

# Micropatterned hydrogels in microfluidic devices

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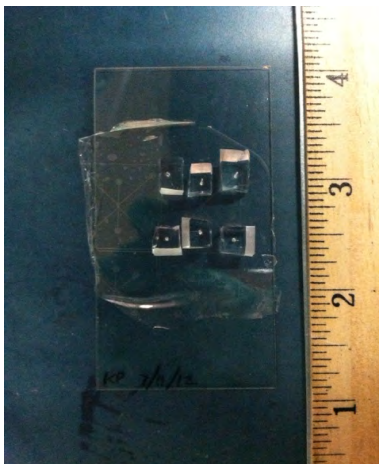
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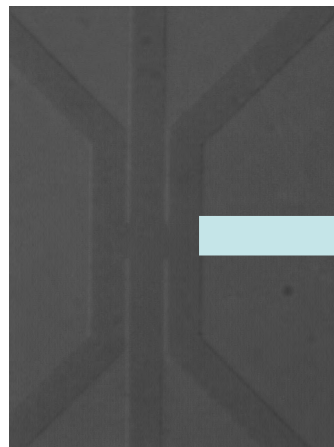
Squires Group, UCSB Chemical  
Engineering

# What Are Hydrogels?

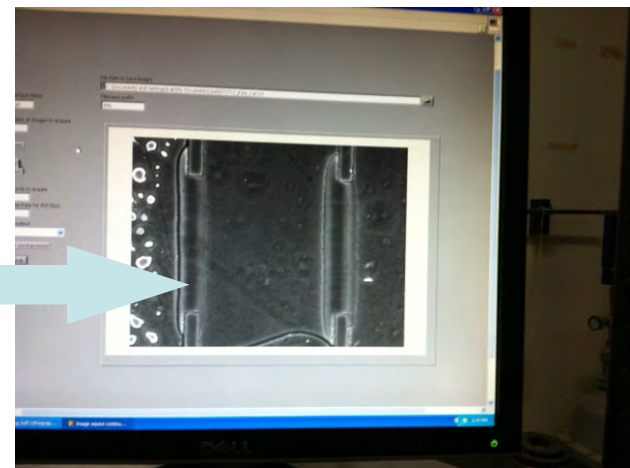
- A semi-permeable material (e.g., PEG-DA)
- Allows certain chemicals to diffuse through one micro-channel into another
- Stop flow; allow for only diffusion



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 ( $10\mu\text{m}$  versus  $100\mu\text{m}$ )
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

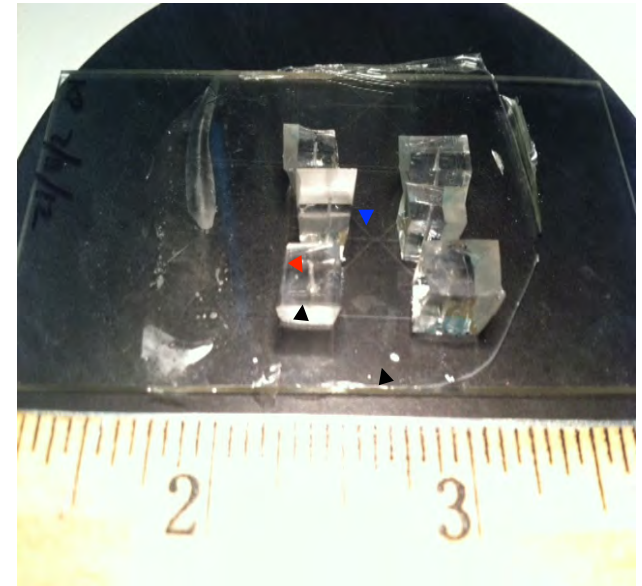
Using:

- 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

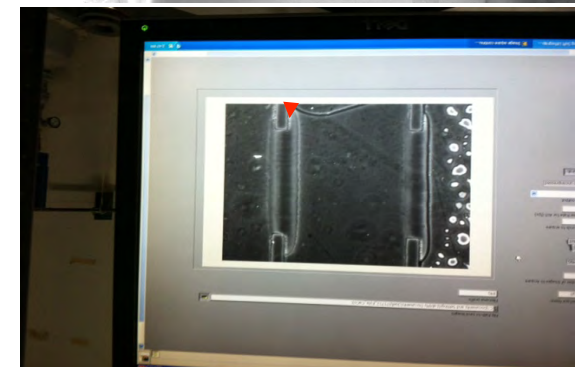
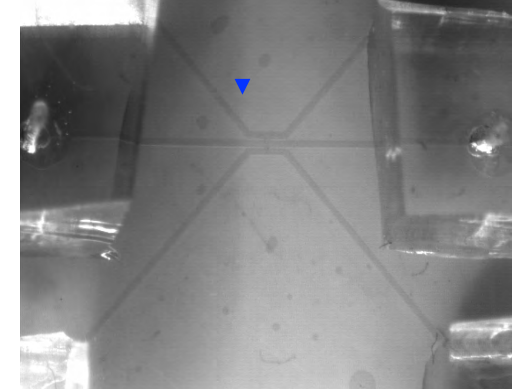
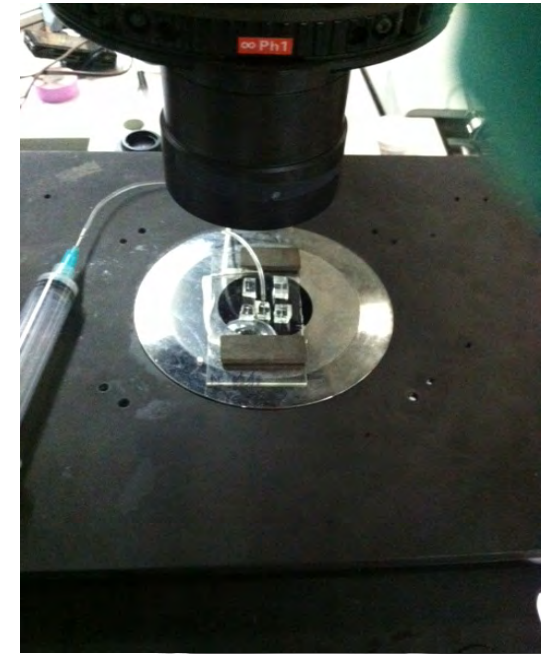


Sticker

# Methods

## 2. Creating a patterned hydrogel

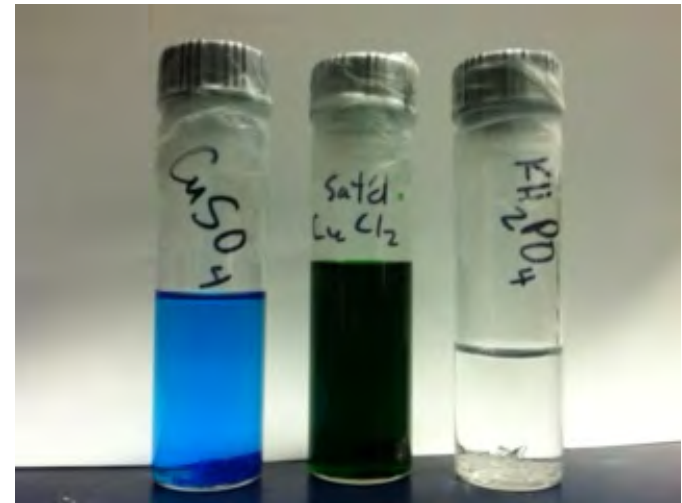
- PEG is flowed through channels
- A photomask allows UV light to 'crosslink' the PEG, forming the hydrogel between the open channels





# Methods

## 3. Observing Diffusion Through 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*

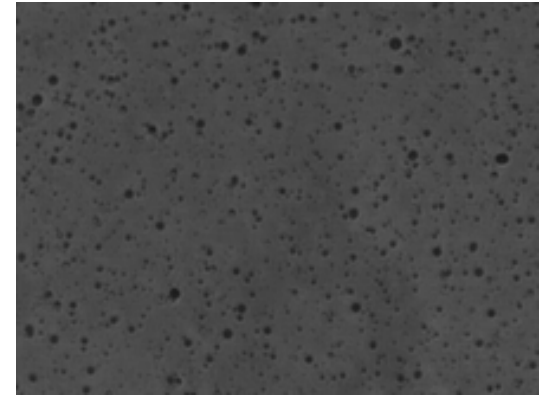
- Ethanol decreases solubility of potassium chloride as it flows through the hydrogels, inducing crystallization.

Courtesy of Joel Paustian

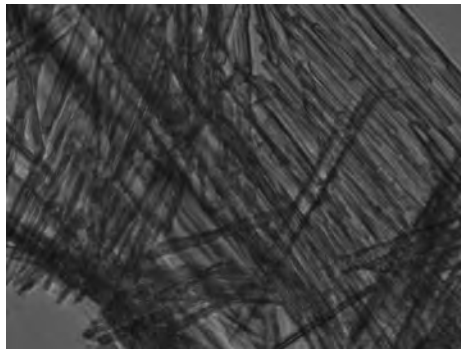
# Results

Predicting crystallization through the hydrogel:

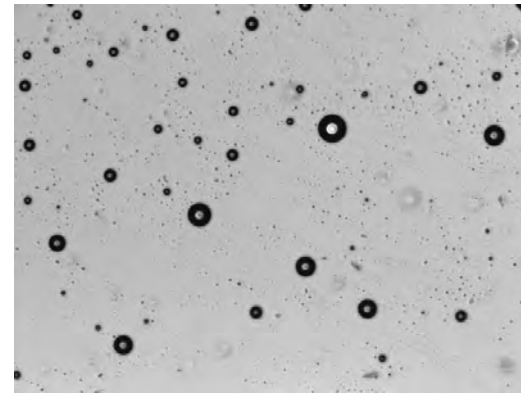
1. Copper chloride
2. Copper (II) sulfate
3. Potassium phosphate



CuSO<sub>4</sub>



KH<sub>2</sub>PO<sub>4</sub>



CuCl<sub>2</sub>

# Results

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



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# 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 hydrogel 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.

# Acknowledgements

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