Cyclic Voltammetric Behavior of Ascorbic Acid at CDO Nanoparticles Modified Carbon Paste Electrode

Bony K. John
Assistant Professor (on contract) Department of Chemistry, Deva Matha College Kuravilangad P.O., Kottayam Dist. Kerala 686633 (Affiliated to Mahatma Ganhi University, Kottayam, Kerala), India

Abstract

Out of the all metal oxide nanoparticles, recently Cadmium oxide has been widely investigated due to their potential application in electro-chromic films, sensor, electrochemical capacitors, photo catalysts, batteries, photo electrodes etc .The CdO nanoparticles of desired properties are synthesized using various techniques. Objectives of the project is to Synthesis CdO nanoparticles by precipitation method in presence of surfactant CTAB method and study of Cyclic voltammetric behavior of ascorbic acid at CdO nanoparticles modified carbon paste electrode . This method results in the formation of CdO nanoparticles of size 22.4 nm. Cyclic voltammetry (CV) is a versatile electroanalytical technique used to characterize electroactive species. The oxidation/reduction potential of electro active species under study can be easily located using CV experiment. CV also provides information about the mechanism of electrode reaction and electron transfer kinetics at electrode solution interface. Presently CdO have significant applications in the fields of catalysis, battery electrodes, gas sensors, electro chromic films, photo-electronic devices, solid oxide fuel cell applications , nanoscale optoelectrochromic display , optical fibres, photovoltaic applications etc

INTRODUCTION

Metal oxides play a very important role in many areas of chemistry, physics and materials science. Out of the all metal oxide nanoparticles, CdO nanoparticles are an interesting material due to its useful electronic and magnetic properties. CdO nanoparticle is used as sensors, catalyst, anode material in Li–ion batteries solid oxide fuel cell applications, nanoscale optoelectrochromic display, optical fibres, photovoltaic applications. Several methods have been used and developed for synthesising oxide powders in nanoscale dimensions. In many of them, the main objective is to reduce the costs of chemical synthesis and to produce materials for technological applications. The purpose of this work is to Synthesis CdO nanoparticles by precipitation method in presence of surfactant CTAB and study of cyclic voltammetric behaviour of ascorbic acid at CdO nanoparticles modified carbon paste electrode . Chemical precipitation is a simple way and low in cost since the starting materials are inexpensive and which could be carried out in any lab without any sophistication. Uniform sized with well-dispersed CdO nanoparticles as a kind of functional material has attracted extensive interests due to its novel optical, electronic, magnetic, thermal and mechanical properties and potential application in catalysis, battery electrodes, gas sensors, electro chromic films, photo-electronic devices and so on.

Material and Methods

Reagents and Solutions

$CdSO_4$ (S.D Fine), NaOH pellets, Glacial CH_3COOH, Ethanol, KH_2PO_4, ortho H_3PO_4, ascorbic acid, silicone oil (all from Merck), graphite powder (Himedia) and cetyl trimethyl ammonium bromide (CTAB) (SRL) were of analytical grade and used as received. All aqueous solutions were prepared in double distilled water. Phosphate buffer solutions were prepared from KH_2PO_4 and pH was adjusted using H_3PO_4 or NaOH.

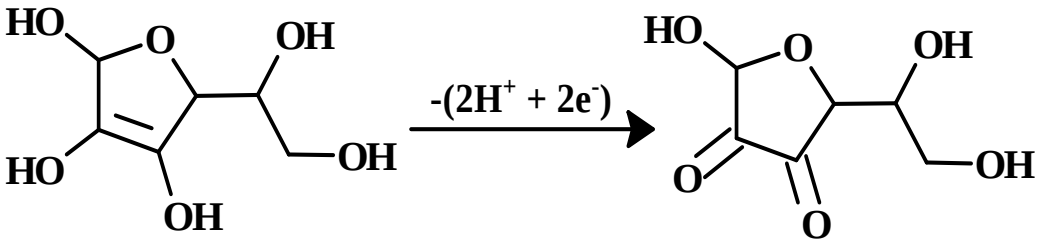
Synthesis of CdO nanoparticles

The CdO nanoparticles were prepared by simple precipitation method. In this method, 500 mL of 0.09 M ethanolic NaOH (25 mL rectified spirit + 475 mL double distilled water) solution is prepared and transferred into a 1 L beaker. A mixture of 500 mL, 0.03 M $CdSO_4$, 0.06 M CH_3COOH and 40 mg CTAB were prepared in double distilled water. This solution is filled in burette and added drop wise into the 0.09 M ethanolic NaOH solution under constant stirring. The obtained white precipitate is filtered using Whatman No 41 filter paper. The precipitate is washed several times with double distilled water. The washed precipitate is transferred carefully into a watch glass and dried in hot air oven for an overnight. The dried precipitate is transferred into silica crucible and heated to 500 °C for five hours. The obtained slightly yellowish powder is called CdO nanoparticles. The prepared CdO nanoparticles were characterized using IR spectroscopy and PXRD.

Cyclic voltammetric behavior of ascorbic acid at CdO nanoparticles modified Carbon paste electrode

The carbon paste is prepared by mixing graphite powder (40 mg) and 4 μL of silicone oil in agate mortar using a pestle to obtain a homogeneous paste. The prepared CdO (10 mg) was then hand mixed with graphite powder (40 mg) and 4 μL of silicone oil in agate mortar using a pestle to obtain a homogeneous paste incorporating CdO nanaparticles. The prepared homogeneous paste is called CdO nanoparticles modified carbon paste. A portion of the resulting homogeneous pastes were packed into the cave of the Teflon tube. A copper wire fixed to a graphite rod and inserted into the Teflon tube served to establish electrical contact with the external circuit. The prepared electrodes are called bare carbon paste electrode (CPE) and CdO nanoparticles modified carbon paste electrodes (MCPE/CdO).

The cyclic voltammograms (CVs) of 4.0×10^{-3} M ascorbic acid (AA) were recorded at CPE and MCPE/CdO, respectively in 0.1 M phosphate buffer solution (PBS) of pH 7.0. The resulted CVs are shown in Fig. 1. AA shows an irreversible behavior at both electrodes. The anodic peak potentials (Epa) of AA at CPE and MCPE/CdO are observed at 259.1 and 263.5 mV respectively. The anodic peak current (Ipa) of AA at CPE is 45.6 μA while the same in that of MCPE/CdO is 66.4 μA. The current sensitivity is increased by 1.45 times at MCPE/CdO. The enhancement in current is an indicative of electrocatalytic activity of MCPE/CdO towards AA oxidation. This increase in sensitivity is attributed to the increased surface area of bare carbon paste on modification with CdO nanoparticles. Therefore, MCPE/CdO can act as electrochemical sensor for the determination of AA in various samples under physiological pH. The mechanism of electrocatalytic oxidation of AA at MCPE/CdO is shown in scheme 1.



AA *Dehydroascorbic acid*

Scheme 1: Electrochemical oxidation mechanism of AA at MCPE/CdO

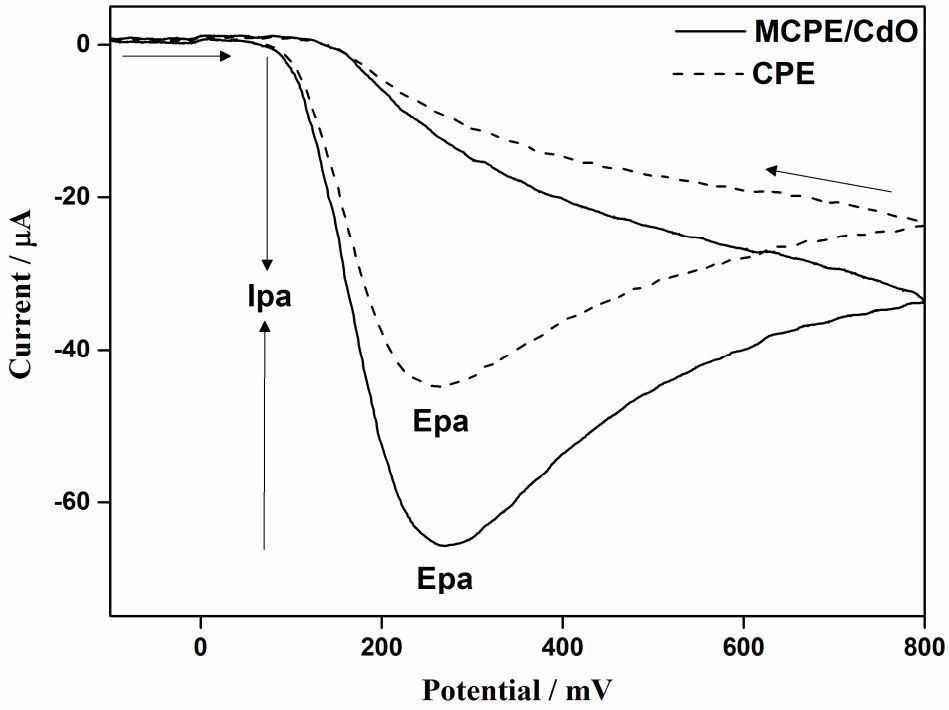


Figure 1: CVs of 4.0 × 10^{-3} M AA in 0.1 M KPBS of pH 7.0 at bare CPE (dashed line) and MCPE/CdO (solid line). Scan rate: 50 mV s^{-1}.

CONCLUSION

Uniform sized with well-dispersed CdO nanoparticles as a kind of functional material has attracted extensive interests in future due to its novel optical, electronic, magnetic, thermal and mechanical properties. CdO nanoparticles of size 22.4 nm were successfully prepared by precipitation method in presence of surfactant CTAB. The application of prepared CdO nanoparticles was demonstrated by CV studies. CdO nanoparticles modified carbon paste electrode shows an electrocatalytic activity towards the oxidation of AA. Further studies have to be carried out to come up with electrochemical sensor based on CdO nanoparticles for AA at physiological pH.

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