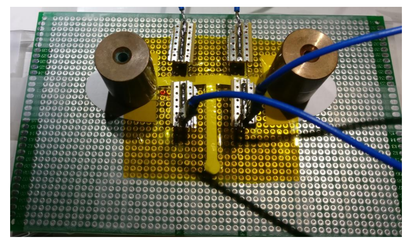
Electrochemical sensor platform for MIP incorporated microfluidic paper-based analytical devices

Frederik Vreys[1,2], Gilles Oudebrouckx[1,2], Thijs Vandenryt[1,2]
Anitha Ethirajan[1,2], Tanja Junkers[1,2], Ronald Thoelen[1,2]

[1]Institute for Materials Research (IMO), Hasselt University, Diepenbeek, Belgium | [2]IMOMEC, IMEC vzw, Diepenbeek, Belgium

Introduction

A biomimetic sensor platform capable of performing electrochemical impedance spectroscopy(EIS) measurements for the detection of molecules was developed by incorporating **molecularly imprinted polymers (MIPs)** into **microfluidic paper-based analytical devices(µPADs)**. **Carbon electrodes** were **screen printed** on the top side of the paper. The back of the electrode was padded with SU-8 to prevent fluid from flowing underneath the electrodes. **MIPs** and non-imprinted polymers**(NIPs)** were applied on the same side as the electrodes. The amplitude of the impedance was monitored and a full spectrum was measured continuously. The spectrum was fitted to an Q(QR) model for both the MIP and NIP. A control experiment was performed to check the viability of the sensor. The usage of µPADs in combination with electrochemical impedance measurements vastly decreases the cost of the sensor compared to lab-sized setups. This makes it ideal for point-of-care applications.



Clamping setup for measuring the electrical impedance of the paper-based analytical device

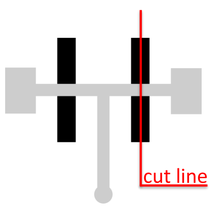
Layer by Layer

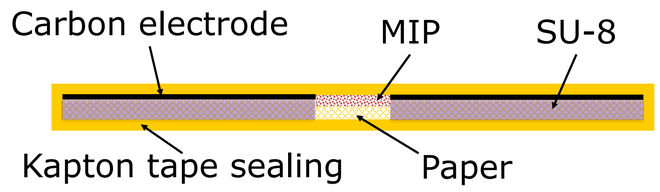
Carbon electrode: electrochemical impedance spectroscopy electrode

MIP: the biomimetic receptor

SU-8: prevents flow underneath the electrode

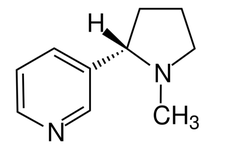
Sealing: prevents unwanted capillary wetting on the base



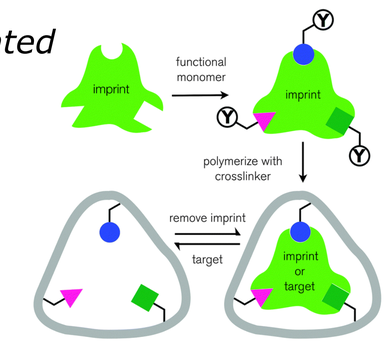


Receptor

Molecularly imprinted polymer(MIP) imprinted for *Nicotine*



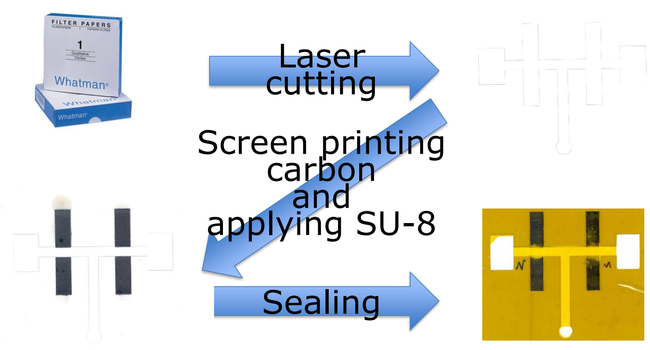
Nicotine molecule



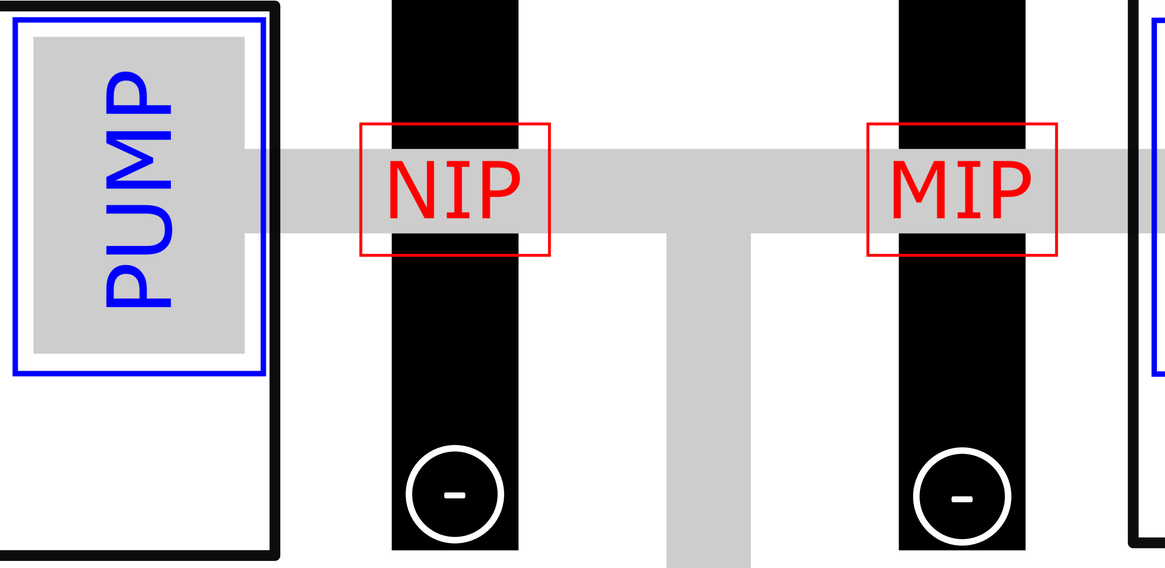
Synthesis MIP

Development

Production steps of a cut *µPAD* with *carbon electrodes*, *SU-8 padding*, *MIP* and *NIP* functionalization and *Kapton tape sealing*.



Samples



Flow

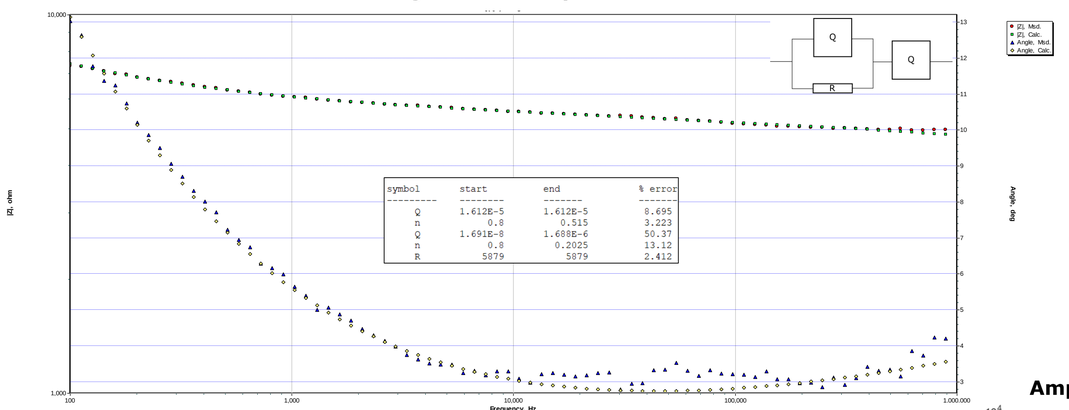
Pump: Provides flow of fluid for a prolonged period of time. When the pump is completely wetted flow stops.

Sample reservoir: (represented by the droplet) The sample under test is applied here.

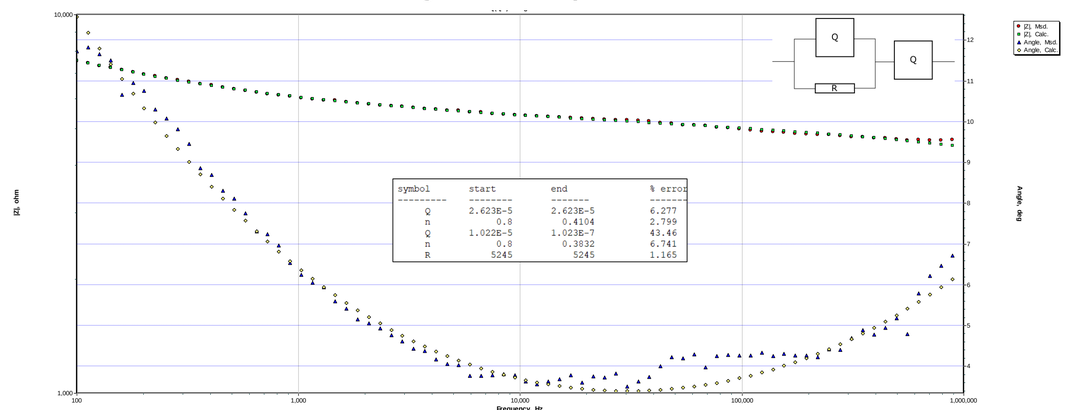
MIP & NIP region: fluid passes and the analyte binds to the MIP cavities.

Results

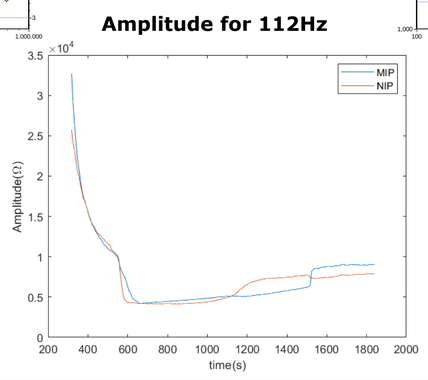
Fitting of the MIP spectrum



Fitting of the NIP spectrum



Amplitude for 112Hz



The MIP spectrum most closely resembles an (RQ)Q model.(χ^2=6,939.10^{-5}) The same accounts for the NIP spectrum (χ^2=8,733.10^{-5}) Both spectrums were taken after 800 seconds. It is clear from the amplitude of 112Hz that the measurement has stabilized at this moment and is the same for both MIP and NIP.

During the control experiment pure water was first applied. (This data has been cut from the graph since it is very high ohmic.) Next, phosphate-bufferd saline(PBS) was added. The amplitude drops and stabilizes for both MIP and NIP. Finally a PBS dilution is added. The signal visibly rises however some anomalies occur, possibly caused by leakages to the contacts.

Acknowledgement

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Conclusion

The spiked nicotine solution did not show a clear difference, however there is still a lot of improvement possible. Furthermore, the promising result of the Q(QR) fit for both the MIP and NIP spectrums makes it worthwhile to look further into the combination of low-cost, disposable paper-based microfluidics and EIS as an point-of-care application.