Adaptive Polymeric Materials: Developing Integrated Opto-Chemical Sensors in Micro-Fluidic Devices

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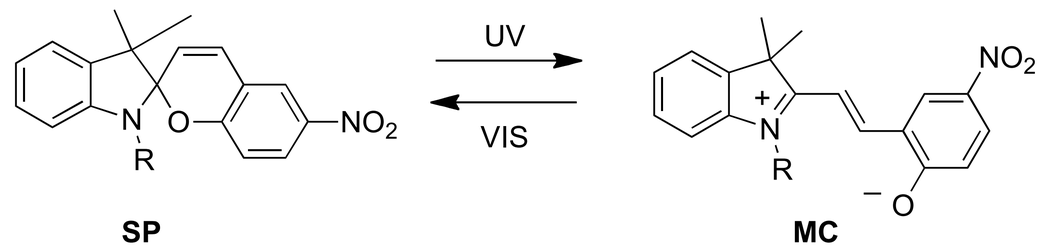
INTRODUCTION

Polymer brush coatings containing the photochromic molecule, spiropyran, or the conducting polymer, polyaniline, were synthesised on the interior of micro-capillaries and micro-fluidic channels using the "grafting from" approach. Due to their switchable sensing capabilities, these coatings can be successfully used for metal ion- and pH- sensing, respectively, in continuous flow mode.

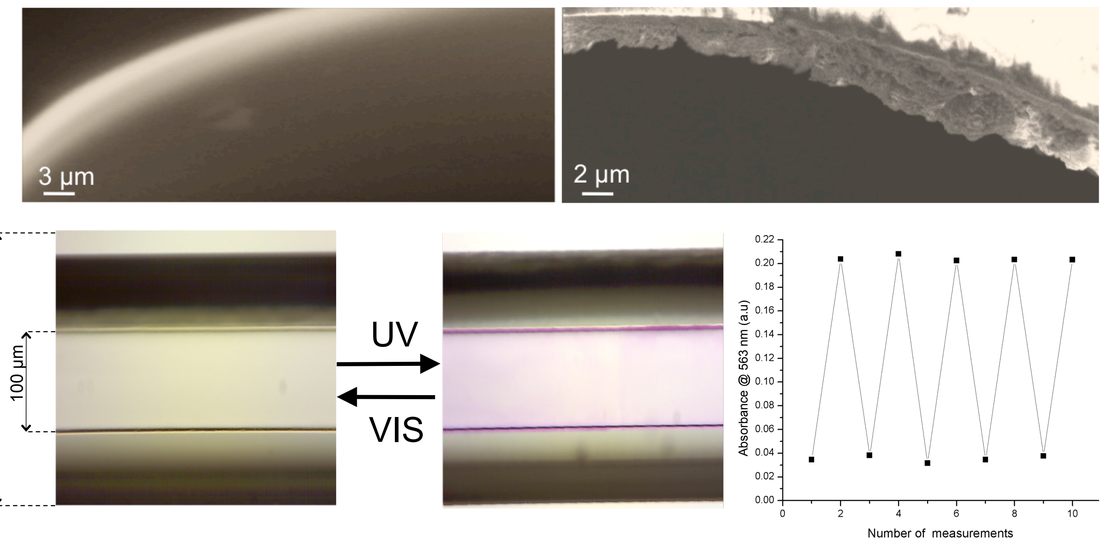
METAL IONS SENSING

The photocromism of spiropyrans is due to photocleavage of the C–O spiro-bond of the colourless spiropyran (SP) upon UV irradiation, producing the coloured merocyanine (MC) that can return to the SP form by ring closing under visible light.

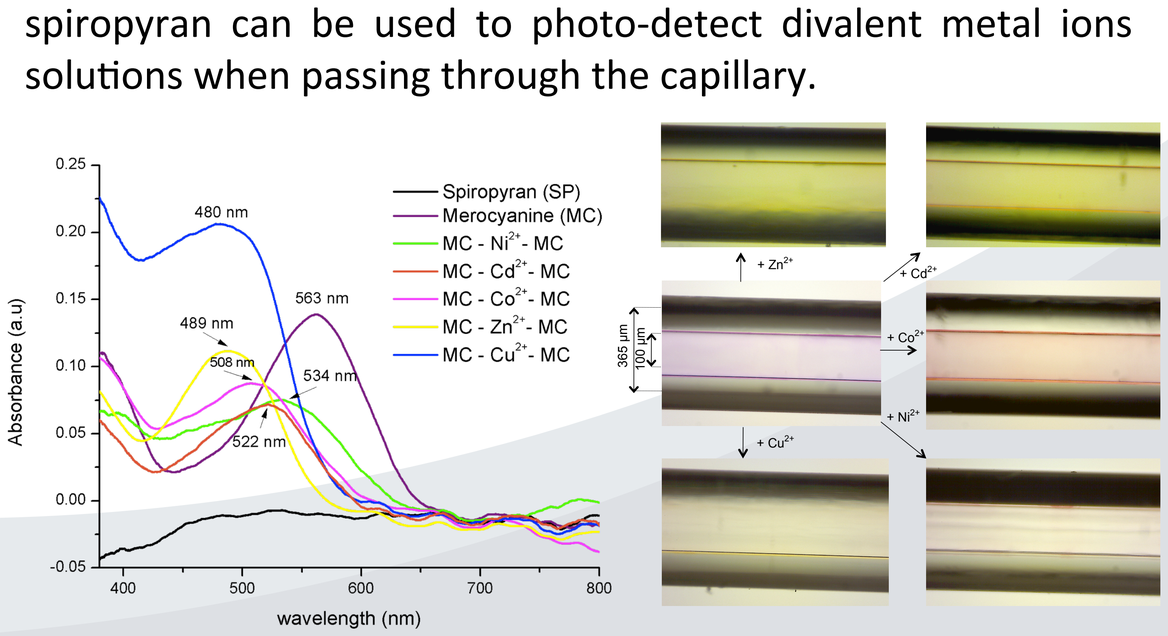


SPIROPYRAN-BASED COATINGS

Spiropyran based coatings were obtained in the interior of fused-silica micro-capillaries (100 μm I.D.) using ring-opening metathesis polymerisation of an appropriate spiro-monomer. The coatings obtained are covalently attached to the inner wall of the micro-capillary and inherit the photocromic proprieties of the spiropyran, showing no photobleaching.

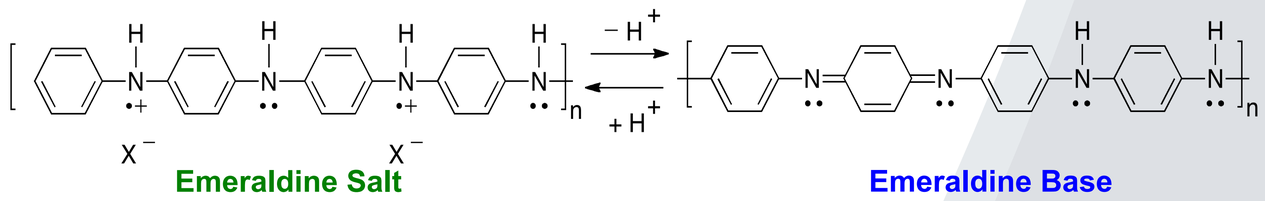


The open MC form exibits particular metal ion binding proprieties - this behaviour is not manifested by the closed spiropyran form. Photoswitchable coatings based on spiropyran can be used to photo-detect divalent metal ions solutions when passing through the capillary.



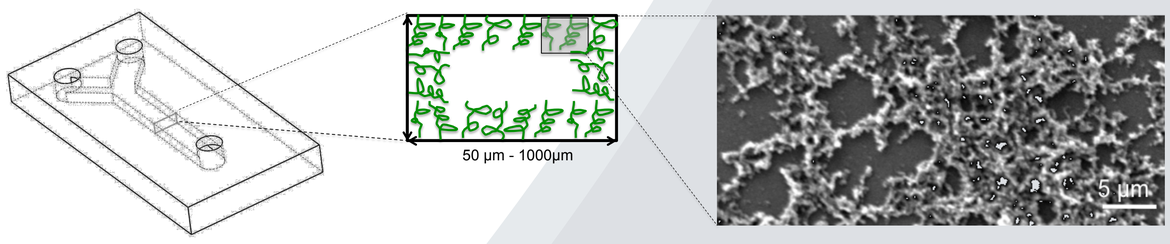
pH SENSING

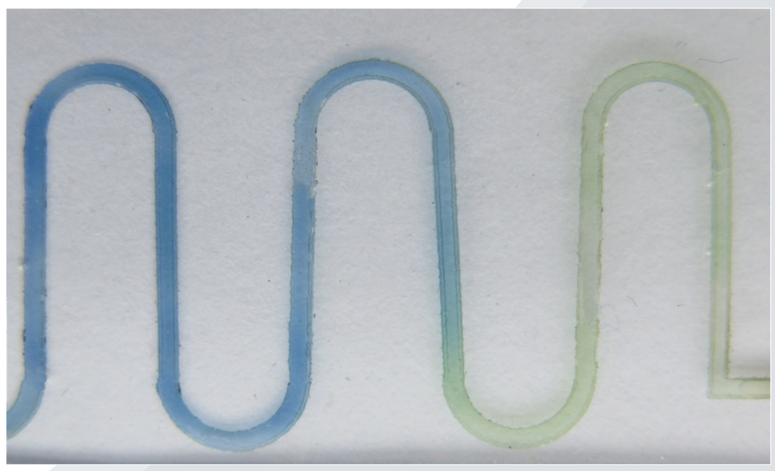
Polyaniline (PAni) is an example of a conducting polymer whose properties (optical/electrical) change in response to variations in the immediate environment of the material. The emeraldine base form (blue) can be reversibly doped with acidic species to the emeraldine salt (green). This property makes polyaniline coatings a new tool for the developing of optical pH sensors.



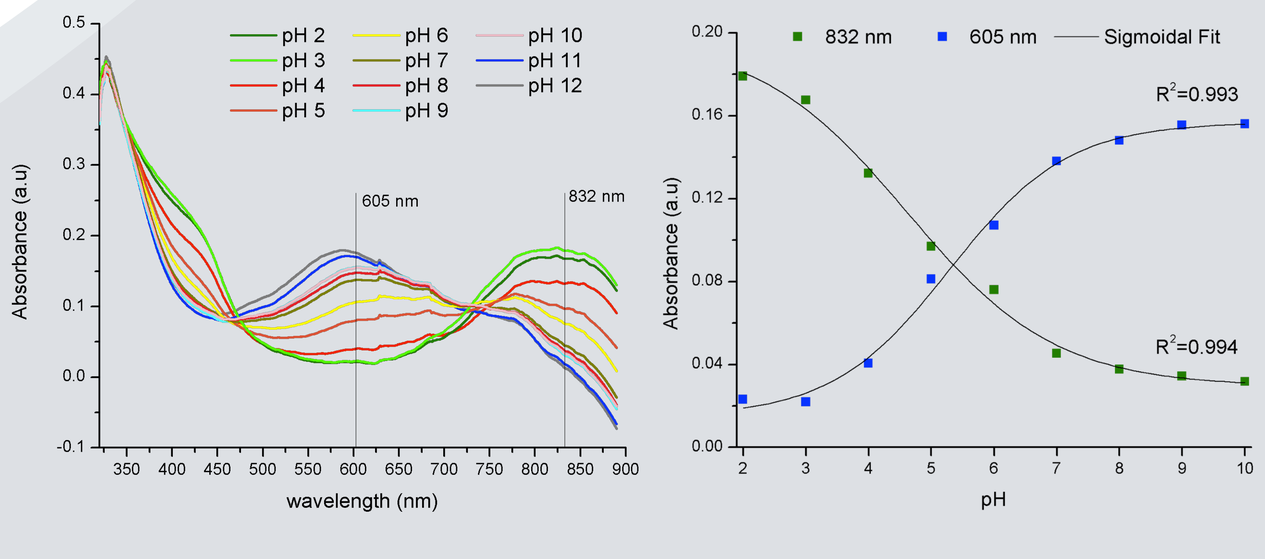
POLYANILINE-BASED COATINGS

Using the "grafting from" approach, polyaniline nanofibres, covalently attached to the inner wall of the micro-fluidic channel are obtained. Their nano-configuration ensures short diffusion paths and therefore fast response times.





UV–Vis spectra of PAni coatings are measured for each pH solutions that is passed through the channel. Moreover, the PAni coatings have the ability of sensing pH gradients induced in the micro-channel.



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