Next Generation Autonomous Analytical Platforms for Remote Environmental Monitoring

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Introduction:

Current flow control solutions in analytical platforms have high power consumption and are prone to mechanical failure.
To scale down such analytical platforms and enable them to be incorporated into wireless sensor networks we believe that revolutionary flow manipulation solutions are needed,[1] and they are possible by the integration of stimuli responsive materials in micro-fluidic devices.

Stimuli-responsive materials can: **Shrink, Bend & Move.**

After applying one of the follwing: **Light, Magnetic field or Heat.**

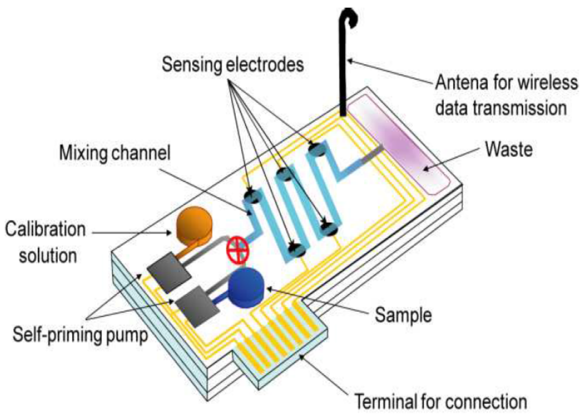


Figure 1. Schematic of an ideal wireless sensor micro-fluidic platform.

The use of flow controllers made out of there materials will dramatically decrease power consumption and device size, reducing manufacturing cost and scaling up device production, Fig. 1. Research in this field will allow better water quality and environment monitoring by enabling live water analysis over large and remote areas

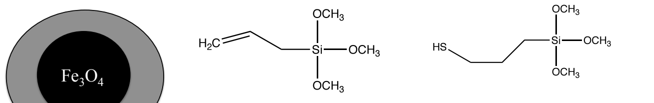
Aim:

- Generate and control liquid flow within micro-fluidic manifolds using smart, stimuli responsive materials.
- Synthesis, characterisation and development of magnetic-responsive materials.
- Synthesis, characterisation and development of photo-responsive materials.
- Fabrication, manufacturing and testing of actuators for micro-fluidics devices for water monitoring.

Experimental:

Magnetic responsive material: Fe_3O_4 particles

Magnetic Fe_3O_4 particles were coated with polymer linking groups such as allyltrimethoxysilane (ATMS) or (3-mercaptopropyl)trimethoxysilane (MPTMS), Fig. 2. These coated particles and N-isopropylacrylamide monomer (NIPAM) were dissolved in a hydrophobic ionic liquid, Trihexyl-tetradecylphosphonium dicyanamide $[P_{6,6,6,14}][DCA]$,[2] and then heated to form a soft magnetically actuated ionogel, Fig. 4.



allyltrimethoxysilane
ATMS

(3-mercaptopropyl)trimethoxysilane
MPTMS

Fig. 2. Schematic representation of the magnetic nano particle. The grey outer shell consists of ATMS or MPTMS coating

Light responsive material:

The same *N*-isopropylacrylamide and ionic liquid were linked with a light responsive spirooxazine molecule. The switching of the molecule induces hydrophilic-hydrophobic changes in the polymer chains

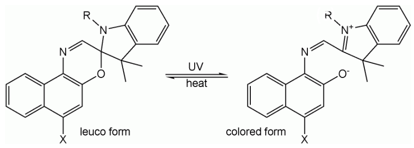


Fig. 3. An example of a spirooxazine molecule which opens in ultraviolet light (hydrophilic state) and closes in visible light (more hydrophobic state)

Results:

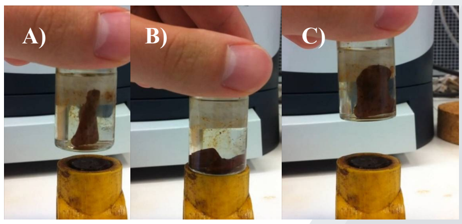


Fig. 4. Magnetic ionogel contracts rapidly after placing above a permanent magnet (A-B). After removing the magnetic field (C) the gel returns to its original shape quickly and reversibly.

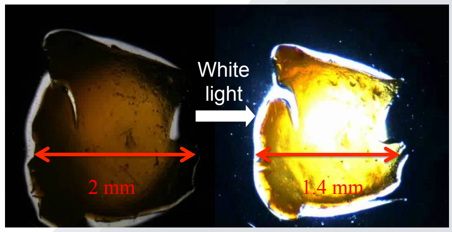


Fig. 5. The photo-responsive iongel shrinks as the contained spirooxazine molecule closes in white light.[3] In this example the volume of the spiropyran-NIPAM-$[P_{6,6,6,14}][DCA]$ ionogel decreases by 30 %

Conclusions and future work:

- The synthesis and characterisation of magnetic ionogels has been carried out.
- Photo-responsive ionogels work as valves in micro-fluidic devices.[3]
- Both materials require minimum energy to activate: permanent magnets and low power consumption LEDs.
- Non toxic and hazardous substances contained in these materials allow them to be used for environmental monitoring systems.
- Magnetically actuated gels will be incorporated into microfluidic devices as pumping elements

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References

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[3] F. Benito-Lopez, R. Byrne, A. M. Raduta, N. E. Vrana, G. McGuinness and D. Diamond, *Lab Chip*, 2010, **10**, 195-201.