Applications of Novel Functional Materials: from Microfluidics to Chemical Sensing

Fernando Benito-Lopez,[1] Robert Byrne,[1] Shirley Coyle,[1] Silvia Scarmagnani,[1] Zarah Walsh,[2]

Dermot Diamond[1]

[1]CLARITY: The Centre for Sensor Web Technologies, [2]Irish Separation Science Cluster.
National Centre for Sensor Research, School of Chemical Sciences, Dublin City University

Novel functional materials offer unique capabilities hitherto inaccessible using conventional materials. In particular, we focus on photo-controlled guest binding and release, inherent signalling of status, photo-actuation and solvent driven motion of small structures as examples of the fascinating behaviour of these exceptional materials.

We have shown that by integrating the beneficial characteristics of PDMS micro-fluidic devices and spiropyrans dyes, a micro-chip configured as an on-line photonically controlled self-indicating system for metal ion accumulation and release can be realised. Moreover, spiropyran functionalised micro-beads were incorporated into micro-fluidic flow systems, such as capillary separation columns. In addition, photochromic monolithic scaffolds were synthesised within polytetrafluoroethylene coated fused silica capillaries and used as stationary phases in micro-chips to function as photo-controllable electro-osmotic pumps.

Novel multifunctional materials based on ionogels, consisting of a polymeric structure incorporating spiropyran units and phosphonium based ionic liquids, have been used as light-actuated valve structures in micro-fluidic platforms. Through variation of the composition of the ionogels, the micro-valves can be tuned to open at different times under similar illumination conditions. In parallel, the ionogels were soaked in ethanol and then transferred to water, where they moved spontaneously. This movement is driven by the expulsion of the ethanol from the gel and subsequent ethanol spreading at the air-water interface. We have investigated this solvent driven motion for as a driving force for moving small objects in aqueous media.

We have also developed an innovative miniaturised system for continuous measurement of the pH of sample solutions and vapour streams during chemical or biological processes. It consists of a simple barcode sensor with several pH dyes doped in an ionogel matrix which is able to generate a characteristic fingerprint-type colour response within a single "snapshot" for different pH solutions and vapours. As the sensor is based on an ionogel polymer, it has extremely long stability, and the sensor dyes show no measureable leaching into aqueous sample solutions.

Finally a wearable, robust, flexible and disposable micro-fluidic device which incorporates micro-Light Emitting Diodes (μ-LEDs) as a detection system, for real time monitoring of the pH of sweat generated during an exercise period has been fabricated and assessed. In our approach, the sensors are immobilised within ECG electrodes, as this allows the pH measurements to be gathered without changing the conventional form of ECG monitoring during exercise. This provides immediate feedback regarding sweat composition to an athlete and coach, which can be used to optimise the hydration and performance of the athlete.

The project has been carried out with the support of the Irish Research Council for Science, Engineering and Technology (IRCSET) fellowship number 2089 and Science Foundation Ireland under grant 07/CE/I1147.