Chapter 5
Green Biosynthesis of Carbon-Based Nanomaterials for Antioxidant, Anti-Bacterial, and Anti-Cancer Applications

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ABSTRACT

This chapter focused on the development of nano-scaled carbon-based materials based on simple, green approach using natural resources such as extracts of various plants or fruit/vegetable peel waste, tea, coffee, alovera, as well as citrus fruits- grape, lemons, oranges etc. for antioxidant, anti-bacterial and anti-cancer applications. The surface functionalization with the high level of polyphenolic compounds, that resist the body from free-radical damage, have been confirmed through FTIR, EDX analysis which can enhance their stability, impart bio-compatibility, anti-bacterial, anti-microbial and anti-cancer activity. The antioxidant activities have been investigated using DPPH free-radical scavenging assay. Furthermore, the bacterial activity of the synthesized nano-materials against various pathogenic organism (gram-positive and gram-negative bacterial strains) has been evaluated. Finally, dose-dependent anti-cancer activity in both in-vitro and in-vivo setting has established the anti-proliferative properties of the nano-materials against different cancer cell-lines.

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INTRODUCTION

Carbon is one of the most abundant elements on the Earth and also most useful in the Periodic Table. Carbon brushes, Graphite, a more stable form of Carbon, are well known essential component of electric motors and have been extensively utilised as lubricant (Morstein & Dienwiebel, 2021). Again, activated charcoal or activated carbon granules are very popular and have been widely used in cosmetics, personal care products and water filtration process over the past three decades (W. A. Helbig, 1946). Now-a-days, so many research works have been concentrated to develop alternative cost-effective and next-generation multi-functional materials with the help of these virtually unlimited and free carbon-based sources, though so many metal-based multi-functional nanomaterials provide incredible benefits to the society and have already been used in everyday consumer products. Metal-based nanomaterials, while offering unique properties, present drawbacks like potential toxicity, environmental concerns, and limitations in sustainable synthesis and recycling (Dutta, 2023). Moreover, carbon-based materials usually possess unique structural dimension, outstanding electrical conductivity, excellent mechanical, thermal, optical properties, enabled them attracted significant interest in diverse area. Carbon also exists in a wide variety of allotropic forms with 0D to 3D structures. Again, in the field of nano-technology, when the dimension of a material be so small, in the nano-scaled range, new interesting properties have been generated such as interesting chemical and physical properties, large specific surface area, large specific surface to volume ratio, greater surface tension, greater surface activity, high catalyst-loading capacity and better light absorption capacity. As a whole, carbon-based nano-materials become 'Revolutionary Materials' which have been developed for enormous attainable applications and can be utilised in daily life and everyday consumer products. Various types of Carbon-nanomaterials such as fullerene, nano-diamond, different nano-sized carbon allotropes, more popular carbon nanotubes (CNT), graphene, graphene oxide (GO), reduced graphene oxide (rGO) nano-sheet, carbon nano-fibers, carbon quantum dots (CQDs), carbon dots (CDs), polymeric graphite carbon nitride ($g\text{-}C_3N_4$), carbonized polymer dots (CPDs) etc. have been thoroughly investigated and started to be commercialized for the sake of society. Graphene nano-materials is commonly known as wondering material owing to possessing of unique 2D flat-layered graphite-like honeycomb lattice structure (graphitic allotropes), usually possess Π-conjugated electrons in the sp^2 hybridised domains which can effectively accelerate the electron transfer, scavenge photo-generated electron from semiconductor surface, enhance photo-generated charge-carrier separation and electron mobility or migration efficiency. This delocalised Π-electron cloud also responsible for Π-plasmon resonances and extensively used in plasmonic (LSPR)-based sensing application in health or biomedical, environ-

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