Studies on Polyaniline based Composites for Biosensors

Thesis submitted in partial fulfillment for the

Award of Degree

Doctor of Philosophy

By

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9.1. Summary and Conclusion of the Thesis

In the present thesis, a set of polyaniline based composite materials have been developed and structural, electrical, thermal, electrochemical properties were thoroughly investigated using different instrumental techniques. We have developed electrochemical sensors based on prepared ternary composites. The present research work is summarized below

1) First three chapter deals with background and introduction.

2) Chapter 4: Comparativly study on four polyaniline/polysaccharide composite materials. Despite of same initial amount of aniline monomer and polysaccharides (starch, CMC, cellulose acetate and chitosan) significant variation in the yield and content of polysaccharide in composites, confirmed from gravimetric analysis. FTIR spectrums used to derived structural information. From SEM images, it was concluded that PANI/S is more porous, where as PANI/CH and PANI/CA has compact morphology. From cyclovoltammogram, we have studied the redox behavior of all the four composites and they show good electro-activity in the solution at pH=7. (Polymer Science A 38, 2016)

3) Chapter 5: On comparing four set of materials (PANI, PANI/MWCNTs, PANI/STARCH, PANI/MWCNTs/Starch), the ternary composite system PANI/MWCNTs/Starch is found to be better than binary system. The three individual contributed a specific role to define the characteristics of the ternary composite material. Starch improves the biocompatibility, biodegradability and hydrophilicity of the composite system, MWCNTs alongside increase the bulk conductivity of the material. It has definite turmeric shape porous morphology having amine/imine and hydroxyl functionality.The properties indicate that PANI/Polysaccharide systems are suitable for bioanalytical applications. (Polymer composite 58, 2017)

4) Chapter 6: PANI/MWCNTs/Starch (PCS) based composite material was successfully used for the fabricate hydrogen peroxide biosensor using PCS and Hemoglobin. PCS/HB/CPE based biosensor has good operational/storage stability and selective response to H_2O_2. We have successfully used to detect glucose by using glucose oxidase along with PCS and HB modified carbon paste electrode. The Sensor performance was evaluated by using CV. (accepted in International journal of biological macromolecules 2017)
5) In chapter 7, we describe the important characteristics of binary and ternary composite materials based on PANI, MWCNTs and CMC. Hydroxyl groups and bonded water molecules of CMC contributed to hydrophilic character, whereas a small amount of MWCNTs contributed to hydrophobic character. Nanotubes lead to a large surface area, higher stability, and better electrochemical properties. The developed material is easily dispersed in the CMC hydrogel solution. Good dispersion indicates that this material is a potential candidate for electroactive ink and membrane formation. (communicated in Carbohydrate Polymer)
6) Chapter 8 described the comparative analysis of three polyaniline sample - PANI-HCl, PANI-Citric acid and PANI-Lemon. The important aspects and presumptions of "Multi-component Template Effects" have been discussed. Molecules of lemon juice produce template like effects on the morphology of PANI. SEM, HR-SEM, TEM and AFM images confirm the formation of rod shape nanostructures (dimension: diameter ~ 100 nm, length ~ 300 - 600 nm). PANI-Lemon is found to be superior to PANI-HCl and PANI-Citric acid. An XRD and electron diffraction pattern confirms regular arrangement of chains. We have proposed that in the similar protonation conditions, (i) spatial arrangement of chains is the dominating factor which decides conductivity and electroactivity of PANI (due to better

inter-chain charge transfer) and (ii) the alignment of chains is more significant structural parameter than size and surface area. PANI-Lemon modified carbon paste capillary electrode was successfully used for catechol sensing. (ACS Sustainable Chemistry and Engineering DOI: 10.1021/ acssuschemeng.7b03705)

7) On the basis of our results, we have concluded that polyaniline/polysaccharide systems are promising electrode material for sensors/biosensors. A little amount of carbonaceous conducting nanomaterials within the polymer matrix improved the catalytic properties, strength and stability of the material.

9.2. Future Scope

Other polysaccharide could be blended with conducting polymers; there is enormous scope to develop novel materials. The hybrid system of natural and synthetic fibers provides opportunities to develop advanced multifunctional biocompatible nanocomposite materials. Such materials have synergistically improved properties in term of better conductivity, biocompatibility, and interesting functionalities. The developed materials could be used to formulate electroactive conducting water based ink for printed sensor strips, membranes, biosensors.