Micropatterned hydrogels in microfluidic devices

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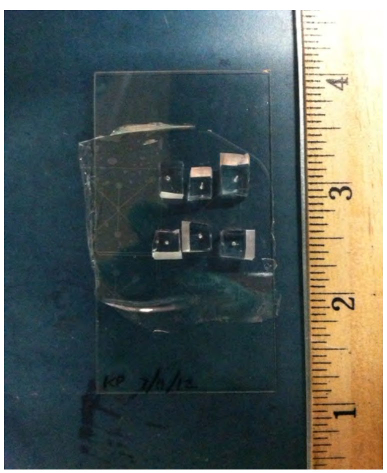
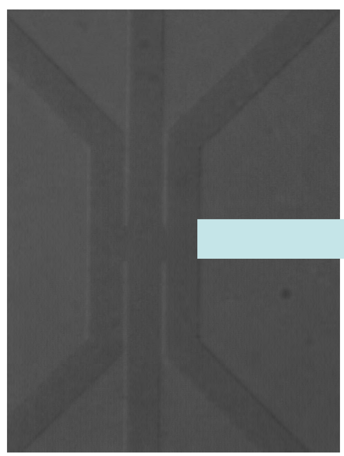
What Are Hydrogels?

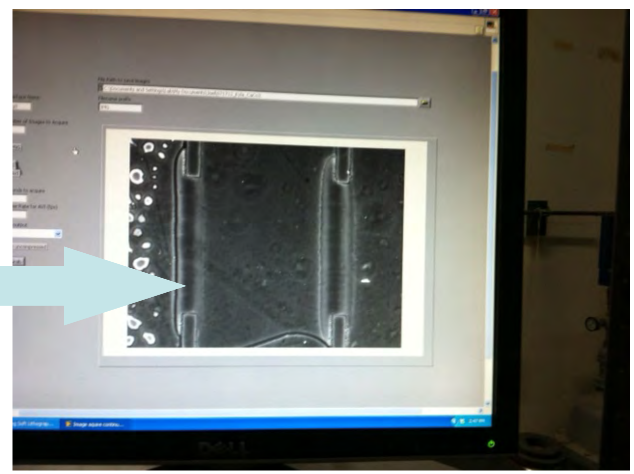
- A semi-permeable material (e.g.,PEG-DA)
- Allows certain chemicals to diffuse through one micro-channel into another
- Stop flow; allow for only diffusion



Microfluidic sticker device



Microfluidic channels

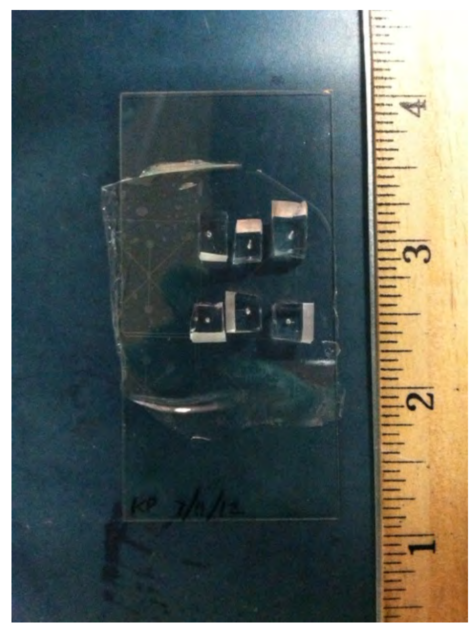


Hydrogels in channel

Uses of Micropatterned Hydrogels

- "Lab on a Chip"
  - Smaller; uses less material, safer, cheaper
  - Allows for more controlled experiments in medicine, bacteriology, cell biology, desalinization, etc.

- Provides more control:
  - Geometry
  - Amount of substance
  - Flow rate/diffusion



Improved Hydrogels

How are these new sticker devices and hydrogels different from previous models?

1. Smaller hydrogel (10µm versus 100µm)
2. Only the hydrogel is permeable
3. More robust device
4. Channels are in a sticker (not PDMS): allows for valves (more control)

Microfluidic Hydrogels

Goals

1. To successfully create a microfluidic sticker device with permeable hydrogels that allow diffusion, but act as a wall to microscopic forces applied to it.

2. To demonstrate the capabilities of a hydrogel like salt diffusion and to characterize attributes like porosity.

Methods-Overview

Part I: Create a useful device

1. Create a “microfluidic sticker” device.
2. Create a patterned hydrogel.

Part II: Demonstrate capabilities and characteristics

3. Salt crystallization
4. Porosity

Methods

1. Creating a "Microfluidic Sticker" Device

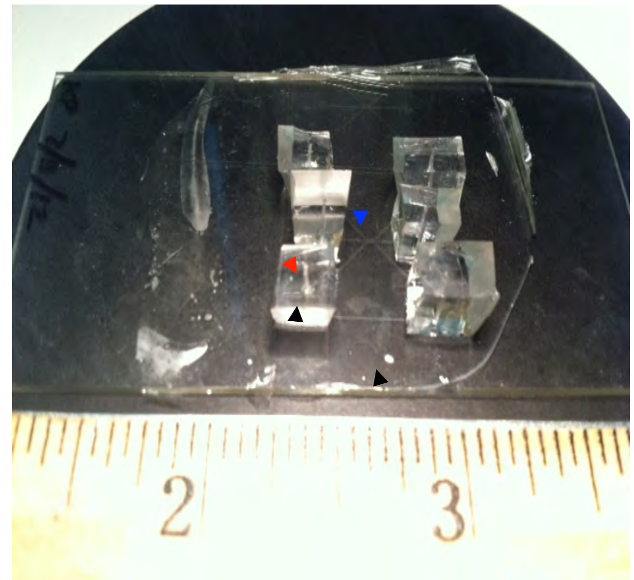
Using:

- glass slide,
- flat PDMS,
- hydrogel channels on PDMS,
- NOA-81 (sticker material),

We create a sticker device that has channels to flow fluid through.

Inlet hole

Channels



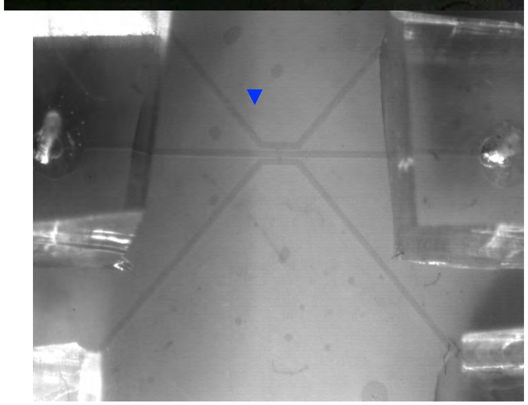
PDMS

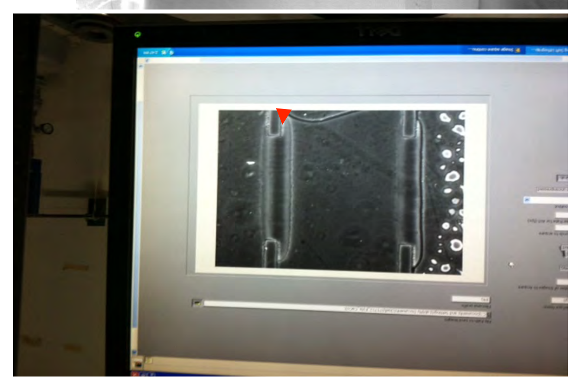
Sticker

Methods

2. Creating a patterned hydrogel

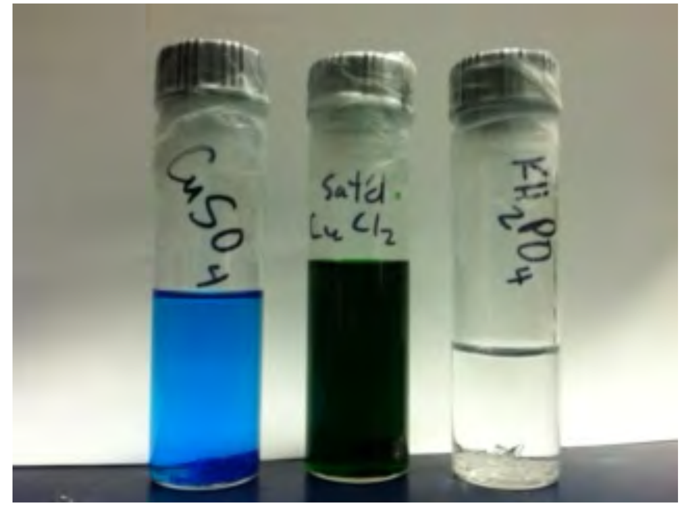
- PEG is flowed through channels
- A photomask allows UV light to ‘crosslink’ the PEG, forming the hydrogel between the open channels





Methods

3. Observing Diffusion Though a Hydrogel



a.) Mix salt with ethanol on a slide under a microscope to predict possible crystallization:

--Copper chloride

–Copper (II) sulfate

–Potassium phosphate

b.) Observe diffusion of ethanol into salt solution through a hydrogel:

Methods

4. Measuring porosity of a hydrogel

•regulating pressure of water in the side channels

•calculate velocity of the photo beads in middle channel

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Flow of photobeads in water-video by Joel Paustian.

Results

Previous Observations of Diffusion Through a Hydrogel

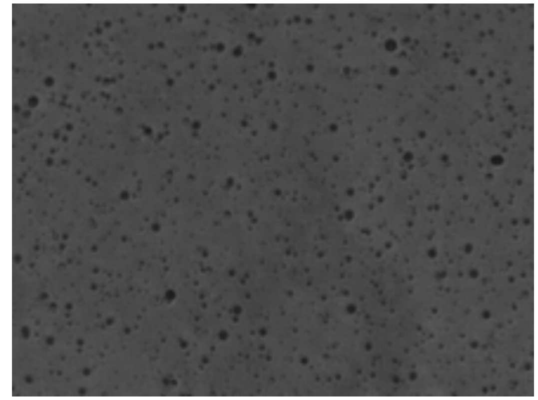
- Ethanol decreases solubility of potassium chloride as it flows through the hydrogels, inducing crystallization.

Courtesy of Joel Paustian

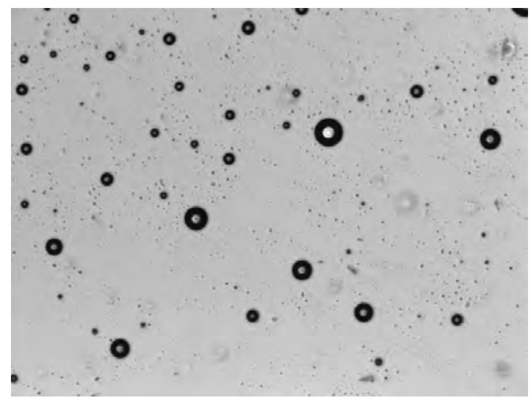
Results

Predicting crystallization through the hydrogel:

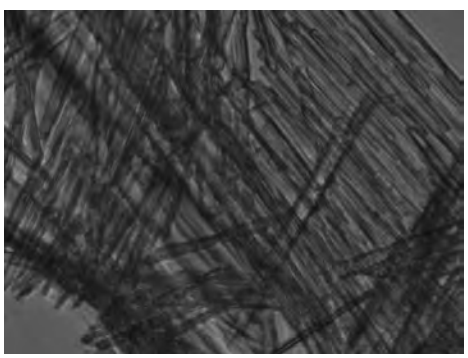
1. Copper chloride
2. Copper (II) sulfate
3. Potassium phosphate



$CuSO_4$



$CuCl_2$



KH_2PO_4

Results

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- Only *potassium phosphate* showed an interesting crystal structure as it diffused through the hydrogel.

Results

Measuring Porosity

- The hydrogels (PEG) became too crosslinked for me to observe any flow and therefore porosity could not be measured.

Analysis

- Potassium phosphate makes a more interesting crystal pattern than the copper solutions.
- Lack of flow would indicate that the porosity of a hydrogel is very small.
- Porosity of a hydrogel is difficult to predict as it is influenced by many factors such as:
  - Time of exposure to UV light
  - Brightness of light
  - Concentration of PEG

Discussion

- What can go wrong, will go wrong:
  - Air bubbles in channels, blocking flow
  - Missing a step in methods- I forgot to cure the sticker with UV light
  - Longevity of hydogel by crosslinking: oxygen added to the PEG initially inhibits cross-linking, but this is time-sensitive
  - Malfunction or broken equipment- photomask burned, allowing for too much light which crosslinked PEG, stopping flow in channels.

•Each step has been discovered and implemented for a reason.

Conclusions

- Hydrogel technology will allow for more controlled experiments on a much smaller scale.
- Characterization and experimentation with hydrogels will promote more useful micro fluidic devices in the future.
- Hydrogels are most effective when porosity is decreased, allowing only for diffusion.

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