Functionalization of carbon and graphene quantum dots

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M.A. Saadiah[1,2], *N.F. Shaafi*[2], *S.K. Muzakir*[2] and *A.S. Samsudin*[2]
[1]Department of Chemistry, Centre for Foundation Studies, International Islamic University Malaysia, Gambang, Pahang, Malaysia, [2]Ionic Materials Team, Faculty of Industrial Sciences and Technology, Universiti Malaysia Pahang, Kuantan, Pahang, Malaysia

13.1 Introduction

Carbon is usually a black-powdered substance, which is not very soluble in water and exhibits weak fluorescence. Substantial research efforts have been concentrated on carbon-based materials in the past few years to improve their physicochemical and stability properties. The attention of many researchers from a wide range of interdisciplinary sciences, including nanotechnology and material sciences, is now focused on quantum dots (QDs)-based materials, comprising carbon quantum dots (CQDs) and graphene quantum dots (GQDs). Quantum dots are tiny nanoparticles of semiconducting material that are 10 nm or less in diameter and consist of 10−50 atoms. Meanwhile, GQDs, which are a division of CQDs, are made from graphene oxide and exhibit physical and chemical properties that are similar to graphene [1]. GQDs have a very small cross dimension of 2−10 nm, considering the ten layers of graphene that the final nanoparticles are made out of [2,3]. After the discovery of QDs, which was reported by Xu et al., in 2004, [4] research efforts have been directed to explore new approaches to achieve large scale production, uniform size and better properties of CQDs and GQDs. Based on the findings, it was revealed the QDs have excellent fluorescent properties, primarily with excitation wavelength-dependent emission, together with high chemical stability, luminescence, good photo-stability and optical broadband absorption inertness [5].

QDs materials have applications in various fields of science, including in biosensing, vitro and in vivo bio-imaging, photo-electrochemical water splitting, photo-catalysis, energy devices and light-emitting diodes to date. In addition, GQDs are considered to be good electron carriers, especially in biomedical technology because of its large surface area that increases contact with the analytic. This results in a larger active electrochemical surface area that promotes direct electron transfers with electroactive species. Therefore, adjustments of diverse substrates with GQDs can result in increased rates of electrochemical reaction since the geometric superficial area is an essential factor in electrochemistry [6,7]. On the other hand, biocompatibility of CQDs and GQDs are used in drug delivery systems, which give a significant contribution toward aqueous solubility. Quantum dots consist of two free functional groups, namely carboxyl (−COOH) and amine ($-NH_2$) for binding

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