Micro-bioreactors Controlled with Photonic Ionogel Actuators

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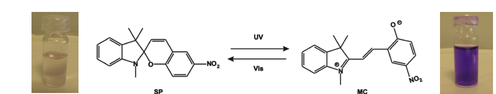
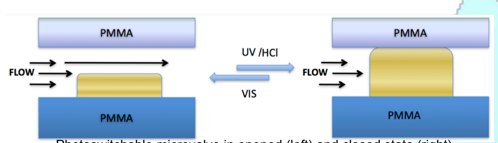
1. Abstract

In the recent years, advances in micro-fluidic techniques for environmental applications have brought wide opportunities for improving of the capacity to monitor water quality. However, the development of fully integrated micro-fluidic devices capable of performing complex functions requires the integration of micro-valve with appropriate performance, since they are essential tools for the control and manipulation of flows in micro-channels.[1] Ionogels with incorporated spiropyran can be used as valves by photopolymerizing the gels in certain shapes. Depending on the ionic liquid, ionogels give the possibility of tuning several micro-valve actuation times and so independently control liquid flows within the channels under a common illumination source.[2]

2. Introduction

- Ionogel containing spiropyran expands when immersed in HCl and contracts with white light back, and due to this property it can be used as a valve to block microchannel as shown below.
- Non invasive stimuli such as light offers improvements in versatility using manifold fabrication and control of actuation mechanism.



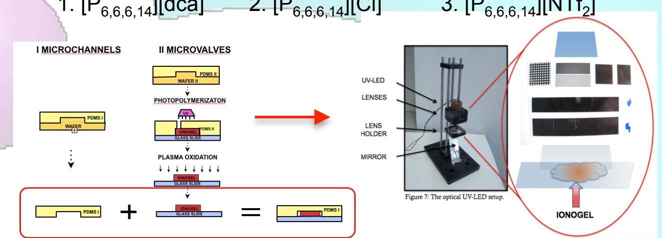


Photoswitchable microvalve in opened (left) and closed state (right).

3. Methods

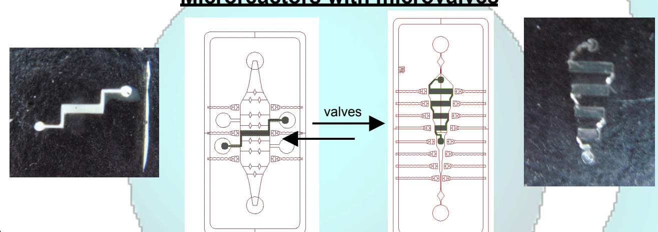
Fabrication of microstructures and microreactors

Fabrication of microstructures with three different ionic liquids:
1. $[P_{6,6,6,14}]$[dca] 2. $[P_{6,6,6,14}]$[Cl] 3. $[P_{6,6,6,14}][NTf_2]$



Fabrication of microreactors (left)microstructures (left) and set up for photopolymerisation of microstructures. (right)

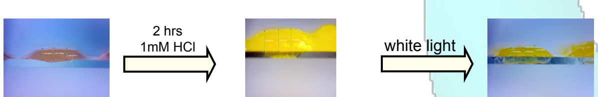
Microreactors with microvalves



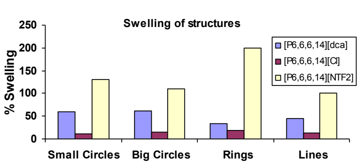
Various types of microvalves for respective microreactor .

4. Results

Swelling and shrinking of microstructures



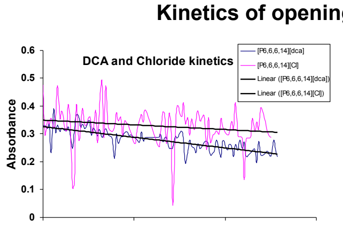
Ionogel in the initial state (left), after 2 hours in HCl (centre) after white light irradiation (right).



Ionic Liquid	% Shrinking after 15 mins
$[P_{6,6,6,14}]$[DCA]	31.8
$[P_{6,6,6,14}]$[Cl]	6.1
$[P_{6,6,6,14}][NTF_2]$	95.8

Swelling of microstructures in different ionogels (left) and shrinking of these after 15 min (right)

Kinetics of opening the microvalve



$[P_{666,14}]$[dca] K= 0.0008

$[P_{666,14}]$[Cl] K= 0.0003

1st order kinetics for $[P_{666,14}]$[dca] and $[P_{666,14}]$[Cl] (left) and kinetic values (above)

5. Conclusion

- Successful fabrication and actuation of photoswitchable microvalves.
- Greatest height change obtained for $[P_{6,6,6,14}][NTF_2]$ with 95.83 %.
- Fastest shrinking obtained for $[P_{6,6,6,14}][NTF_2]$ with 95.8% in 15 mins.
- Successful fabrication of microbioreactors and microvalves.
- Initial kinetics results show the faster response of the microvalve with $[P_{6,6,6,14}]$[dca], with kinetic constant of k=0.0008.

6. Future Work

1. Carry out the kinetic tests for ionogel with $[P_{6,6,6,14}][NTF_2]$ and control tests using UV-Vis spectroscopy.
2. Test the effect of different concentrations of HCl on the kinetics of the valves.
3. Test the performance of the microreactor with dye solutions.

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[1] M. Czugala *et. al.*, Proceedings SPIE 8107, 81070C, (2011); doi:10.1117/12.895330. [2] F. Benito-Lopez *et. al.* Lab Chip 10, (2010), 195-201

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