Nanocarbons for electroanalysis

Edited by S. Szunerits, R. Boukherroub, A. Downard, J.-J. Zhu.

Wiley, 2017.

Book's topic: The neophyte electroanalytical researcher wishing to explore carbon materials as a basis for new electroanalytical methods or sensors is faced with an incredible range of materials. How to choose between glassy carbon, boron-doped diamond, the resurgence of pyrolytic graphite via its edge and basal planes, screen-printed carbons, and the myriad of nanocarbons now available must be daunting to the new comer. But never fear – help is available in the selection of nanocarbons via this new volume published in 2017. Nanocarbon is the generic name for the many forms of carbon nanoscale materials that have been discovered and that have exploded into popularity in recent decades. Principle amongst these are carbon nanotubes, whether multiwalled or single walled, fullerenes (C60 *et al*.) and of course, the monster of them all, graphene. This book, a volume in the series "Nanocarbon Chemistry and Interfaces" discusses these popular types of nanocarbons and many more, such as carbon dots, carbon nanofibres, and diamond nanostructures. The conductive and redox behaviour of these materials make them attractive tools for various electrochemical applications, and their combination with modern nanoscience and nanofabrication has enabled the creation of a wide selection of nanostructured surfaces and materials. Adding this material technology to the suite of electrochemical measurements for detection of target substances has resulted in the blossoming of studies into their applications in chemical analysis, including within biomedical and biochemical detection, environmental analysis and more. This book aims, as the editors state, "to present the most widely employed carbon based electrode materials and the numerous electroanalytical applications associated with then".

Contents: the book consists of nine chapters written by experts in the respective areas. Chapter 1 (Shiba, Kamata, Kato and Niwa) discusses carbon film electrodes and their uses in electroanalysis. This chapter reviews fabrication methods, which are based on pyrolysis in various formats, as well as electrochemical properties and applications of these film electrodes, including doping with metallic nanoparticles, to improve performances. Chapter 2 (You, Liu, Li) introduces carbon nanofibers as electrodes, including their preparation by electrospinning, their formation into nanocomposites with cellulose, and their loading with metal nanoparticles. Applications including enzymatic, non-enzymatic and immunochemical biosensors are reviewed. Chapter 3 (Yang and Venton) discusses the various forms of carbon nanomaterials employed in neurochemical analysis, such as carbon nanotubes in cast or directly grown films and carbon nanoelectrode arrays. Specific challenges that need to be addressed for neurochemical applications of these electrodes (anti-fouling, re-useability) are discussed. Chapter 4 (Chen, Li, Zhu) presents a review on carbon and graphene dots and encompasses also immobilisation strategies to add molecular function, electrocatalysis behaviour and demonstrator applications including metal ion detection, protein and DNA sensing, and merging with optical/photochemical methods. Chapter 5 (Randviir, Banks)

deals exclusively with graphene, tracing its birth, the various types (including graphene foam and screen printed graphene), and the electrochemical behaviour that makes it attractive for electroanalysis. Chapter 6 (Szunerits, Wang, Vasilescu, Li, Boukherroub) presents the combination of graphene with gold nanoparticles, discussing ways to combine these two nanomaterials as well as applications in small molecule detection (drugs, explosives, neurotransmitters) and large molecule sensing (DNA, protein biomarkers). In chapter 7, Pilehvar and De Wael discuss the use of fullerene-C60 materials in biosensors, encompassing the design of such modified electrodes, and interactions with DNA and various proteins for biosensing purposes. Diamond in the form of micro or nanostructures are discussed by Gao and Nebel in chapter 8, in which fabrication strategies are presented prior to examination of electrochemical properties that serve roles in biosensors, energy storage, catalysis and separations. The final chapter, 9 (Amiri) deals with carbon nitrides and silicon carbides as electrode materials, including their synthesis and uses in electroanalysis particularly in electrochemiluminescence and photoelectrochemistry and uses in biosensors.

Comparison with existing literature: This volume appears quite specialised, dealing with nanocarbons in electroanalysis. Based on my searching of well-known databases and my university library, most books dealing with carbon nanomaterials and electrochemistry tend to be focused on material properties and/or energy applications. Similarly, books dedicated to electroanalysis or sensors do have individual chapters on nanocarbon devices but not in a comprehensive way. For instance, the recent Frontiers of Graphene and Carbon Nanotubes (edited by K. Matsumoto, Springer 2015) deals with these materials in terms of their properties and uses in electronic devices, and does not cover in any comprehensive way the topic of electroanalysis. In contrast, the Handbook of Graphene Electrochemistry (D.A.C. Brownson and C.E. Banks, Springer 2014), which deals with graphene but not other nanocarbons, does discuss the uses of this material in electroanalysis and sensors. Hence, for those interested in a broad range of nanocarbon materials and their possibilities in new electroanalytical strategies, I think the current volume provides an excellent introduction and overview of recent advances.

Critical assessment: This volume covers a broad range of nanocarbon materials and their uses in electroanalytical methods/sensors. It is comprehensive in its coverage, introducing each material, its properties and the ways these have been exploited or investigated for analytical electrochemical assays. Each chapter contains well-chosen figures, mostly from the primary literature, and all have up-to-date citations of the literature so that readers can read the primary reports where needing fuller details. Most of the electroanalytical applications discussed throughout the chapters have a bio or medical basis, as is the case with most of the published research, obviously where researchers are looking for extra sensitivity or other performance parameter to meet the needs to particular measurements, e.g. in biomedical diagnostics. I did not notice any glaring omissions of materials or applications, so I think the editors have done a great job to be comprehensive in their selection of topics and authors for this volume.

Readership recommendation: I think this would be a fine book to give to a starting research student commencing work in this area or to experienced researchers in industry or academia seeking a quick survey of the state-of-the-art of nanocarbon materials in electroanalytical chemistry. I imagine materials scientists and fabrication engineers will also be interested in this volume as it displays the many applications of these materials and tools.

Summary: This volume provides a timely overview of the ways in which nanoscale forms of carbon can be used in electroanalytical chemistry. It provides a comprehensive coverage of the materials and their applications, with a bias towards bio and medical uses. It will be a valuable information resource for those interested in developing new materials and biosensors.