

Photo-responsive Ionogels: Versatile Flow Control in Micro-fluidic Manifolds

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Nowadays, precise flow control, provision of exact reagent amounts, contamination prevention between reagents, autonomy, disposability and low-cost manufacture are factors that can not be found together for micro-fluidic valves [1-2].

Valves made using photo-responsive gels are of great interest as functional materials within micro-fluidic systems since actuation can be controlled by light irradiation. Nevertheless, their poor versatility, slow response times and limited robustness render them currently as scientific curiosities rather than ideally functioning devices [3].

The incorporation of photo-responsive gels with ILs produces hybrid ionogels with many advantages over conventional materials. For example, through the tailoring of chemical and physical properties of ILs, robustness, acid/ base character, viscosity and other critical operational characteristics can be finely adjusted. Therefore, the characteristics of the ionogels can be tuned by simply changing the IL and so the actuation behaviour of micro-valves made from these novel materials can be more closely controlled.

This paper presents the synthesis, characterization and micro-valve actuation in a micro-fluidic device of novel polymeric materials based on phosphonium ionic liquids (ILs), ionogels. When photo-responsive gels are co-polymerised within different IL matrixes, high versatility in the ionogels actuation can be achieved when incorporated in a micro-fluidic system as micro-valves.

Figure 1 shows the chemical polymerization strategy of four different ionogels at two different photo-responsive monomer concentrations and their physical robustness' structure.

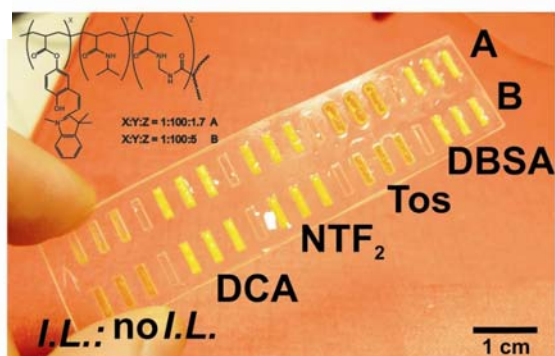


Figure 1 Chemical structure of the photo-responsive gel (up-left side of the picture) and four phosphonium ionogels polymerised in a (1×2 mm) PMMA mould.

Photo-control of the micro-valve by localised light irradiation was demonstrated using the micro-fluidic device shown in Figure 2a. A drop of solution containing a strongly coloured dye was placed in each inlet whilst in the outlet vacuum was applied as a fluidic driving force. Virtually equal amounts of visible light were irradiated to

all ionogel micro-valves, and they were found to open at different times as shown in Figure.2b-f: No IL: 2s; DCA: 4s, Tos: 18s; DBSA: 44s; NTF₂: 49s. The results demonstrate that local light irradiation allows the independent control of multiple micro-valves, while the synthesis of ionogels with different ILs enables distinct valve actuation. Moreover, it is possible to reuse the micro-valves repeatedly. This approach provides non-contact operation and flexible manipulation of liquid movement in complex micro-fluidic devices as well as parallel control of multiple micro-valves with a single light source.

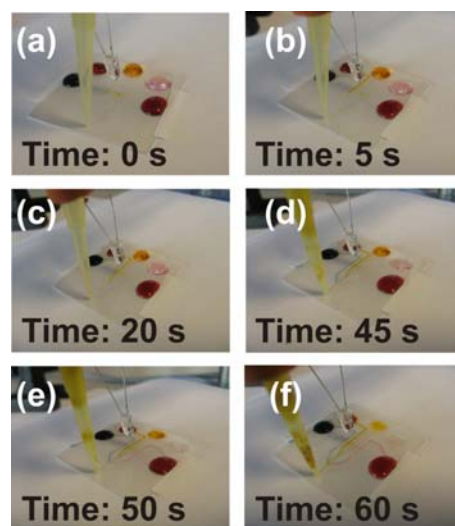


Figure 2 a) Micro-valves closed; vacuum is unable to pull the dyes through the microchannels. White light is applied for the time specified in each picture b) 'No IL' valve is first to actuate followed by phosphonium DCA, c) Tos valve opens, d) DBSA valve opens, e) NTF₂ valve opens; f) all valves are open.

References

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3. Sugiura, S., Sumaru, K., Ohi, K., Hiroki, K., Takagi, T., Kanamori, T., *Sens. Actuators A*, **2007**, 140, 174 –184.