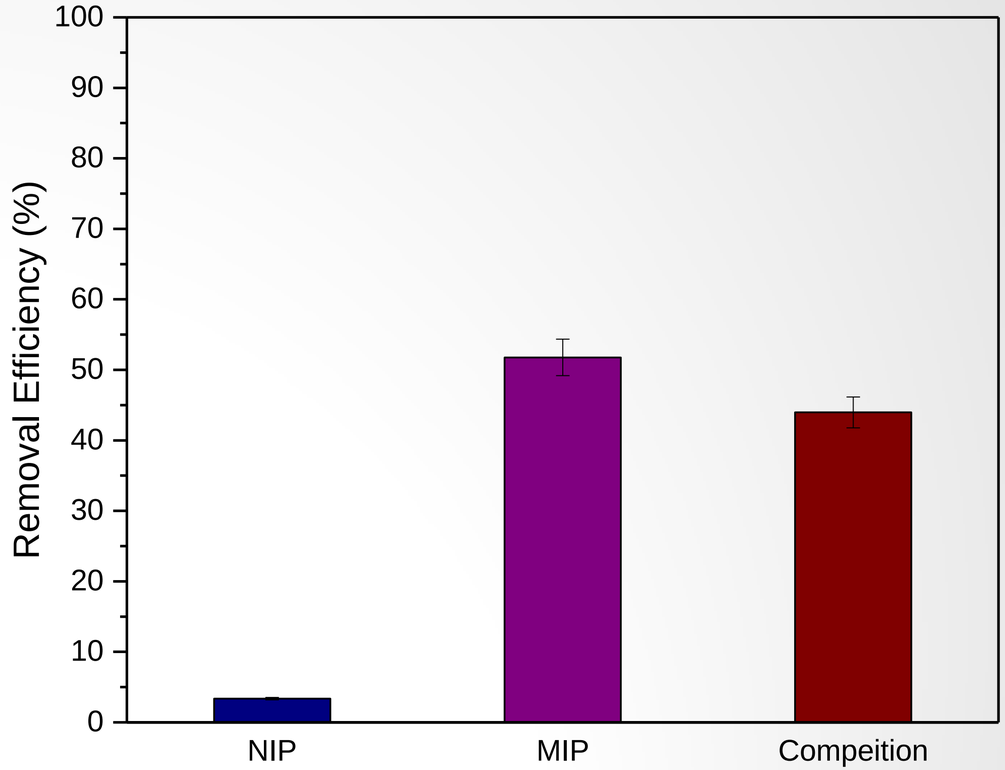
Performance of Membranes

Arsenate Resin



Arsenate initial concentration = 20 mg/L

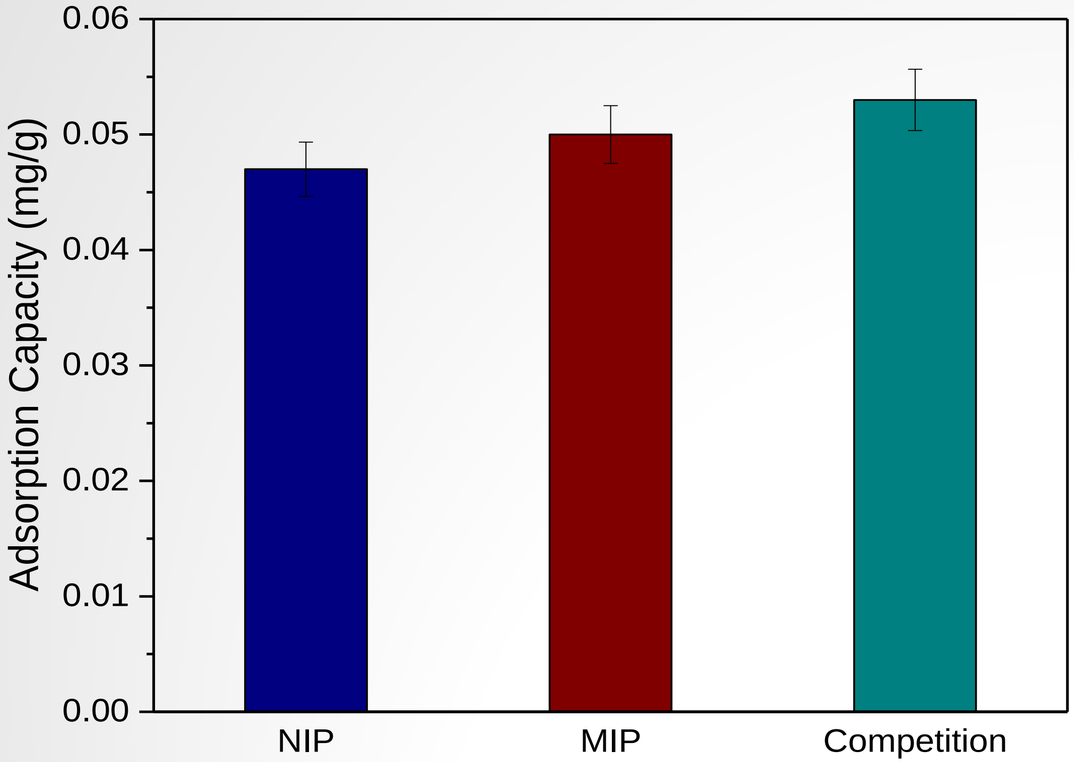
Ammonia Resin



Ammonia initial concentration = 8 mg/L

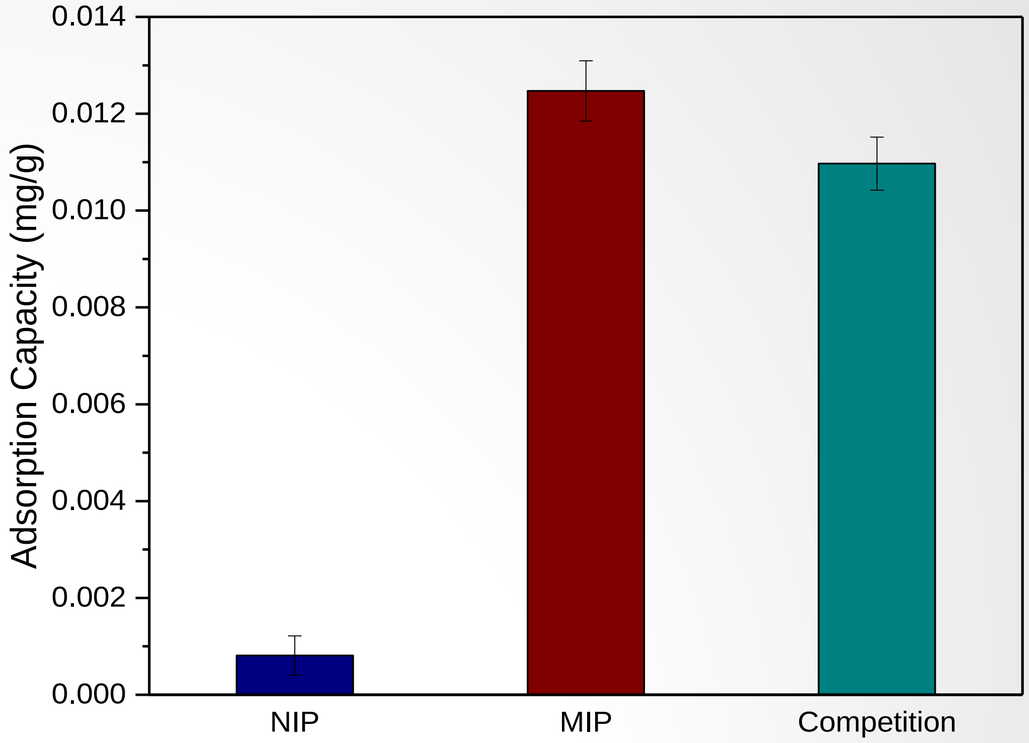
Performance of Membranes

Arsenate Imprinted Membrane



Arsenate initial concentration = 20 mg/L

Ammonia Imprinted Membrane



Ammonia initial concentration = 8 mg/L

Results Summary

- High contaminant adsorption capacity was achieved with the MIP resins and membranes.
- In the case of arsenate, the competition experiments showed an increase in adsorption capacity.
- In the case of ammonia, the resins and membranes still need optimization to increase selectivity.

Future Work

- Improve mechanical strength of imprinted membranes.
- Study the binding strength of the arsenate polymer resins and membranes.
- Expand this work to other contaminants.