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Microfluidic biomimetic sensor for drug detection

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Abstract (style "IMCS2018_Headline"):

The work presented in this study, focuses on the biomimetic detection of narcotics in biological fluids. To this extent, a previously developed thermal biosensor readout unit was combined with sensitive nano-sized molecularly imprinted polymer (MIP) particles. The platform has recently been combined with disposable, microfluidic flow cells for the detection of neurotransmitters in whole blood samples in physiological concentrations. In this work, the concept was extended by developing a new microfluidic flow cell containing 6 measuring chambers connected to a single fluid inlet. Administering a drop of blood to the central inlet, distributes the drop over the entire flow cell, allowing the end-user to detect five different narcotic substances in a differential manner.

Key words: MIPs, microfluidics, drug detection, whole blood samples, differential set-up

Introduction

Over the past few years, the combination of MIPs and the so-called heat-transfer method has led to the development of biomimetic sensor platforms for the detection of various compounds ranging from low-molecular weight targets such as neurotransmitters,[1,2] to bigger entities such as peptides and proteins.[3] Recently, the concept was extended from a laboratory device to a disposable, portable prototype that allows for point-of-care detection of neurotransmitters in whole blood samples.[4]

In this work, a disposable microfluidic flow cell was developed allowing the end-user to simultaneously detect five different drug molecules in whole blood samples. In addition, the methodology allows for differential measurements comparing the response of a sensitive MIP channel to that of a non-imprinted reference channel (NIP channel).

Methods

Microfluidic cells were made by casting hydrophilic poly-dimethyl siloxane (PDMS) onto 3D-printed polylactic acid (PLLA) molds. These flow cells were coupled to a single heater and a single fluid inlet, allowing blood samples to be administered passively through capillary force. Heat transfer measurements were performed in five active (coated with nano MIPs) and one reference channel (NIP) simultaneously.

Results

A proof-of-principle experiment using the current microfluidic flow cell illustrates its potential for detecting small molecules (serotonin was used as a model target) in physiologically relevant concentrations in whole blood (Figure 1).[4]

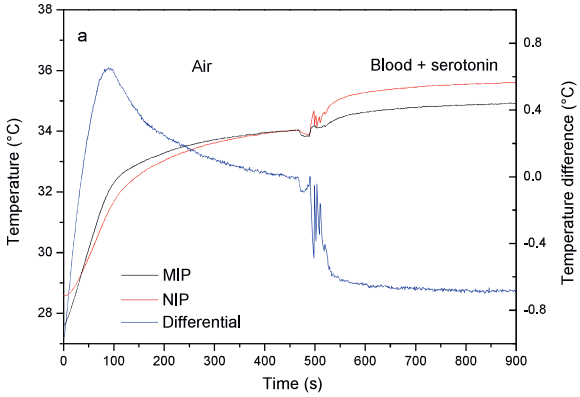

Fig. 1. Serotonin detection in whole blood samples using the thermal detection platform. Upon addition of blood, the temperature inside the flow cell rises as a result of blood being a better conductor than air. The increase observed in the MIP channel is lower as the binding of serotonin to the MIP increases the heat-transfer resistance of the solid-liquid interface.

The concept illustrated in Figure 1 can be readily extended towards the detection of so-called “designer drugs” in blood. As these compounds are continuously changed to avoid legal restrictions, little is known about the dangers associated with abusing these substances. A low-cost sensor that allows to detect multiple drug classes in blood in minutes, would allow first line healthcare workers to identify substance abuse and take appropriate measures to prevent overdose-related deaths. A microfluidic flow cell designed for this purpose that allows the end-user to measure up to five different drug-imprinted MIPs and a non-imprinted reference in real-time, is shown in Figure 2.

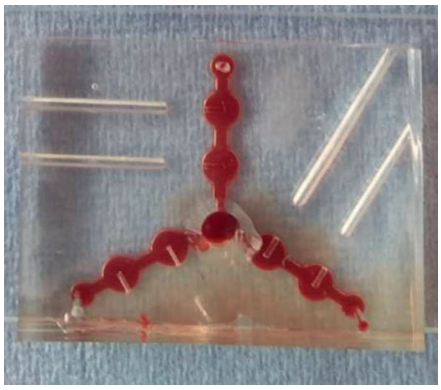

Fig. 2. Disposable microfluidic flow cell allowing to measure five functionalized MIP channels and a NIP channel simultaneously using a single shared inlet.

Discussion

The results in Figure 1 illustrate that it is possible to combine the current biomimetic sensing methodology with a disposable flow cell for the low-cost detection of small compounds in whole blood samples.[4] The work presented here, illustrates that the concept can be readily extended towards the detection of both traditional narcotics and so-called designer drugs.

References

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