A Molecularly Imprinted Polymer on a Novel Surface Plasmon Resonance Sensor

Maria Pesavento, Simone Marchetti, Luigi Zeni and Nunzio Cennamo

Abstract As a proof of principle, we have developed a novel surface plasmon resonance (SPR) sensor used to monitor the interaction between a molecularly imprinted polymer (MIP) and a small molecule as the substrate. This plasmonic platform is based on a removable polymethyl methacrylate (PMMA) chip with a thin gold film on the top, two PMMA plastic optical fibers (POFs) and a special holder, designed to obtain the plasmonic phenomenon. We have experimentally tested whether the optical sensitivity is sufficient for monitoring an MIP receptor. The advantage of MIPs is that they can be directly deposited on a flat gold surface by a spin coater machine, without modifying the surface, as needed for the bio-receptors. With this new sensor, it is possible to achieve remote sensing capabilities, by POFs, and also to realize an engineered platform with a removable chip sensor.

Keywords Surface plasmon resonance sensors · Molecularly imprinted polymers Slab waveguides

1 Introduction

Optical chemical sensors and biosensors have been shown to be able to play an important role in numerous fields, especially the biosensors based on optical fibers and surface plasmon resonance (SPR) phenomenon [1–3]. They selectively recognize and capture the analyte present in a liquid sample so producing a local increase of the refractive index of the dielectric layer in contact with the metal film. The use of SPR sensor devices often requires replaceable parts and disposable chips for easy, fast and on site detection analysis.

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In this framework, we propose a novel low-cost SPR sensor platform for selective detection of analytes in aqueous solutions. It is based on a PMMA slab waveguide covered with a thin gold film and inserted in a special holder, designed to produce the plasmonic resonance at the gold-dielectric interface [4]. On the gold film an MIP receptor has been deposited by a simple procedure, only based on a spin coater machine and an oven [5].

MIPs are synthetic receptors with many favorable aspects with respect to bio-receptors, such as an easier and faster preparation, the possibility of application outside the laboratory and, for example, a longer durability under environmental conditions [6]. The advantage of MIPs is that they can be directly deposited on a flat gold surface without modifying the surface (functionalization and passivation), as needed for the bio-receptors.

In this work, as proof of principle, a selective MIP was considered as the receptor for furfural (furan-2-carbaldehyde, 2-FAL) and the possibility of using the device obtained for detection of 2-FAL in aqueous media was investigated.

The determination of 2-FAL in wine or beer, aqueous matrices of interest in food industry, is becoming a very crucial task in relation to its toxic and carcinogenic effect on human beings. Moreover, 2-FAL is also relevant for food flavor and aroma, which are important factors in terms of quality control and quality assurance. In wines for example, this factor is among the most important ones [7]. During the ageing, the concentration of some compounds, formed during the alcoholic fermentation, decreases and new compounds appear, some deriving from the evolution of the wine components themselves and some extracted from wood. Furanic compounds, in particular 2-FAL, which can be formed in wine by sugar dehydration, and can be extracted from wood as well, has a high impact on the aroma. Moreover, they can be used as ageing markers as well.

2 Plasmonic Platform

Figure 1 shows the novel SPR sensor configuration. It is based on a slab waveguide (a layer of PMMA of 1 cm $\times$ 1 cm $\times$ 0.5 mm in size) with a thin gold film on the top surface (60 nm thick deposited by the sputter coater Baltec SCD 500) inserted in a special holder, designed to produce the plasmonic resonance at the gold-dielectric interface [4]. As shown in Fig. 1, the light is launched in the slab waveguide through a trench, realized into the holder, and illuminated with a POF, to excite the surface plasmon waves. The output light is then collected by another POF, positioned at the end of the slab waveguide, at an angle of 90° with respect to the trench, and carried to a spectrometer. In this configuration, the trench has been used because a large incident angle is required for SPR excitation [4].

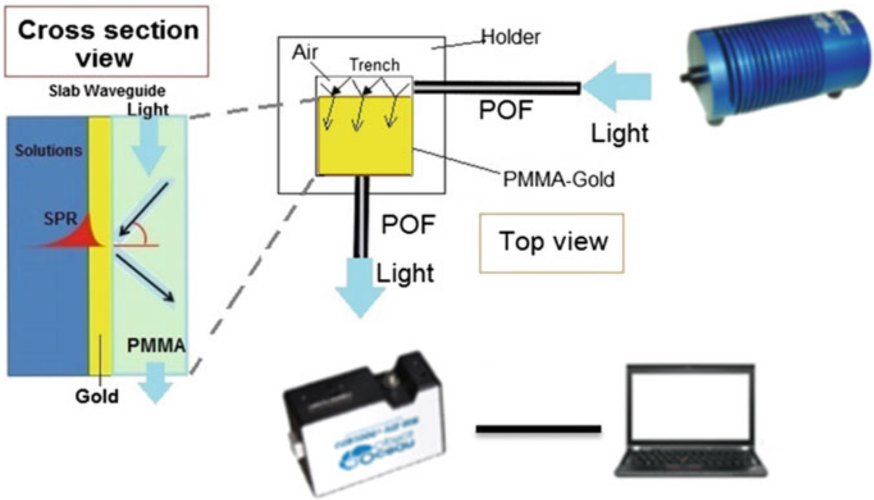

Fig. 1 Sensor system outline and top and cross section view of the chip

On the gold film of the removable chip (slab waveguide) an MIP layer is deposited. The experimental setup is based on a halogen lamp (HL–2000–LL, Ocean Optics), used to illuminate the first POF, and a spectrometer (FLAME-S-VIS-NIR-ES, Ocean Optics) connected to the second POF, used to observe the transmitted spectra (see Fig. 1).

3 Experimental Results

About 50 μL of solutions with different concentrations of 2-FAL were dropped over the MIP layer and the spectrum recorded after ten minutes incubation. The SPR transmission spectra were normalized to the reference spectrum by Matlab software. In particular, the transmission spectra have been normalized to the spectra obtained in air before MIP deposition, in which no plasmon resonance is excited. The dose-response curves were obtained by plotting the resonance wavelengths versus the 2-FAL concentrations.

In a semi-log scale, Fig. 2 shows the resonance wavelengths versus the 2-FAL concentration (ppm) together with the Hill fitting. The obtained results have shown the good performance in terms of sensitivity and limit of detection (LOD) of this novel approach.

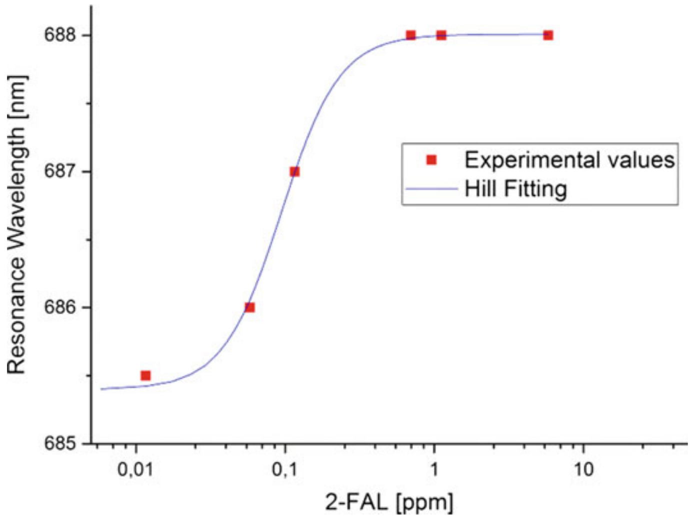

Fig. 2 Resonance wavelengths (nm) versus the concentrations of 2-FAL (ppm), in semi-logarithmic axes, with Hill fitting of data

4 Conclusions

The removable PMMA chip, with gold film on the top, is suitable for chemical applications after the deposition of a specific receptor (MIP). This chip can be changed and optimized for each test. The easy replacement of the chip allows for the production of an engineered platform by simplifying the measurement procedures.

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