Design, synthesis, and characterization of carbon-based nanocomposites with conducting polymers /metal oxides and their application

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Currently the knowledge of low dimensional nanomaterial's attains global consideration, due to their outstanding applications in various fields such as sustainable energy, electrocatalysis, sensors, waste water management, environmental and bio-medical fields to have pollution free environment. Thus, it becomes necessary to examine the potential of low cost and ecofriendly two-dimensional (2D) nanomaterials. These 2D nanomaterials include carbon nanotubes, graphene oxide, layered metal hydroxides (LMHs) [layered single metal hydroxides (LSHs) and layered double hydroxides (LDHs)], graphitic carbon nitride (g-C3N4), metal carbides, nitrides (MXenes) and single- or few-layered transition metal dichalcogenides (TMDs). Organic-inorganic hybrid materials combine the advantages of synergistic interactions from organic and inorganic precursors and possess promising application prospect. Layered double hydroxides (LDH's) incorporated with carbon-based materials and other conducting polymers have been investigated due to their versatile and unique features.Carbon nanotubes (CNTs) provide a new model system for basic scientific study of material science. Substantive efforts have also been made to explore their applications. For example, CNTs have been used as nanofillers for preparing composite materials with enhanced mechanical and/or electrical properties, such as scanning probe tips, field emitters, diodes, quantum wires, support for catalysts, electrodes and so on. The utilization of carbon nanotubes was based on their unique structure and excellent physical properties, such as their good mechanical properties, electrical properties, one dimensional nanostructure, even at times many of or all these properties as a whole. Modification of CNTs with functional materials will greatly broaden and enhance their applications. The preparation of hybrid materials, based on the combination of metal oxides/conducting polymers and CNTs possessing the properties of each component, or even with a synergistic effect, would be useful in field emission displays, polymer or ceramic reinforcement, super capacitors, chemical sensors and drug delivery, biosensors, photocatalysts and electronic or photoelectrical devices. Furthermore, the use of biopolymers, polymers, metal oxides and carbon materials has been proposed for the preparation of innovative drug delivery devices. One of the most promising materials in this field are the carbon nanotube composites and hybrid materials coupling the advantages of polymers (biocompatibility and biodegradability) with those of carbon nanotubes (cellular uptake, stability, electromagnetic, and magnetic behavior). The CNT network has found to facilitate dispersion of the oxide nanoparticles because of their large surface and the ability to provide continuous conducting pathways for the transportation of electrons. These characteristics are beneficial for the applications of the hybrid materials of CNTs and metal oxides/conducting polymers.

There have been some investigations concerning the attachment of various inorganic oxides onto single-walled carbon nanotubes (SWCNTs) and multiwalled carbon nanotubes (MWCNTs). For example, oxide nanoparticles such as SiO_2, SnO_2, ZnO, TiO_2 in the presence of conducting polymers (polypyrrole, polyaniline, poly-o-Anisidine) have been coated onto CNTs by impregnation, sol–gel, hydrothermal synthesis, thermal evaporation-deposition and so on. In order to get strong combination and homogeneous distribution of oxide nanoparticles on functionalized CNT. Carbon supported nanomaterials possess high surface area, high conductivity, enhanced adsorption efficiency and thermal stability which makes the hybrid nanomaterials best candidates in catalysis, adsorption, drug delivery, photocatalysis, along with several other miscellaneous applications. Carbon based nanomaterials represent one of

the most technologically promising areas. However, still, there are many challenges that must be sorted out to explore the potential of these nanomaterials in other fields. The first challenge related to graphene-based nanomaterials is the method of preparation to get uniform size distribution so that all the surface atoms are fully exposed to utilize the maximum surface area. The second challenge in graphene oxide nanomaterials is to improve the overall electrochemical performance due to synergistic effects. The electrochemical applications of graphene oxide can be enhanced by varying various factors such as changing the metal ions, varying bivalent to trivalent or tetravalent metal ion ratios, doping, use of other various conducting materials (CNTs, CNFs, Carbon dots). Another major challenge in this rapidly growing field is to improve the functionalities of carbon supported nanomaterials. In addition, we are also looking for future developments in the use of graphene- CNT based nanocomposites in catalysis.

Currently we are working on synthesis, characterization and application of graphene, rGO, MWCNT, SWCNT, supported rare earth doped nanocomposites. These nanomaterials are evaluated in various applications like adsorption of heavy toxic metals from real water samples, photodegradation of toxic organic compounds and dyes present in waste water, Nano carriers for drug molecules, sensors for gases and liquids, supercapacitors.

Adsorption of toxic heavy metals from waste water is our prime motive. But regeneration or recyclability of the adsorbent is still pending issue. From the literature the efficiency of the adsorbent is almost reduced to its half as compared to initial efficiency after ten or twenty cycles.

Leakage of dangerous gases either from industries or labs is very harmful to mankind, hence, there detection is of prime importance. Recently we synthesized novel nanomaterials which have shown excellent sensing properties for both gases as well as liquids.

Using non-enzymatic biosensors which are economic instead of enzyme supported sensors is an emerging field of science and currently we are focusing in this area.

Due to the conductive nature of conducting polymers and high specific area, we are designing our materials for supercapacitors which is also another blooming area.

Biography:

Dr. Amjad Mumtaz Khan joined Department of Chemistry, Aligarh Muslim University, India in 2011 on permanent position as Assistant Professor at a young age. His area of specialization is Analytical chemistry and research interest includes chromatography, development of new nano materials in environmental pollution control and drug delivery systems. He has published 23 research articles in high impact journals of international repute and also published 5 book chapters in international publications such as CRC Press and Apple Academic Press.

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