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D/o: Applied Science and Humanities, F/o Engineering & technology

Title of the Ph.D.: Synthesis of Graphene and Its Characterization.

Abstract

1. Honey, Zante Currant (Black Raisins), Ficus carica (Fig), and Phyllanthus emblica (Indian Gooseberry) used as Natural Reducing Agents.

Honey, *Ficus-carica* (Fig), Zante Currant (Black Raisins), and *Phyllanthus emblica* (Indian Gooseberry) have enough potential to reduce the exfoliated graphene oxide into green synthesized Graphene nano-sheets (GNS). All these natural reductants have several polyphenolic compounds like reducing sugars, vitamin C which have enough great ability to reduce graphene oxide. It enhances the hope of Green synthesis in field. These naturally occurring reducing agents (NRAs) have many advantages over hazardous chemical reducing agents. These are as follows:

- They are non-toxic, therefore have beneficial health effects.
- Their by-products are non-hazardous and act as stabilising agent for graphene layers and prevents their agglomeration.
- Cost effective, easily accessible, and abundant in nature.
- Easy to handle due owing to its non-hazardous nature.
- Works at moderate temperature.
- Eco-friendly, energy saving and inexpensive.
- Surface-functionalization of synthesized GNS can be done in-situ.
- Quality of GNS produced is comparatively good.
- Synthesized GNS have biomedical applications because of having high biocompatibility.
- Scalable and mass production of graphene nanosheets.
- Though graphene obtained is not of good quality but still it has potential applications viz., nano-electronics, conductive layers, bio applications, sensors, ink/paint, energy storage and composites etc., due to imperfections.

- Further obtained graphene confirmed by various characterization like XRD, UV, FTIR, Raman as well as DLS study.
- Morphological evaluation like HR-TEM and FE-SEM also confirm the successful reduction of exfoliated graphene oxide.
- Thermal study (TGA) of obtained Graphene matches with previous reported literature.

2. Use of Nature -based reductant in the Synthesis of Graphene nanocomposite material that used as a Nano-catalyst:

Generally heavy metal like Platinum, Palladium used as a heterogenous catalyst for organic synthesis but they several limitations like cost issue, poor yielding of product, non-recyclability of catalyst and others, while all these issues are solved nano-catalyst. So, it creates an area of research for using nanomaterial as a Nano catalyst.

In one of the experimental works we use Honey as a reductant which reduces graphene oxide as well as nickel acetate and copper acetate to form Nickel (II) peroxide/ copper (I) Oxide ($Gr@NiO_2/Cu_2O$ NCs) graphene nanocomposite material. It's not only reduced the material but also play stabilizing and capping agent. Further Graphene-based ($Gr@NiO_2/Cu_2O$ NCs) green heterogeneous catalyst used for an easy and effective synthesis of substituted Schiff base derivatives under ligand-free conditions, which provided good to excellent yields.

3. Utility of Phyllanthus emblica (Indian Gooseberry) mediated chemically derived graphene in photovoltaic activity

The new category of sensitizer called as perovskite materials has emerged and has drawn a lot of attention. It shows promising conversion efficiency and considered as a promising competitor for commercialization of solar cells. The sensitizer is the key component of "perovskite sensitized solar cell" (PSSC) because it absorbs sunlight and generates photo excited electrons in the semiconductor interface. Presently we have

used graphene oxide and reduced graphene oxide as counter electrode material in PSSC and show better performance and give a comparison between them.

Future scope of the Work

Naturally reduced graphene coated with metal nanoparticle used as a nano catalyst for large n organic synthesis reactions, water treatment applications like heavy metal adsorption, degradation of organic and inorganic pollutants, antimicrobial activity as well cytotoxicity of various cell lines. Other applications like use in making supercapacitor, li- ion batteries as well as solar energy cell may be possible. So, it concluded that green synthesized Graphene can be used in multidimensional field of research.