Antibody-nanocluster Biohybrids and Multimodal Wearable Biosensors for Cost-Effective and Personalized Health Monitoring

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In recent years, nano- and micromaterials have revolutionized the field of advanced healthcare, offering unparalleled opportunities for the development of innovative diagnostic tools. Two areas of research in this context are the design of highly sensitive and low-cost assays for disease detection and their implementation in point-of-care and wearable biosensors for continuous monitoring.

Our research team has been actively involved in advancing both fronts. On one hand, the modification of bioreceptors using nanomaterials has enabled the incorporation of novel functionalities that can be exploited for signal transduction. Nanoclusters (NCs) in particular, have emerged as a powerful tool in biodetection, offering higher surface-to-volume ratios and catalytic activity compared to larger nanoparticles [1]. The modification of antibodies with bimetallic catalytic NCs has demonstrated extended stability and sensitivity compared to the traditional conjugation with biological labels, showing robustness when implemented in paper-based immunoassays [2]. These advances hold great promise for the development of point-of-care diagnostics, enabling rapid and cost-effective disease detection in resource-poor settings.

On the other hand, the development of wearable transdermal biosensors enables comfortable access to biomarkers in interstitial fluid (ISF), which provide continuous insights into health status [3]. We report a fully printed flexible patch [4] that incorporates the multimodal detection of various parameters along with iontophoretic extraction of analytes from ISF via electromigration [5] without drug delivery. The patch has been designed for applications where no sweat can be easily produced (e.g. older adults), and integrates sensors for conductivity/ionic strength, temperature, and two biomarkers such as cortisol and sodium ions. The analytical capability of each sensor has been tested in vitro within expected skin ranges, and we report a proof-of-concept assessment of dehydration in ex vivo settings using pig skin models.

The convergence of these two research areas is expected to usher in a new era of advanced healthcare, where wearable biosensors and ultra-sensitive assays combine to provide comprehensive and personalized health monitoring continuously. By harnessing the unique properties of nanomaterials and the scalability of printed electronics, the detection and monitoring of diseases is improved toward a more accessible, timely and personalized manner, ultimately improving human health and well-being.

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