Development of a Portable, Tattoo-Based Biosensor for the Non-Invasive, Low-Cost Diagnosis of Atherosclerosis via Iontophoresis of Macrophage-Targeting Silver Nanoparticles

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Atherosclerosis and subsequent cardiovascular disease causes nearly one-third of all deaths in the world. Unfortunately, atherosclerosis commonly remains asymptomatic for decades, and is properly diagnosed only after a severe, life-threatening cardiac event. A simple, portable, and inexpensive method for early detection of atherosclerosis is highly desirable. This research details the fabrication of a cost-effective and portable tattoo-based system for the detection and quantification of atherosclerosis progression. The system is contained within a screen-printed biosensor which utilizes human immune response in order to quantify macrophage concentration in the bloodstream via the transdermal iontophoretic administration of spermine-silver nanoparticles (spAg-NPs). In clinical usage, the patch is placed on the skin directly above the carotid bifurcation, where plaque quantification/diagnostic accuracy is especially high. The patch utilizes an iontophoretic circuit to introduce spAg-NPs into the interstitial fluid matrix. The patient then waits for macrophages to enter into the matrix and engulf a portion of the spAg-NPs. Remaining spAg-NPs are then extracted via a reversed current, which then react with amine oxidase to produce H2O2, which in turn electrochemically reduces Prussian-Blue ‘artificial peroxidase’. Current produced is measured to determine concentration of spAg-NPs, and thus the concentration of macrophages in the bloodstream, which correlates directly with progression of the atherosclerotic plaque. The biosensor demonstrated a limit of detection of 3.26x10-5M spAg-NPs, with a sensitivity of 5.07 μA/μM-cm2, allowing for the precise, cost-effective detection of as little as 0.059% arterial cross-sectional plaque buildup within the carotid bifurcation.

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