11th International Conference
on Advanced Materials

Rio de Janeiro Brazil
September 20 - 25

ICAM2009

Towards structured-fibre based porphyrin gas sensors

George Huyang* (1), (3), Mattias Åslund(1), John Canning(1), (3), Tony Khoury(3), Maxwell J. Crossley(3), Cicero Martelli(2),

(1) Interdisciplinary Photonics Laboratories, School of Chemistry, The University of Sydney, NSW 2006, Australia
(2) Departamento de Engenharia Mecânica, Pontifícia Universidade Católica do Rio de Janeiro, RJ 22453-900, Brasil
(3) School of Chemistry, The University of Sydney, NSW 2006, Australia
* Corresponding author (shhu2628@mail.usyd.edu.au).

Abstract – Photonic crystal fibres (PCF) with adsorbed porphyrins have been prepared by reaction with various chemicals in a reaction sequence to allow eventual porphyrin reaction with the silica surface. The porphyrins, which have known activity with certain gases such as nitrogen oxides and hydrogen chloride, were analysed in THF solution spectroscopically for their potential as in-line fibre gas sensors.

Gas detection based on chemical interaction has been a well-investigated area of research [1,2]. Porphyrins, an aromatic heterocyclic organic compound, were commonly applied for these sensors due to strong activities with a variety of acids and certain gases, such as nitrogen oxides. An application for this process based on porphyrin gas sensing involves the use of porphyrins within optic fibres, which would allow for remote gas detection due to the high toxicity of these gases. Binding of the porphyrin onto silica can be achieved by chlorination of the surface, followed by addition of a hydroxy-porphyrin [3]. For our development of a porphyrin-based gas sensor, 5,10,15-tri-(di-*tert*-butylphenyl)-20-(*p*-hydroxyphenyl)porphyrin was used **(Figure 1)**. The porphyrin solution shows noticeable changes in light absorbance in the UV-visible spectra when under nitrogen dioxide and hydrogen chloride containing atmospheres **(Figure 2)**.

In order for chemisorption onto an optics fibre, a holey photonic-crystal fibre (PCF) was used to allow porphyrin uptake into its core. The filling of these fibres were done using pressures of 5 – 10 bars to load the porphyrin within the fibre [4]. These fibres were treated chemically for hydroxy termination (increased Si-OH coverage on surface) by piranha solution and chlorination with thionyl chloride, following the procedure of Hergenrother et al., [5] and finally reacted with hydroxyphenylporphyrin in THF. After removal of excess porphyrin not bound to the fibre by chemisorption, the fibre was analysed with an optical spectrum analyzer (OSA) at 350 – 1750 nm, and its optical absorbance due to porphyrin were analysed under various conditions to measure gas-related influence to the porphyrin within the fibre. Results will be presented at the conference.

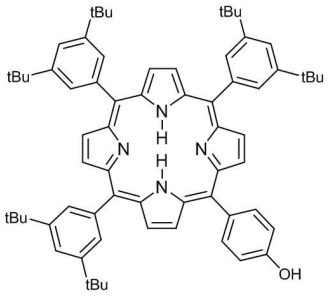

Figure 1: The structure of 5,10,15-tri-(di-*tert*-butylphenyl)-20-(*p*-hydroxy-phenyl) porphyrin

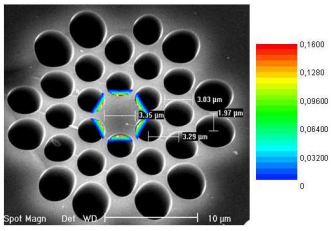

Figure 2: SEM structure of a PCF fibre cross-section, with calculated evanescent field within fibre

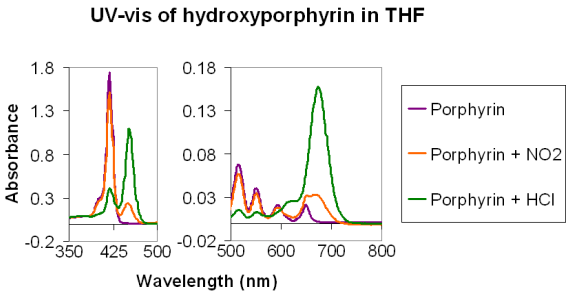

Figure 3: UV-vis spectrum of 5,10,15-tri-(di-*tert*-butylphenyl)-20-(*p*-hydroxy-phenyl)porphyrin in THF solution after exposure to NO_2 and HCl gases for 1 minute.

[1] T. Malinski and Z. Taha, Nature 358 (1992), 676 – 678

[2] A. Tepore, A. Serra, D. P. Arnold, D. Manno, G. Micocci, A. Genga, and L. Valli. Langmuir 17 (2001), 8139 – 8144

[3] A. Gulino, S. Bazzano, P. Mineo, E. Scamporrino, D. Vitalini, I. Fragala, Chem. Mater. 17 (2005), 521 – 526

[4] Cicero Martelli PhD Thesis, Interdisciplinary Photonics Laboratories (iPL), University of Sydney, Australia 2007

[5] P. J. Hergenrother, K. M. Depew, and S. L. Schreiber, J. Am. Chem. Soc. 122 (2000), 7849 – 7850