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Short communication

Impedance-based haptentation of skin sensitizers with self-assembled monolayer of gold nanoparticles and cysteine modified screen printed carbon electrode

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Highlights

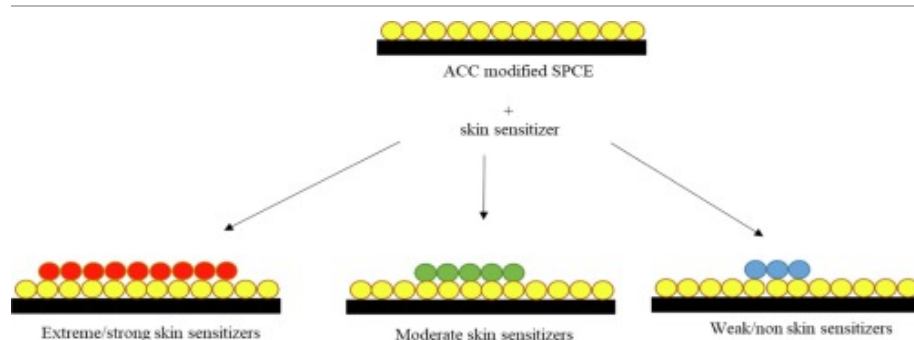
- To explore the haptentation of skin sensitizer with a modified screen printed carbon electrode and a self-assembled monolayer of gold nanoparticles and cysteine using the impedance technique.
- The interaction of extreme/strong skin sensitizer was discovered with a high value of changes of charge transfer resistance of skin sensitizer ($\Delta R_{CT}^{\text{skin sensitizer}}$).
- A total of 9 min was reported to be the optimum contact time with skin sensitizer.
- The adsorption isotherm studies showed Langmuir isotherm adsorption and spontaneous mechanism.

Abstract

Haptentation of skin sensitizer is indicated because of the covalent attachment of a skin sensitizer to a skin protein. The idea of this research is to explore the haptentation of skin sensitizer with a modified screen printed carbon electrode (SPCE) and a self-assembled monolayer of gold nanoparticles (AuNPs) and cysteine (designated as ACC modified SPCE) using the impedance technique. The ACC modified SPCE was characterized using Fourier-Transform infrared spectroscopy-attenuated total reflectance (FTIR-ATR), atomic force microscopy (AFM), and Energy Dispersive X-Ray Spectroscopy (EDX). The presence of AuNPs and cysteine on the working electrode of the ACC modified electrode was detected by FTIR-ATR and EDX. AuNPs, possessing a homogeneous dot shape, and cysteine was randomly distributed on the carbon surface of SPCE shown by FESEM images. The AFM images indicated the possibility of a monolayer of adsorption of skin sensitizer onto ACC modified SPCE. The ACC modified SPCE has good reproducibility and stability with an RSD of 8.43%. In addition, the interaction of extreme/strong skin sensitizer with the ACC modified SPCE was discovered with a high value of changes of charge transfer resistance of skin sensitizer ($\Delta R_{CT}^{\text{skin sensitizer}}$) when compared to moderate and weak/non skin sensitizers. A total of 9 min was reported to be the optimum contact time of the skin sensitizer onto ACC modified SPCE. The adsorption isotherm studies of skin sensitizers with ACC modified SPCE showed Langmuir isotherm adsorption and spontaneous mechanism. Maleic anhydride (as a model of extreme/strong skin sensitizers) showed a fast-binding rate (18.2149M^{-1}) with the addition of a slow dissociation rate of 0.0549M , while glycerol (as a model of weak/non skin sensitizer) showed a slow binding rate of 4.5977M^{-1} as a result of a rapid dissociation rate of 0.2175M . The change in Gibbs free energy (ΔG°) was calculated for ACC modified SPCE with glycerol and maleic anhydride to be at $-3.78 \times 10^{+03} \text{ kJ/mol}$ and $-7.19 \times 10^{+03} \text{ kJ/mol}$, respectively. This study proved that the ACC modified SPCE could be used for routine screening during the early product development stage in qualitative skin sensitization measurements.

Graphical abstract

The schematic model of ACC modified SPCE immobilized with different potency of skin sensitizers (extreme/strong (red), moderate (green) and weak/non sensitizers (blue)).



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Introduction