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MATERIALS SCIENCE

Enhancing binding properties of imprinted polymers for the detection of small molecules

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Abstract. This study demonstrates the promising steps towards improving the detection of small analytes in an aqueous solution by the quartz crystal microbalance (QCM) modified with a molecularly imprinted polymer (MIP) based sensitive layer. A homogeneous thin polymer film of poly(*m*-phenylenediamine) (PmPD) was electrochemically deposited on the surface of a QCM sensor in the presence of sulphamethizole (SMZ) acting as a template molecule. The binding capacity of the resulting SMZ–MIP films was enhanced by modifying the sensing surface with a diethylaminoethyl-dextran (DEAE-Dex) layer, forming a SMZ–MIP(Dex) film. The dextran layer allows further preconcentration of template molecules on the sensor electrode before polymer electrodeposition. The relative adsorption of the SMZ–MIP(Dex) films, as designated by the imprinting factors, was found to be in all cases significantly higher than that of the other films. At least about three times enhanced relative binding capacity of the modified imprinted polymer on the QCM sensor was established. A probe of the analysed sensor signals revealed that the modification steps significantly reduced the contribution from nonspecific interaction of the polymer matrix, thus suggesting beneficial effects of the dextran modification and template preconcentration. The presented approach promises a positive route towards an improved specific detection of small molecules by molecular imprinting on QCM sensor transducers.

Key words: molecularly imprinted polymer, small molecule detection, sulphamethizole, quartz crystal microbalance, DEAE-dextran.

1. INTRODUCTION

The detection of small molecular weight analytes (drugs, toxins, chemicals, pollutants, etc.) is vital for environmental and biological interests (food safety, public security, environmental monitoring as well as pharmaceutical and biomedical analyses). Numerous analytical techniques (enzyme-linked immunosorbent assay, liquid chromatography, gas chromatography, mass spectrometry, and their coupling techniques) exist for the detection of various small analytes [1–4]. However, most of these techniques lack high specificity and their continued utilization is limited by the expensive detection instruments and complex procedures involved. Molecular imprinting is a technique that creates synthetic recognition materials, the so-called molecularly imprinted polymer (MIP), for detecting any molecule of interest, thus mimicking biological receptors. It polymerizes functional monomers in the presence of the target molecule that acts as a template. During polymerization, the template induces binding sites in the reticulated polymer that are capable of selectively recognizing the target molecules or similar structures following the removal of the templates from the polymer. The challenges of the traditional methods of detection are thus greatly overcome since MIP has been shown to

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possess several advantages as an alternative recognition material. These include low cost, ease of preparation, storage stability, durability to heat and pressure, as well as applicability in harsh chemical media [5,6].

For the accurate analysis and interpretation of the performance of a MIP, its robust interface with a sensor transducer that converts the molecular recognition into a readable electrical signal, is very crucial. Consequently, numerous MIPs have been fabricated on different sensor transducers: electrochemical, calorimetric, optical, and piezoelectric, with mass-sensitive (piezoelectric) devices making up a somewhat substantial proportion [7–17]. Mass-sensitive devices such as the quartz crystal microbalance (QCM), also known as the bulk acoustic wave sensor, respond to mass changes on their surface by a resonant frequency shift that is directly proportional to the mass of the analyte adsorbed. This allows them to play a pivotal role in molecular detection and analysis since mass is a fundamental property of all compounds [18]. As a result, the QCM has been employed in the fabrication of MIP-based sensors for small analyte detection with literature reviews published on the subject matter [19–22].

In sensor fabrication, sensitivity is one of the critical factors. However, the sensitivity of the QCM, like of other affinity sensors, is comparable to the molecular mass of the analyte among other factors. Furthermore, the universal sensitivity of the QCM sensor encourages unsolicited contributions to the sensor signal, especially when operated in a liquid [23]. Also, QCM transducers integrated with a MIP recognition layer, although offering an elegant label-free detection platform, suffer from an intrinsic limitation of the contribution to the sensor signals from nonspecific binding of other matrix elements [24,25]. As the degree of nonspecific interaction affects the sensitivity of a sensor, reducing nonspecific adsorption is of importance in MIP sensor fabrication.

While an increased sensitivity for piezoelectric transducers can be achieved by increasing the device frequency, increasing the amount of the binding sites in the recognition element (e.g. MIP) will also lead to a lower contribution from nonspecific interaction to the sensor signal, thereby facilitating the specific adsorption of the target molecules [18,26]. For small molecule detection by mass-sensitive devices, increasing the number of the recognition sites is therefore key to achieving a higher sensitivity. This leads to a shift in frequency only when a sensible amount of the template has been adsorbed unto the recognition sites. This can be accomplished by the bulk molecular imprinting approach in which the template molecule provides the sterical and chemical qualities as well as the diffusion path for the subsequent recognition of the analytes [27]. Furthermore, to reduce the nonspecific interaction, a quantitative association of the functional monomer with the template molecules is essential for increasing the imprinted sites while reducing the chances of nonspecific interaction. This is achieved by ensuring that an appreciable amount of the template is available within the forming polymer during the preparative stage, thus resulting in the MIP having a considerable rebinding of the template as compared with the reference non-imprinted polymer (NIP) [28].

Diethylaminoethyl-dextran (DEAE-Dex) is a polycationic stabilizing molecule having an average molecular weight of up to 500 kDa. It is commonly used in nucleic acid transfection, sustained protein delivery, and in biosensors for cell immobilization. It is quite similar to the carboxymethyl dextran (CM-Dex) analogue that has been employed in developing certain sensor chips for the surface plasmon resonance (SPR) sensing platform but differs in the absence of a carboxyl functional group. The dextran immobilized sensor layer has a tendency to minimize the nonspecific binding of the analyte on the sensor due to the barrier formation between the analyte and the underlying electrode substrate of the sensor [29,30]. Most interesting is the flexible nature of the layer that encourages binding site accessibility on a recognition layer, thus enhancing sensitivity especially for small molecular weight analytes.

This work attempts to improve the specific binding capacity of a MIP on a QCM sensor as a mass-sensitive, label-free transducer for small molecule detection. For this purpose, a promising approach to enhance the amount of the binding sites within the MIP matrix was adopted. This involves the preconcentration of the small molecular weight template molecules on the sensor surface prior to the electropolymerization. To achieve the template preconcentration, a monolayer assembly of an anion exchanger, DEAE-Dex, was formed on the sensor electrode prior to the electropolymerization. The different stages of the modification were probed by the electrochemical impedance spectroscopic (EIS) technique. Although DEAE-Dex has been widely used in cell and/or enzyme immobilization biosensor technology [31], this is, to the best of our knowledge, its first use for the preconcentration of a small target molecule in MIP research. Sulphamethizole (SMZ) was selected as a model small molecule and *m*-phenylenediamine (mPD) as an electropolymerizable functional monomer for polymer matrix formation based on the previously established strong, non-covalent interaction existing between their complementary functional groups [32]. Efforts were made to optimize the performance of the prepared MIP on the chosen QCM sensor transducer. This involves ensuring a homogeneous film

deposition and accurate control of the polymer film growth. The beneficial influence of such dextran modification and the following preconcentration on the binding capacity of the prepared MIP are presented as an important step towards an improved detection of small analytes by MIPs on mass sensitive transducers.

2. EXPERIMENTAL SECTION

2.1. Chemicals and materials

All chemicals, except acetic acid, sulphuric acid, and hydrogen peroxide that were provided by Lachner, were purchased from Sigma-Aldrich. All chemicals were of analytical grade and were used as received without any further purification. Ultrapure water (resistivity 18.2 MΩ·cm, Millipore, USA) was used to prepare all aqueous solutions, and phosphate buffered saline (PBS) solution (0.01 M, pH 7.4) was used in preparing the synthesis and analyte solutions.

2.2. Sensor modification and characterization

The gold (Au) electrodes of a 5 MHz QCM (Maxtek, Inc.) were used in this work for SMZ–MIP and the reference NIP film deposition. An $Ag/AgCl/KCl_{sat}$ electrode was used as the reference electrode in all electrochemical measurements. Before electrochemical deposition of the films, the QCM sensors were cleaned for 3 min in the hot piranha solution consisting of 30% H_2O_2 and concentrated H_2SO_4 in 1 : 3 ratio followed by electrochemical cleaning in 0.1 M H_2SO_4 aqueous solution by cycling the electrode potential in the range from –0.2 to +1.5 V with a scan rate of 50 mV/s until the cyclic voltammograms were reproducible. Finally, the electrodes were washed thoroughly with ultrapure water and dried again in nitrogen stream. A pre-cleaned Au surface of the sensor was modified with DEAE-Dex ($M_r \approx 500\,000$ g/mol), purchased from Sigma-Aldrich, by directly applying DEAE-Dex solution (0.1 mg/mL) for 30 min after which the surface was rinsed with water and dried under nitrogen stream. Then SMZ was pre-adsorbed on the Au/DEAE-Dex surface by a direct covering of the surface with the PBS buffer solution containing 3.5 mM SMZ and allowed to stand for 30 min followed by careful rinsing with water and drying under nitrogen. Each stage of the modification processes was monitored by EIS by measuring, fitting in ZView software, and comparing the EIS data collected from bare Au, Au/DEAE-Dex, and Au/DEAE-Dex with adsorbed SMZ (Au/DEAE-Dex/SMZ) surfaces.

2.3. Preparation of SMZ–MIP films

After SMZ preconcentration on a sensor electrode, electropolymerization of mPD was conducted on the modified electrode at a constant potential of 0.6 V in PBS buffer solution containing 5 mM mPD and 3.5 mM SMZ resulting in a PmPD/SMZ film on the sensor electrode. Following electrodeposition, the template molecules (SMZ) were removed from the polymeric matrix of the electrodeposited PmPD/SMZ film to create SMZ–MIP(Dex) with complementary cavities suitable for the specific recognition of SMZ molecules. This was achieved by immersing the PmPD/SMZ-modified sensors in a mixture of acetic acid/methanol (1 : 3) and allowed to stay for a period of 24 h with continuous stirring. Then the sensors were washed with distilled water and dried under nitrogen stream.

For the control studies, the following films were fabricated omitting one or several of the above steps: (a) the DEAE-Dex modified non-imprinted PmPD film (NIP(Dex)) was prepared without the SMZ template preadsorption step as well as excluding SMZ molecules from the pre-polymerization solution, (b) the imprinted PmPD (SMZ–MIP) is the same as SMZ–MIP(Dex) but without the DEAE-Dex surface modification and pre-adsorption steps, (c) the non-imprinted PmPD (NIP) is the same as NIP(Dex) but without the DEAE-Dex modification and preadsorption steps. It should be noted that all films were subjected to the template washing step, independent of whether a SMZ template was introduced in their matrices or not, in order to ensure similar treatments for all films.

2.4. Rebinding studies

The capability of the fabricated SMZ–MIP films to recognize SMZ was studied by QCM combined with a flow injection analysis (FIA) to set up a QCM–FIA system allowing on-line analysis of SMZ rebinding on the SMZ–MIP surface. The system consists of a programmable precision pump (M6, VICI® Valco Instruments Company Inc., USA), a motorized six-way port injection valve controlled by a microelectric actuator (C22-3186EH, VICI® Valco Instruments Company Inc., USA), and a small volume (150 μL) axial flow cell attached to the QCM sensor holder (Stanford Research Systems, Inc.). Sensors modified with SMZ–MIP, SMZ–MIP(Dex), NIP(Dex), and NIP films were loaded into the QCM–FIA system and equilibrated by running a PBS buffer through the system till a stable baseline was established. Then analyte solutions were consecutively injected into the QCM–FIA system at a flow rate of

40 µL/min in the order from the lower to the higher concentrations, and the signal changes of the sensors were monitored. The analyte solutions with SMZ concentrations in the range of 0.040–1.0 mM were prepared in a filtered and degassed PBS buffer (pH 7.4). The prepared analyte solutions were also degassed before their injection into the sensor system. The sensorgrams recorded were fitted to a pseudo-first-order kinetic binding model in order to determine the equilibrium responses for all prepared films. At least three replicas of all experiments were conducted. The scheme representing the entire molecular imprinting approach from dextran modification to the rebinding study is shown in Fig. 1.

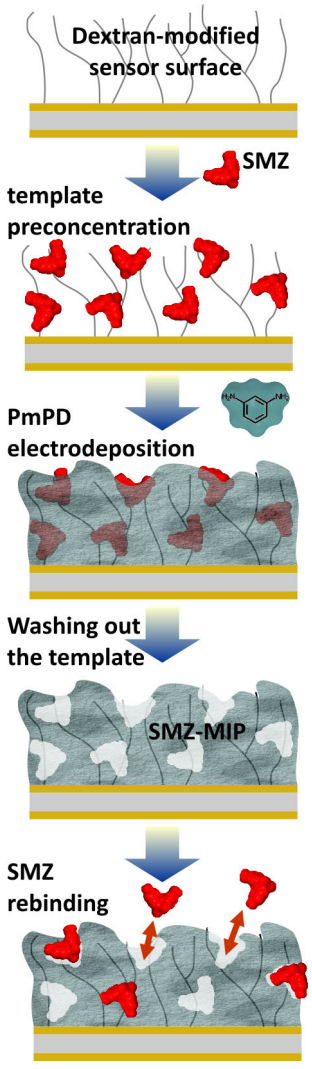

Fig. 1. Schematic representation of the molecular imprinting approach for the preparation of sulphamethizole–molecularly imprinted polymer–dextran (SMZ–MIP(Dex)) films on a gold electrode of a sensor.

3. RESULTS AND DISCUSSION

3.1. Sensor surface modification and characterization

The surface modification with a dextran layer was applied to preconcentrate the small molecular weight template molecules at the sensor surface before polymer matrix formation. This aims to enhance the imprinting capacity of the resulting MIP-based sensor. The EIS technique was used to evaluate the changes in the electrochemical behaviour of the Au electrode. This technique has already been shown as an effective method for probing the hindrances towards electron transfer reactions across a surface-modified electrode/electrolyte interface using the $K_3[Fe(CN)_6]/K_4[Fe(CN)_6]$ redox couple as a probe solution [33,34].

The EIS data and fitted spectra of the different modification steps were as shown in Fig. 2. An equivalent circuit consisting of a solution resistance (R_s), a charge transfer resistance (R_{ct}), a constant phase element (CPE1), and a Warburg impedance (Wd), shown in the inset figure, was used to model the EIS pattern. As shown in Table 1, the solution resistances for all surfaces have a similar value of approximately 5 Ω; however, as evident in the EIS spectra in Fig. 2 and the fitting parameters in Table 1, the modification of the Au electrode by a DEAE-Dex layer results in an increase in the semicircle diameter corresponding to the charge

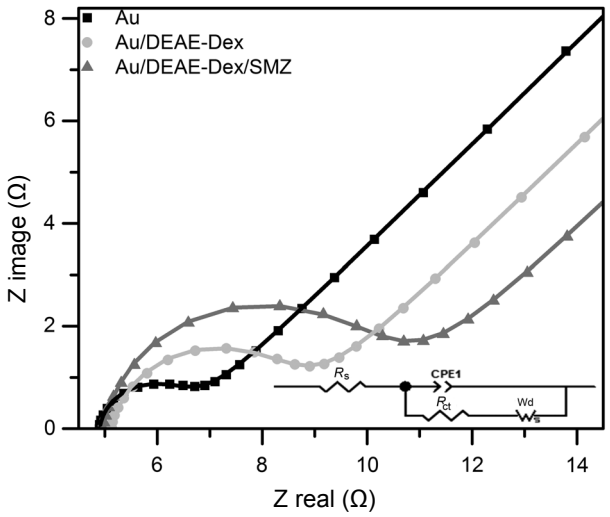

Fig. 2. Electrochemical impedance spectroscopic images of a bare gold electrode (Au), Au–diethylaminoethyl–dextran (Au/DEAE-Dex), and Au/DEAE-Dex–sulphamethizole (Au/DEAE-Dex/SMZ) modified surfaces in 0.1 M KCl containing 4 mM $Fe(CN)_6^{3-}/Fe(CN)_6^{4-}$ at a scan rate of 50 mV/s. R_s – solution resistance, R_{ct} – charge transfer resistance, Wd – Waburg impedance.

Table 1. Summary of the results of electrochemical impedance spectroscopic fitting

	Au	Au/DEAE-Dex	Au/DEAE-Dex/SMZ
Solution resistance, Ω	4.90 ± 0.02	5.13 ± 0.02	4.97
Charge transfer resistance, Ω	1.67 ± 0.04	3.47 ± 0.07	5.37

DEAE-Dex – diethylaminoethyl-dextran, SMZ – sulphamethizole.

transfer resistance (R_{ct}) at the electrode interface. The R_{ct} value of 3.5 Ω for DEAE-Dex modified gold is more than two times the R_{ct} value of bare gold (1.7 Ω).

The slight inhibition of the electron transfer despite the significant molecular weight of DEAE-Dex, can be possibly explained by the nature of the electrostatic interactions between the polycationic dextran and anions of the redox probe. Namely, the polycationic sites of DEAE can attract the negatively charged $Fe(CN)_6^{3-}/Fe(CN)_6^{4-}$, thus facilitating the electron transfer between the solution and the electrode surface. After the incubation in the SMZ solution, R_{ct} has a further increased value revealing an enhanced inhibition of the electron transfer at the interface due to the SMZ adsorption on the DEAE-Dex-modified surface. The electrochemical measurements therefore confirmed the sensor surface modification with the DEAE-Dex layer and the subsequent SMZ preconcentration on the surface. It is worth mentioning that the ion permeability of the DEAE-Dex layer, which allows the charge transfer at the modified electrode interface, is essential for the subsequent electrodeposition of the PmPD matrix.

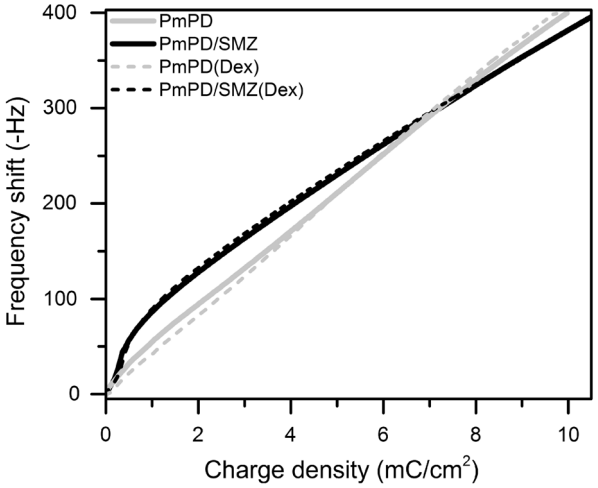

Fig. 3. In situ responses of a quartz crystal microbalance (QCM) sensor as a function of the electrical charge passed during the potentiostatic (0.6 V vs Ag/AgCl) electrodeposition of *m*-phenylenediamine (PmPD) and PmPD–sulphamethizole (PmPD/SMZ) on diethylaminoethyl–dextran modified and unmodified sensor electrodes from the phosphate buffered saline solution (pH = 7.4).

3.2. Preparation of SMZ–MIP films

The electrochemical syntheses of PmPD/SMZ and PmPD films were performed directly on the unmodified (PmPD and PmPD/SMZ) as well as on the dextran-modified (PmPD(Dex) and PmPD/SMZ(Dex)) QCM sensor surfaces. In the case of the PmPD(Dex), the preadsorption of SMZ on the dextran-modified sensor was skipped. The potentiostatic electrodeposition process was controlled by passing an amount of charge through the electrode of the sensor with respect to QCM responses that were being recorded at the same time (Fig. 3). This is to ensure that the resulting imprinted SMZ–MIP and SMZ–MIP(Dex) films forming on the sensor surfaces had equal thickness with their corresponding non-imprinted control films, NIP and NIP(Dex), respectively. Thus, PmPD and PmPD/SMZ films with the possible thicknesses corresponding to a QCM sensor frequency decay of –400 Hz, under the given experimental conditions, were prepared. As seen in Fig. 3, the electrodeposition of mPD in the presence of SMZ required less charge to produce polymer films of identical response compared with the mPD electrodeposition in the absence of SMZ. It also reveals that the difference in the generated polymer amount became less pronounced after 6 mC/cm^2. More importantly, it should be noted that the dextran modification did not affect to any significant extent the electrodeposition of the PmPD and PmPD/SMZ polymer films as predicted earlier (see Section 3.1).

3.3. Rebinding study

The rebinding of the target antibiotic molecule (SMZ) on the imprinted film was studied by the QCM-FIA technique, which allows real-time monitoring of molecular interactions in a film on the surface of the sensor. To estimate the relative binding capacity of the fabricated MIP towards the SMZ template molecules, a control experiment was performed with the corresponding NIP film. This was followed by the analysis

of the sensor signals and evaluation of the relative recognition capacity of the MIP by the imprinting factor (IF), a parameter that indicates the relative binding ability of the interaction of the imprinted polymer towards the analyte as compared with its non-imprinted counterpart. With larger IF values, more binding sites are available in the resulting imprinted polymer as compared with the reference polymer suggesting thus that a MIP with a higher IF should give a correspondingly higher selectivity as observed in many reported works [32,35–37].

The following equation was used to calculate IF:

$$\mathrm{IF} = Q_{\mathrm{eq(MIP)}}/Q_{\mathrm{eq(NIP)}}, \qquad (1)$$

where $Q_{\mathrm{eq(MIP)}}$ and $Q_{\mathrm{eq(NIP)}}$ are equilibrium binding capacities of MIP and NIP, respectively. To calculate the value of Q_{eq}, the adsorption kinetics data from the corresponding sensor responses (Fig. 4) were firstly modelled as the sum of two integrated rate equations for the association phase:

$$Q_{\mathrm{eq}} = Q_{\mathrm{eq1}}[1-e^{-kobs1*t}] + Q_{\mathrm{eq2}}[1-e^{-kobs2*t}], \qquad (2)$$

where *kobs*1, *kobs*2, and Q_{eq1}, Q_{eq2} are pseudo-first-order kinetic constants and equilibrium adsorption capacities for binding sites of types 1 and 2, respectively. Such approach postulates the presence of two types of binding sites offering different binding interactions and provides improved goodness of fit for heterogeneous imprinted polymers [38]. The value of Q_{eq} was calculated as the sum of the respective Q_{eq1} and Q_{eq2} obtained from fitting the kinetics data to Eq. (2). The calculated values of the IF for the sensor response at 1 mM SMZ injection are presented in Table 2.

Table 2. Binding capacities, correlation coefficients, and imprinting factors derived from the fitting of the kinetic data of 1 mM injection signals of Fig. 4 to Eq. (2)

Polymer matrix	Q_{eq} (Hz)	R^2	IF
SMZ–MIP	–15.52 ± 0.04	0.999	
NIP	–14.97 ± 0.13	0.996	1.0
SMZ–MIP(Dex)	–16.85 ± 0.04	0.999	
NIP(Dex)	–6.40 ± 0.06	0.992	2.6

Figure 4a shows the frequency responses of the QCM sensors coated with the SMZ–MIP and NIP films upon consecutive injections of the solution with increasing concentrations of SMZ in the PBS buffer. It can be seen that the SMZ injections of 0.04 mM caused the response of the SMZ–MIP coated sensor to be only slightly higher than that from the corresponding NIP. The difference in the responses of the SMZ–MIP and NIP films was more evident only after the SMZ injection of 1 mM. The calculated IF for this MIP–NIP pair is 1.0 (Table 2), indicating a weak adsorption capacity of the given SMZ–NIP film over its corresponding NIP along with the high nonspecific adsorption of SMZ.

However, analysis of the signal responses of the SMZ–MIP(Dex) and NIP(Dex) modified QCM sensors reveals a rather different behaviour (Fig. 4b). Namely, the MIP sensor has noticeably higher frequency shifts than those of the NIP sensor starting from 0.04 mM analyte injection. Moreover, the signal difference became more pronounced with the injection of increasingly higher SMZ concentrations, yielding in the end an IF value of approximately 3 at 1 mM SMZ injection

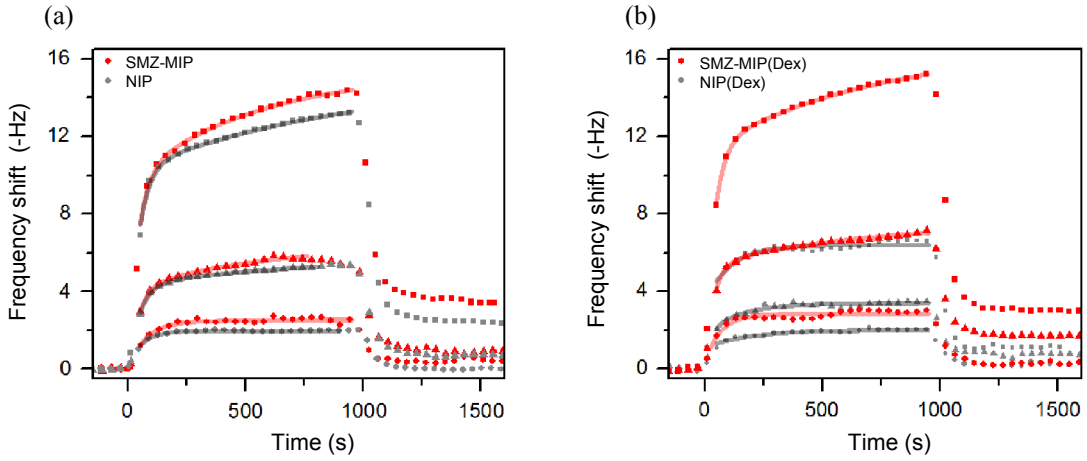

Fig. 4. Frequency responses of the quartz crystal microbalance (QCM) sensor modified with (a) sulphamethizole–molecularly imprinted polymer (SMZ-MIP; red) and non-imprinted polymer (NIP; grey) and (b) SMZ-MIP(Dex) (red) and NIP(Dex) (grey) upon injections of 0.04 (circle), 0.2 (triangle), and 1 mM (square) SMZ concentrations in phosphate buffered saline solution. The solid lines represent the fits to Eq. (2).

(Table 2), which is significantly better than the corresponding IF for the non-dextran modified films (IF = 1.0).

A careful observation of the response signals in Fig. 4 and the equilibrium parameters obtained from the kinetic fit of the signals (Table 2) reveals two important phenomena, including the fact that the dextran modification substantially decreases SMZ adsorption on the NIP film (–14.97 Hz vs –6.40 Hz). This means that unsolicited interactions of the analyte with the polymer matrix are greatly reduced on the reference film and by extension, on the imprinted polymer. Secondly, the dextran-enabled SMZ immobilization improves the binding capacity of the SMZ–MIP film (–16.85 Hz vs –15.52 Hz) by providing, probably, more binding sites in the reticulated polymer matrix. Although little difference can be observed between the equilibrium signals for dextran-modified and non-modified imprinted films, it can be explained by the fact that the reduction of the contribution from nonspecific signals leads to a corresponding reduction in the overall signals. Furthermore, Fig. 5a shows that the dextran-modified imprinted (SMZ–MIP(Dex)) and non-imprinted (NIP(Dex)) films show higher and lower change in frequency responses, respectively, as compared to their non-modified counterparts. The corresponding IF values (Fig. 5b) clearly indicate the significantly higher relative binding capacities of the dextran-modified surfaces as compared with the non-modified ones, starting from the very first concentration, with observable increasing difference as the injected concentration increases. These results thus demonstrate, within the space of the available experimental details, the beneficial effects of the SMZ-preconcentrated dextran modification step in the SMZ–MIP synthesis procedure allowing an enhanced sensitivity of the SMZ–MIP(Dex) films towards SMZ.

4. CONCLUSIONS

Quartz crystal microbalance (QCM) has been largely utilized as a low-cost mass-sensitive label-free sensor platform for monitoring and analysing molecular interaction. However, owing to the diminishing sensitivity of the QCM with the decreasing size of the observed target molecules, its reliability for an accurate direct detection and analysis of a small analyte by molecular imprinted polymer (MIP) is limited. This study proposes preliminary steps towards improving the detection of a small analyte by the QCM modified with a MIP-based sensitive layer. By immobilizing sulphamethizole (SMZ) molecules using a preadsorbed dextran layer on the sensor electrode before the electropolymerization of the template–monomer solution complex, more specific recognition sites were created within the SMZ–MIP(Dex) matrix after the SMZ washing out process as compared with the SMZ–MIP having no such dextran modification. This exemplifies the advantage of the sensor surface modification by DEAE–Dex that allows the template preconcentration before the polymer film synthesis, thus yielding an additional entrapment of SMZ molecules within the polymer matrix and thereby leading to an increased imprinting sites within the polymer and consequently an enhanced recognition capacity of the SMZ–MIP(Dex) film. Although further studies are being carried out to analyse the selectivity of detection as well as optimizing and/or improving the binding capacity to cater for analytically relevant sensitivity levels, the presented protocol, within the space of the available experimental details, could be a promising route towards an improved detection of small molecules by molecular imprinting on mass-sensitive sensor transducers such as the QCM.

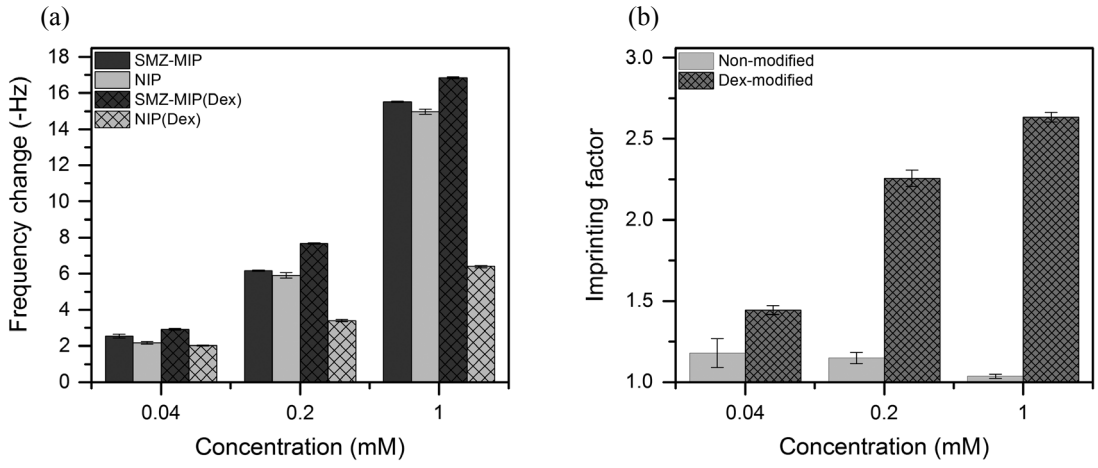

Fig. 5. Graphical comparison of the response signals (a) and the resulting imprinting factors (b) for the prepared sensors as measured at different concentrations of the analyte.

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Parendatud omadustega molekulaarselt jäljendatud polümeerid väikeste molekulide määramiseks

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Molekulaarse jäljendamise meetodi kasutamine erinevate ravimijääkide, nagu sulfametisool (SMZ), määramiseks vesikeskkonnas on keskkonnaseireks täpne, lihtne ja odav tehnoloogia. Antud artiklis on esitatud tehnoloogilised täiendused väikese sihtmolekuli sulfametisooli suhtes molekulaarselt jäljendatud polümeeri (SMZ–MIP) valmistamiseks. Molekulaarse jäljendamise tehnoloogia on kombineeritud piezoelektrilise kvartskristallanduriga, mis võimaldab sihtmolekuli sidumisel tekkiva signaali kiire ja täpse edastamise. Molekulaarselt jäljendatud polümeerkile valmistati elektrokeemilisel polümerisatsioonil piezoelektrilise kvartskristalli kuldelektroodile, kasutades monomeerina *m*-fenüleendiamiini sihtmolekuli SMZ-i juuresolekul. Sihtmolekuli parema sidumise tagamiseks käsitleti jäljendatud polümeeri SMZ–MIP-ga piezoelektrilise kvartskristalli kuldelektroodi eelnevalt dietüülaminoetüül-dekstraani (Dex) lahusega nii, et elektrokeemilise polümerisatsiooni tulemusena tekkis sulfometisooli suhtes jäljendatud SMZ–MIP(Dex)-kile. Eelkäsitlus dekstraaniga võimaldas elektrokeemilisel polümerisatsioonil sihtmolekuli SMZ paremini elektroodi pinnale kontsentreerida ja seeläbi oluliselt suurendada sihtmolekuli suhtes jäljendatud pesade arvu SMZ–MIP(Dex)-kiles. Nagu näitasid sidumise efektiivsuse analüüsi tulemused, oli dekstraaniga käsitletud SMZ–MIP(Dex)-kiledel ilma eelkäsitluseta SMZ–MIP-ga võrreldes sihtmolekuli spetsiifilise sidumise efektiivsus kolm korda suurem. Eelkäsitlus dekstraaniga vähendas ka mittespetsiifilist sihtmolekuli adsorptsiooni, mis omakorda suurendas SMZ–MIP(Dex) efektiivsust sihtmolekuli SMZ sidumisel. Uuringutest võib järeldada, et aluspinna dekstraaniga eelkäsitlus parandab oluliselt SMZ–MIP(Dex)-kilede SMZ-i spetsiifilise sidumise efektiivsust ja on rakendatav ka teiste analoogiliste väikeste molekulide molekulaarsel jäljendamisel ning määramisel piezoelektrilist kvartskristalli kui sensorit kasutades.