Graphene quantum dots electrochemistry and development of sensitive electrochemical biosensor

T. Smith, A. Banaszak and Sanju Gupta

Department of Physics and Astronomy, Western Kentucky University, Bowling Green, KY 42101

Graphene quantum dots (GQDs) are zero-dimensional material derived from graphene derivatives with characteristics from the structure of graphene with quantum confinement and edge effects possessing unique properties. Intense research activity in GQDs is attributed to their novel physical-chemical phenomena arising from the sp^2-bonded carbon core surrounded with edge functional moieties. In this work, GQDs of optimal 5-7 nm size are investigated for their fundamental electrochemical properties and use in electrochemical sensing including enzyme-based glucose biosensor. Glucose oxidase (GO_x) was immobilized on GQDs modified glassy carbon (GC) and the UV-Vis absorption and fluorescence spectroscopy, electron microscopy, cyclic and differential pulse voltammetry and electrochemical impedance spectroscopy, techniques were used for characterizing the electrochemical biosensor. The well-defined quasi-reversible redox peaks were observed under various electrochemical conditions (pH, concentration, scan rate) to determine diffusion coefficient and heterogeneous electron transfer rate constant. The developed biosensor based on GO_x/GQD responds efficiently to glucose presence over the concentration range 10 μM - 3 mM with limit of detection 4.57 μM. The relatively high-performance is attributed to large surface–to–volume ratio, excellent biocompatibility of GQDs, mesoporous GQD/GC and abundant hydrophilic edges and hydrophobic plane in GQDs that favors the GO_x adsorption on electrode surface. We also carried out similar studies with other graphene-based electrode surfaces and biomolecules for electrochemical comparison opening ways for potential sensing applications in medicine as well as biotechnology.