Development of a Molecularly Imprinted Sensing Material for Antibiotics Detection

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**Introduction**

Antibiotic detection has become a major issue in many fields such as water analysis, food control, health, etc. Besides the immediate dangers, the spread of antibiotics everywhere provokes the phenomenon of bacterial resistance which, on the long run, will cause health issues. Indeed, the excessive use of antibiotics allows the bacteria to mutate and thus develop resistance, requiring the development of new compounds.

This work aims to develop and characterize a sensing material to detect multiple antibiotics in liquid phase using various methods. The idea is to conceive low power sensors or even disposable sensors. Therefore, sensors should be low cost and compatible for mass production. The most interesting sensitive materials seem to be molecularly imprinted polymers (also called MIP) using conductive polymers [1],[2].

**Synthesis of the MIP**

Polypyrrole (PPy) is chosen as conductive polymer to be molecularly imprinted. Pyrrole (Py) is used as the cross-linker and pyrrole-3-carboxylic acid as the functional monomer, to obtain chemical interactions between polymer and the target molecule (also called “template”). The synthesis is performed in-situ (also called bulk polymerization) in aqueous media by mixing the target molecule, the functional monomer and the cross-linker with the oxidizer, ammonium persulfate (APS), while pH value is set to around 2.2, well below the template’s pKa to allow better interactions between monomers and the template. While oxidative polymerization takes place, temperature is kept at 30 °C, for 2 hours. The polymer is deposited everywhere in the reactor, and also on the substrates used to get the sensor.

The next step, so-called extraction, consists in removing the template from the polymer. It is performed by using a solution of methanol and HCl (9:1) wherein substrates are immersed for 2 hours [3]. Then, substrates are stored in PBS (phosphate buffered saline) solution before being tested. Non-Imprinted Polymers (NIP) are also synthetized following the same steps, except that the template is not present during the synthesis.

**Measurement methods**

Polymerization has been performed on various substrates allowing to use multiple sensing methods to explore as much path as possible. Up to now, sensors had been performed and tested on chemoresistive plastic IDE sensors to perform impedimetric measurements, on quartz crystal microbalance substrates to perform mass variation measurements and on glass slide to perform UV/VIS/NIR absorbance measurements (the ultimate goal is to use the sensing material on optical fibers), as shown on Fig.1.

**Results and Conclusions**

Sensors are tested in PBS 0.5x solution (half the usual concentration). After the extraction step carried out on the various substrates, detection is performed by adding the target antibiotic into the PBS solution. Fig. 2 shows impedance measurements and this parameter grows nearly linearly as soon as we add a dozen ppb of the antibiotic. Fig.3 shows that for the same measurement method, the NIP nearly doesn’t react when we add the template, which means that the imprinting is functional and significantly increases the performance of the sensor. Fig. 4 and Fig. 5 show the evolution of the NIR spectrum of the sensing layers after contact with the antibiotic, for the MIP ad NIP, respectively. This method exhibits some limitation with a saturation above 50 ppb. Fig.6 shows the mass evolution on a quartz microbalance of the sensitive layer in contact with the target antibiotic and an interferent with the same concentrations to show the sensor specificity. The response shown to the interferent is quite weak in comparison with the one corresponding to the target molecule. In conclusion, the sensors were found to be able to detect concentrations of approximately 15 ppb and are close to the detection limits of conventional methods (10 ppb). In addition, they have proven their specificity to the target molecule by showing no reaction when exposed to the usual interferents. We showed that the MIP is suitable for both impedimetric sensors as well as for optical sensors (optical fibers or dipsticks for instance).

**References**

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