Volatile Organic Compounds Fibre Optic Nanosensor

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Introduction

Detection of VOCs is a very important aim in sensing technology. In the last few years many researching groups have been focusing their attention in this type of sensors towards environmental applications, electronic noses, food or chemical industry, just to mention a few. Fibre optic sensors offer some advantages that make an interesting option, showing a passive nature, immunity to electromagnetic noise among other advantages[1].

In this work, a new vapochromic complex, whose optical properties change in presence of volatile compounds, acts as the sensing material. Following the ESA method, ionic monolayers doped with this complex are deposited on the cleaved end of a fibre optic pigtail in order to develop a nano-cavity sensitive to volatile organic compounds vapors.

Vapochromic material

There is a family of complexes of general formula $[AuAg(C_6F_5)_2L]_n$, where L can be pyridine, 2,2'bipyridine, 1,10 phenantroline, ½ diphenyl-acetylene and other ligands [2], which change from different colour as orange or red to white in the presence of coordinating solvent as methanol or ethanol. Some fibre optic sensor based on this family of complexes was presented and characterized for VOCs detection [3]. In this work, a gold-silver complex based on pyridine has been employed.

Experimental set-up

The multimode optical fibre chosen for this purpose has a core and cladding diameters of 62,5 μm and 125 μm, respectively, and the end of which is cut with a Siemens S46999-M9-A8 precision fibre cleaver. A Y coupler 50:50 was used to connect the system. The sensor head is connected to one port of the coupler, and the other two ports are connected to a 850 nm LED source and to a photodetector, 675RE from RIFOCS Corporation.

Electrostatic Self-Assembly Method

In last few years, the ESA method has been presented as a very useful technique to build up two-beams Fabry-Perot (also called Fizeau) nanocavities on optical fibre with lengths less than a micrometer [7]. This process involves several steps. Firstly, a substrate (in this case optical fibre), is cleaned and chemically treated to produce a charged surface. Then the substrate is alternately dipped into solutions of cationic and anionic polymers to create a multilayer thin film. In our work, a solution of PAH (poly allyamine hydrochloride) was used as the polycation, and PAA (poly acrylic acid) as the anionic polymer. Just monitoring the reflected optical power each time that a monolayer get deposited onto the end of the optical fibre , the evolution of the nanocavity can be registered, which will give a response similar to a Fizeau interferometer.

In this case, we dissolved the vapochromic material in ethanol (just because is not soluble in water), and then some amount of water is added. Thus, the material can be incorporated into the polycationic solution. The polyelectrolite solutions used were 10 mM, and the proportion between the vapochromic complex and ethanol was 1 mg per ml. 600 μl.

Results and discussion

A multilayer structure of form $[PAH^{+}(Vap)/PAA^{-}]_{25}$, so a total of 25 bilayers were deposited. The experimental results obtained during the build up of the multilayer structure process are shown in figure 1. The curves represent the relative optical power for each polymer monolayer. The interferometric phenomenon has been monitored, so a nanocavity has been constructed at the end of the fibre.

The first step in the measuring process is the introduction of the organic solvent into the chamber where the sensor head is located. After several minutes, the VOC gets vaporized, starting the adsorption process at the nanocavity surface, changing its optical properties, and so, the reflected optical power collected. Once the reflected optical power is stabilized, the chamber is opened and the optical power recovers its original value. This cycle has been done twice for ethanol (86 mmol/l) and methanol (125mmol/l), showing a repetitive response. These results can be seen in figure 2.

Acknoledgements

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Figures:

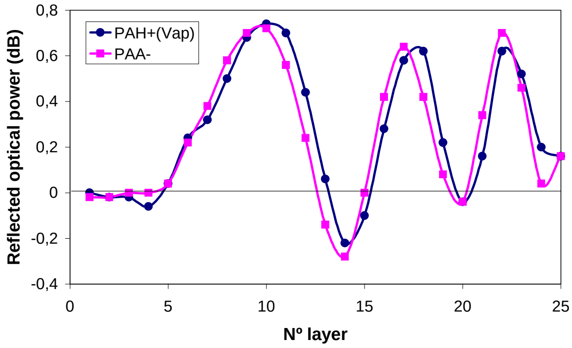

Figure 1: Construction curve of the sensor for the polycation (PAH^{+}/Vap) and polyanion (PAA^{-}).

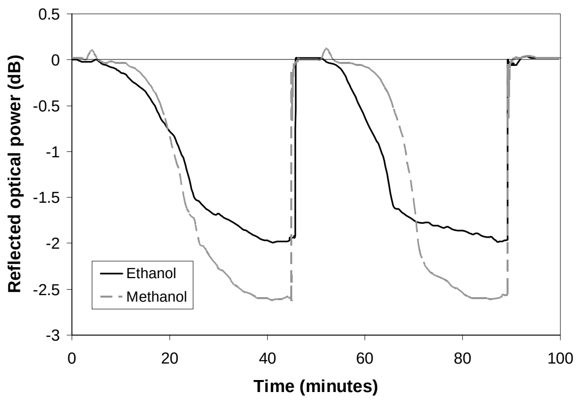

Figure 2: Comparison between the response of the sensor for ethanol and methanol.