Versatile Continuous pH Monitoring Barcode System Based on Ionogels

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Introduction

The online monitoring of pH levels in different environments like bio-engineering [1] and industrial chemistry processes [2] is vital for control of the whole process.

There is a great demand for a miniaturised, versatile and autonomous system which does not require the need for sensor calibration.

Here we present an innovative and miniaturisable system able to continuously measure pH of solutions and vapours streams during chemical or biological processes. It is a simple barcode system comprised of several sensitive pH dyes doped in an ionogel matrix.

[1] M-H Wu *et al.* Biomedical Microdevices (2009) 11, 265-273.
[2] M. Blumentritt *et al.* Sensors and Actuators B (2008) 131, 504-508.

Barcode Fabrication

The barcode system shown in Fig. 1 (78 x 24 mm), consisting of nineteen independent reservoirs, is easily fabricated in three layers of poly(methyl-methacrylate) (PMMA) and pressure-sensitive adhesive (PSA) using a CO_2 ablation laser (Fig. 2).

The ionogel is photo-polymerised in the reservoirs and the dyes are doped into the ionogel.

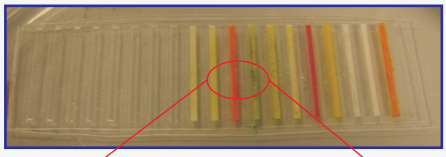
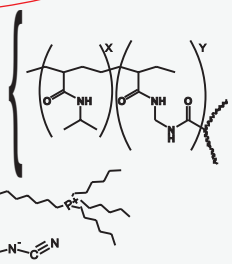


Figure 1: barcode system.

Figure 2: Fabrication of the barcode

COMPONENTS: poly(*N*-isopropylacrylamide)
N,*N*-methylene-bis(acrylamide)
dimethoxy- phenylacetophenone
(photo-initiator)



IONIC LIQUID: $[P_{6,6,6,14}][dca]$

POLYMERISATION: UV irradiation 365 nm.

DOPING: 5 µL ethanol solution of each of the dyes is pipetted over the ionogel and left till dry. Then, the barcode system was washed in ethanol and in water several times until no leaching of the dyes was observed.

Acknowledgments

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Characterisation

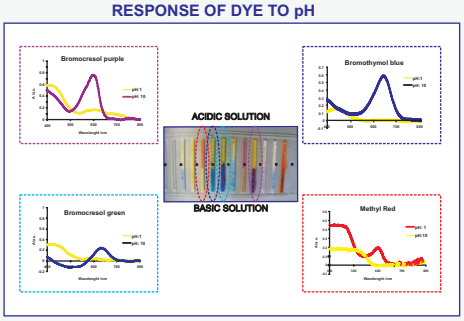

Figure 3: Barcode system with several pH indicators at pH 1, up side part of the barcode, and pH 10, down part side of the barcode and their UV-Vis spectra at both pHs, for four pH indicators.

Figure 4: Snapshots of the barcode during real time pH monitoring.

Results

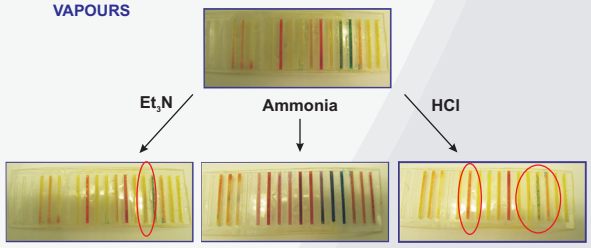

Figure 6: Barcode system after contact with different vapours streams.

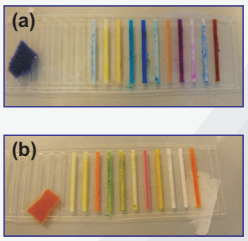

Figure 5: Barcode system at pH 10 (**a**) and pH 2 (**b**).

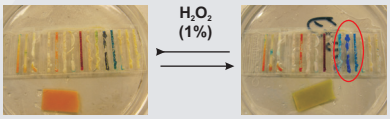

Figure 7: Barcode after 55 experiments.

Conclusions

A novel pH sensitive hybrid material, an ionogel, was fabricated from an hydrogel polymer and an ionic liquid.

Optically responsive molecular recognition ligands (pH-dyes) were incorporated in the ionogel matrix during photo-polymerisation of the monomers.

No leaching of pH dyes occurred during experiments.

The ionogel material was impressively robust under harsh conditions.

The barcode is used as a pH-sensor array for specific sensing applications like colorimetric, environmental or chemical sensing.

The barcode is able to generate a characteristic fingerprint-type colour of response within a single "snapshot" for different pH solutions and vapours.

Moreover the pH response can be monitoring continuously and the barcode is reusable at least fifty times without sensitivity withdrawing.