Abstract

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Enhancing the Sensitivity of the Virus BioResistor by Overoxidation: Detecting IgG Antibodies

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Abstract

Antibodies can be indicators of disease and its progression. A relatable example is the COVID pandemic, during which antibody tests to determine exposure to the SARS-CoV-2 virus are time-consuming, lab-exclusive techniques performed by trained technicians. Detecting antibodies with electrochemical sensors promises to eliminate the complexity and exclusivity of the current test methods. This project presents an electrochemically engineered virus bio-resistor (VBR) composed of a bio-layer embedded with M13 phage particles that supplant antigens to detect antibodies. In prior work, the VBR demonstrated rapid detection of a bladder cancer marker DJ1 (20.8 kDa) using a simple dip and read modality. In the present work, we found that VBRs exhibit a sensitivity that is inversely related to the molecular weight of the protein target. Thus, large proteins, such as IgG antibodies (150 kDa), were undetectable even at high concentrations. To remediate this, overoxidation of the VBR channel was accomplished potentiostatically at +0.8 V vs. MSE for 100−150 s in aqueous 12.5 mM $LiClO_4$. Over-oxidation resulted in an increased electrical impedance, enhancing sensitivity for small and large proteins. The signal generated by these “O2VBRs” was amplified by 3-7 x for the DJ1 biomarker compared to unmodified VBRs. SEM and AFM images illustrated pronounced changes to the topography of the virus-PEDOT layer caused by overoxidation. O2VBRs enabled the detection and quantitation of anti-FLAG IgG and anti-M13 antibody, with a detection limit of 40 ng/mL and a dynamic range of quantification extending to 600 ng/mL. Additionally, KD values of 220 (±20) ng/mL (anti-M13) and 402 (±7) ng/mL (anti-FLAG) suggested that VBR can differentiate between the binding affinities of the two antibodies.

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Biography

Apurva Bhasin is a senior research scientist at PhageTech Inc., a diagnostic company that patented VBR technology co-invented by Dr. Bhasin in her Ph.D. She heads the biosensor research project at PhageTech, where she is designing, evaluating, and optimizing impedimetric biosensors for label-free detection of bladder cancer biomarkers. An alumnus of the University of California Irvine, she pursued her Ph.D. thesis under the guidance of Dr. Reginald Penner. She was awarded the “American Institute of Chemists Graduate Student Award” at UCI in 2020.

