ABSTRACT:

Nanostructured Boron-Doped Diamondized Nanowalls: Engineering Electrochemical Performance for Biosensing Applications

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This study unveils the remarkable electronic, optical, and electrochemical attributes of boron-doped carbon nanowalls (B-CNW) synthesized through microwave plasma-assisted chemical vapor deposition (CVD) using a gas mixture of H2:CH4:B2H6 and N2. These B-CNWs possess distinctive features, including sharp edges, flat and elongated structures, and a high content of sp2 and sp3 hybridized diamond phases. Tailoring the synthesis parameters achieves the desired structure and morphology.
Neurotransmitter sensing is crucial for diagnosing and treating psychological disorders and neurodegenerative diseases. Accurate electrochemical sensors demand a profound understanding of materials at the molecular level and their application in biological fluids. To address this, we have enhanced diamondized boron-doped carbon nanowalls (BCNWs) by coating them with an electropolymerized polydopamine/polyzwitterion (PDA|PZ) layer, offering tunable mechanical and electrochemical properties.
The incorporation of zwitterions, co-deposited with PDA and noncovalently integrated into the structure, facilitates a specific separation of diffusion fields during electrochemical reactions. This leads to an enhanced contribution of steady-state currents in amperometric response, resulting in a 4-fold increase in sensitivity (from 3.1 to 14.3 μA cm−2 μM−1) and a 5-fold decrease in the limit of detection (from 505 to 89 nM) compared to pristine BCNWs. These incorporated zwitterions also impart antifouling capabilities, maintaining sensing enhancement even in the presence of high concentrations of bovine serum albumin (BSA).
The zwitterions further facilitate the transport of dopamine towards the electrode through intermolecular interactions, such as cation-π and hydrogen bonds. Polydopamine units on the surface create molecular pockets driven by hydrogen bonds and π-π interactions,

stabilizing the intermediate state of dopamine-analyte oxidation and enhancing sensing properties. In summary, the potential of BCNW surfaces extends beyond sensor applications, encompassing functions such as electron emission, capacitors, and batteries.