College of Engineering | School of Chemical, Biological, and Environmental Engineering

HYDROGEL BEAD DEVELOPMENT FOR MICROBIAL CULTURE ENCAPSULATION

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INTRODUCTION

Groundwater contamination from volatile organic compounds (VOCs) and co-contaminants, such as 1,4-Dioxane (1,4-D), is a widespread issue in the United States

Common remediation techniques (pump and treat) are not sustainable for low permeability zones in the subsurface

Rhodococcus rhodochrous ATCC 21198 is a alkane-oxidizing bacterium capable of degrading some VOCs and 1,4-D
Proposal: Create permeable reactive barriers (PRB) with R. rhodochrous ATCC 21198 co-encapsulated by hydrogel beads to biodegrade contaminants occurring in groundwater aquifers

MATERIALS AND METHODS

Polymer Solutions:
Polyvinyl Alcohol (PVA), Chitosan, Low Acyl Gellan Gum (LAGG), and Sodium Alginate (NaAlg)

Crosslinkers
Borax, Calcium Chloride, Calcium Lactate, Thermal (temperature), and Sulfuric Acid

Combining Solutions:
Mix the individual solutions together on a magnetic stir plate with the desired weight by volume (w/v)

Bead Creation:
Polymer solution is dropped into a crosslinking solution using a pipette
Drops left in crosslinking solution until total gelation is observed
Time tests are performed to tell when total gelation occurs

Main Polymer	% (w/v)	Temperature
PVA	2 - 8	90 C
Chitosan	2	80 C
LAGG	1 - 2.5	60 C
NaAlg	0.5 - 2	25 C

THANK YOU

Researchers:

Conor Harris - Graduate ChemE
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Margaret Newell - 3rd yr Microbio
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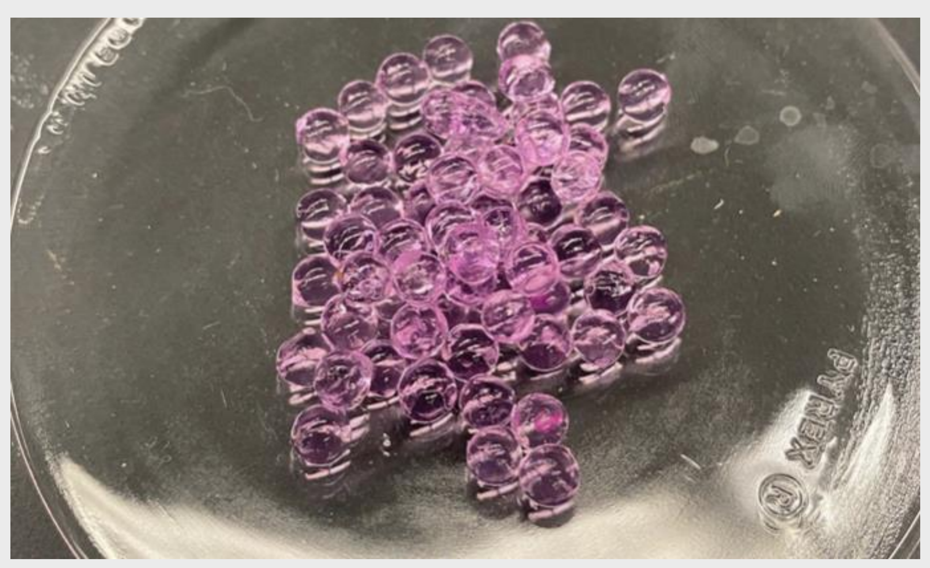
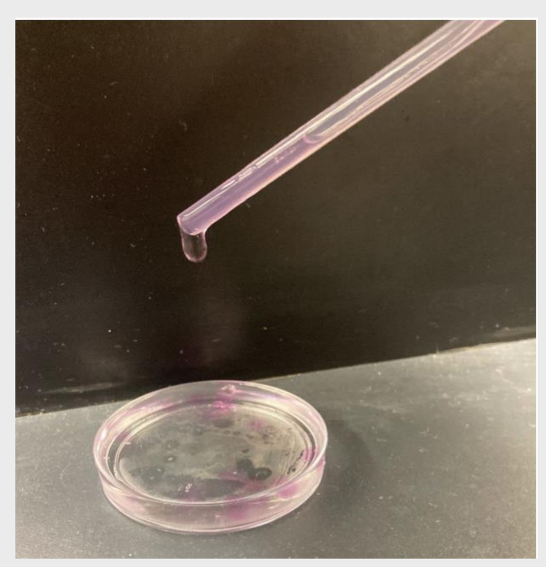
BACKGROUND

Hydrogels are made by crosslinking polymer chains through
Physical crosslinking
Chemical crosslinking
Polymers Explored:
Sodium Alginate (NaAlg): structure
Low-Acyl Gellan Gum: stability
Poly-Vinyl Alcohol (PVA): strength and durability
Chitosan: contains antimicrobial properties

RESULTS

Polymer Combination	% (w/v)	Crosslinker	Properties of Bead formed
PVA	2.0, 4.0, 8.0	Borax	Thick, structureless, gooey
PVA / NaAlg	3.0 / 0.25	Borax / Calcium Chloride	More structure compared to just PVA, precipitate formed prevented crosslinks
PVA	4.0	Calcium Lactate	No gelation
PVA	4.0	Calcium Lactate / Borax	More structure then pure PVA, less precipitate formed
Chitosan	3.6	Thermal	No gelation
Chitosan	4.5	Sulfuric Acid	No gelation
LAGG / Chitosan	2.5 / 0.0099	Calcium Chloride / Thermal	Firm, Round, Very strong
NaAlg / PVA / LAGG	0.50 / 1.3 / 0.33	Calcium Chloride / Thermal	Round, Strong and Uniform beads
NaAlg / PVA / LAGG	0.50 / 1.3 / 0.33	Calcium Lactate	Similar properties to Calcium Chloride but weaker and longer gelation time.
NaAlg / PVA / LAGG	0.50 / 1.3 / 0.33	Calcium Lactate / Borax	Less rigid and weakened structure, compared no beads where PVA was not crosslinked
NaAlg / PVA / LAGG / Chitosan	0.49 / 1.3 / 0.33 / 0.0013	Calcium Chloride / Thermal	Gelation upon mixing LAGG and Chitosan, Unable to bead



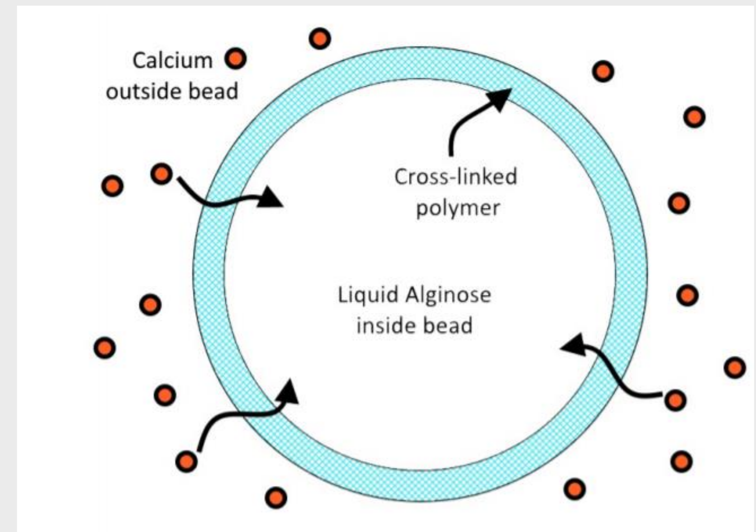


OVERVIEW

Purpose: encapsulate microorganisms in hydrogel beads which degrade contaminants (1,4-dioxane) to treat groundwater

SHORT TERM goal: create durable beads capable providing a sustainable environment for the microorganisms

LONG TERM goal: find the best process to encapsulate the microbes and then scale up the production of the beads



FUTURE WORK

- Moving forward with the NaAlg, PVA, and LAGG polymer solution using the following crosslinking agents

- Cold calcium chloride solution

- Cold calcium lactate solution

- Introduce R. rhodochrous ATC 21198 to hydrogel beads for inspection of growth, degradation, and stability

-Growth will be monitored and recorded through isobutane uptake test in batch reactors

-Degradation will be tested via pilot scale bioreactor to emulate a groundwater aquifer

- Mass production of gel beads containing microorganisms possibly through capillary extrusion

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