

Abstract

Nanotechnology in the field of sensors has played a pivotal role in designing advanced sensors with a low detection limit for the analytes as they have a large surface area, high catalytic activity, ease of functionalization, better biocompatibility, selectivity, and sensitivity. Nanotechnology has made possible the miniaturization of devices into portable sensors. There are several diseases like Alzheimer's, Parkinson, Schizophrenia, cancer, and neurological disorders, which if not identified at an early stage, may become severe and life-threatening. So, there is a crucial demand for portable, cheap, and reliable sensors that can be used to identify them. Motivated by these facts, we are introducing effective electrochemical techniques to quantify the concentration of ascorbic acid, dopamine, and NADH. After the identification of the concentration of these biomolecules, we can find out the diseases, because when a disease is caused the level of these biomolecules is increased or decreased. It is also helpful to find out the drug level. Higher levels of the drugs may have several side effects and even result in organ failures, while low level makes them impotent and ineffective. So, at present day, we need regular monitoring of our health which motivates us to fabricate sensors to identify levels of biomolecules. In the thesis, we are introducing a very facile method to fabricate an ascorbic acid sensor, dopamine sensor, and NADH sensor.

The thesis entitled, *“Studies of Transition Metal Nanoparticles with Tetracyanoquinodimethane for Electrochemical Sensing Application”* described the synthesis of various functional nanomaterials like palladium nanoparticles (PdNPs), cobalt tungstate nanoparticles (CoWO₄), cobalt N-doped carbon (Co@NC), and their composite with palladium metal nanoparticles for the enhancement of their catalytic properties and stability, like Pd-Co@NC. Further, the synthesized nanomaterials mixed

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with tetracyanoquinodimethane and fabricated modified electrodes which have been used for the sensing of different biomolecules such as ascorbic acid, dopamine, and NADH. The nanomaterials have a very crucial role in the improvement of the performances of the sensors in terms of their catalytic activity. Based on the findings the thesis has been divided into six chapters.

Chapter 1 deals with the general idea and basic concepts of biosensors, types of biosensors, nanomaterials, types of nanomaterials, the application of transition metal nanomaterials in biosensors, the redox mediator, tetracyanoquinodimethane, and benefits of the proposed materials for sensing applications.

Chapter 2 describes different experimental techniques that have been used for the characterization of synthesized nanomaterials. The main techniques that have been employed for characterizations are X-ray diffractometer, scanning electron microscopy (SEM), transmission electron microscopy, atomic force microscopy, and X-ray photoelectron spectroscopy, used for morphological and structural investigation. Cyclic voltammetry, differential pulse voltammetry, amperometry, and electrochemical impedance spectroscopy techniques have been used for electrochemical characterization.

Chapter 3 In this chapter, we have synthesized two different size palladium nanoparticles, mixed them with tetracyanoquinodimethane (TCNQ), and fabricated TCNQ-PdNP-1 and TCNQ-PdNP-2 modified carbon paste electrode. This TCNQ-PdNPs modified carbon paste electrode is electrochemically characterized by cyclic voltammetry, amperometry, differential pulse voltammetry, and electrochemical impedance spectroscopy. The sensitivity and limit of detection of TCNQ-PdNP-2 were

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calculated by using amperometric analysis and the sensitivity was found to be $14.8 \mu\text{A mM}^{-1}$ and the limit of detection was $30.35 \mu\text{M}$. Real sample analysis was performed by using standard addition method taking an ascorbic acid tablet sample solution.

Chapter 4 In this chapter, we have synthesized CoWO_4 nanoparticles by hydrothermal method, and the nanoparticle was characterized by scanning electron microscopy, transmission electron microscopy, X-ray diffractometer, and X-ray photoelectron spectroscopy. $\text{TCNQ@CoWO}_4/\text{CPE}$ was fabricated and used for electrochemical sensing of dopamine. The modified electrode was characterized by cyclic voltammetry, differential pulse voltammetry, amperometry, and electrochemical impedance spectroscopy. The amperometric analysis resulted in a broader linear range of $2 \mu\text{M}$ to $80 \mu\text{M}$ for dopamine monitoring and a high sensitivity of $0.202 \mu\text{A mM}^{-1}$. EIS analysis provided the R_{ct} value of $950 \Omega \text{ cm}^2$. Real sample analysis was performed in commercially available dopamine hydrochloride injections by using the standard addition method and the average recovery result was found to be 95.60 to 99.36%.

Chapter 5 In this chapter, we have synthesized Co@NC and Pd-Co@NC . The synthesized nanoparticles were characterized by X-ray diffractometer, scanning electron microscopy, transmission electron microscopy, and X-ray photoelectron spectroscopy. By using TCNQ and Pd-Co@NC design of a low voltage TCNQ-Pd-Co@NC modified electrode and used for electrochemical sensing of NADH. The modified electrode shows good sensitivity ($21.5 \mu\text{A mM}^{-1}$), and a low detection limit ($5.17 \mu\text{M}$). Real sample analysis was performed in the avocado juice sample by using the standard addition method and the recovery result was found to be 95.20 to 99.36%.

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Chapter 6 summarises the thesis work and highlights the scope for future work related to this field.