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Surface modification procedure for biosensor chips made of chemically sensitive polymers

C. Heinemeyer, M. van der Loh, M.-N. Wagner, K. Länge*

Karlsruhe Institute of Technology (KIT), Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany

Abstract

Polymers are common housing materials in biosensor chips, but are often chemically less resistant than the biosensor components. Hence, modification procedures optimized for biosensor surfaces may affect potential chip materials. Still, it might be more economic to re-adapt a surface modification procedure than to re-establish a chip fabrication process with a chemically more stable polymer. In the following, potential means to deal with chemically less stable polymers are shown.

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Keywords: surface modification; silane; polymers; biosensor chips; C-reactive protein

1. Introduction

Polymer housings in biosensor chips enlarge the chemical environment of the device. This has to be considered for the respective biosensor surface modification procedure, as the coating may have an impact on the additional polymer material, while the biosensor component itself remains unharmed. Critical steps regarding polymer stability include organic solvents for dissolving reagents and rinsing steps as well as the reagents themselves, such as silanes, which are used to introduce functional groups on oxidizable device surfaces to allow the subsequent immobilization of protein-repellent hydrogel layers and analyte-specific capture molecules [1]. The solvents can easily be replaced by solvents adapted to the respective polymers [2]. To deal with the silanization, we replaced the two-step coating with silane and hydrogel by a one-step coating with a silane-modified hydrogel. The performance of this chemically milder coating procedure was investigated with surface acoustic wave (SAW) biosensors [3].

* Corresponding author. Tel.: +49-721-608-22673; fax: +49-721-608-26667.
E-mail address: kerstin.laenge@kit.edu

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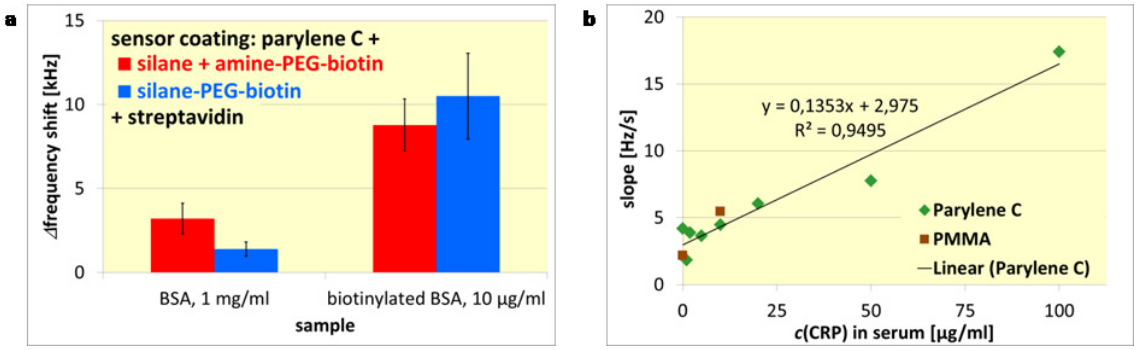

Fig. 1: Performance of SAW biosensors coated with silane-PEG-biotin. (a) Comparison of signal responses obtained by coating parylene C coated SAW devices with either silane plus amine-PEG-biotin or with silane-PEG-biotin. After immobilization of streptavidin, BSA and biotinylated BSA samples were applied subsequently. (b) Signal responses obtained with CRP samples and SAW devices coated subsequently with polymer (parylene C or PMMA), silane-PEG-biotin, streptavidin, and biotinylated anti-CRP.

2. Methods

Chemically sensitive polymers to be tested were polydimethylsiloxane (PDMS), polymethyl methacrylate (PMMA), and polystyrene (PS). Stability tests were performed with 3-(glycidoxypropyl)trimethoxysilane) (GPTMS), 3-aminopropyltriethoxysilane (APTES), and aqueous solutions of polyethylene glycol (PEG) modified with silane and biotin groups (silane-PEG-biotin). SAW devices were coated with parylene C (poly(2-chloro-p-xylylene)) or PMMA to obtain a chemically homogeneous surface. After plasma activation, the devices were either treated with GPTMS and an aqueous solution of PEG providing amino and biotin groups (amine-PEG-biotin) or with an aqueous solution of silane-PEG-biotin. This was followed either by streptavidin immobilization, BSA (bovine serum albumin) blocking and application of biotinylated BSA samples or by subsequent immobilization of neutravidin and biotinylated anti-CRP, followed by application of CRP samples containing 10 % human serum. Details of the SAW device and the SAW biosensor measurement setup have been described earlier [4].

3. Results and discussion

While PDMS, PMMA and PS were visibly affected by the silanes (GPTMS or APTES), even if diluted, the polymers were not visibly affected by treatment with silane-PEG-biotin. SAW biosensor coatings with GPTMS plus amino-PEG-biotin and with silane-PEG-biotin resulted in similar sensor performance (Fig. 1a). After immobilization of streptavidin, low non-specific BSA signals and high specific biotinylated BSA signals were obtained, i.e., the chemically mild coating procedure is equivalent to the coating procedures based on aggressive silanes. Next, CRP samples containing 10 % human serum were applied on SAW devices modified with silane-PEG-biotin, neutravidin and biotinylated anti-CRP. The underlying polymer was either chemically stable parylene C or chemically sensitive PMMA. Similar results were obtained (Fig. 1b), confirming that the chemically mild coating procedure is suitable for sensing layers on chemically sensitive polymers. Furthermore, the newly introduced one-step coating procedure requires less effort than the conventional two-step coating procedure; and it is transferable to other oxidizable surfaces, such as polymers as used for biosensor chips or lab-on-a-chip systems.

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