



Modifying Translucent Carbon Electrode for Recurrent Determination of 1, 2-Dihydroxy Benzene

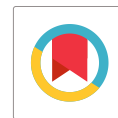
S. Deepa^{1*}, D. Karthirvel²

¹Department of Physics, Government College of Engineering, Salem, TN, India

²Department of Physics, Government Arts College, Coimbatore, TN, India

Received: 18.02.2022 Accepted: 16.03.2022 Published: 30-03-2022

*deepasasi1984@gmail.com



ABSTRACT

A voltammetric 1, 2-dihydroxy benzene assay utilizing a glassy/translucent carbon electrode (GCE) customized with graphene oxide and polycyanurotramine (GO/PM) composition is described. Field fluorescence, SEM, FTIR elemental composition and Raman spectroscopy were used to analyze the enhanced GCE. When comparing conductors adjusted with GO or PM alone, electrochemistry demonstrates a well-defined sensitivity to 1, 2-dihydroxy benzene, with a much higher oxidation peak. The composite's simultaneous synergistic action of GO and PM results in a decreased oxidation potential. In the detection limit of 0.03 to 138 M 1, 2-dihydroxy benzene, differentiating pulse voltammetry (DPV) displays a constant value. The sensibility is 0.537 A M cm², and the detection limit is 8 nM. Though in the context of theoretical contaminants, notably dopamine, hydroquinone and resorcinol, the detector is discriminating for 1, 2-dihydroxybenzene. The modified GCE for detecting 1, 2-dihydroxy benzene in samples collected is extremely repeatable, durable and accurate and it has greater applicability.

Keywords: Carbon Electrode; 1,2-Dihydroxy Benzene.

1. INTRODUCTION

The ortho-isomer of benzenediols, 1, 2-dihydroxy benzene, has long been a key component in chemical processing. It is frequently used in various applications, such as manufacturing pesticides and predecessors to fragrances and medicines. Due to its high toxicity and poor degradability in the natural ecosystem, 1, 2-dihydroxy benzene has been categorized as a recurrent hazardous material and Category 2B human carcinogen. In animals, constant exposure to 1, 2-dihydroxy benzene can cause a protracted increase in blood pressure and neurotoxicity (Nellaiappan *et al.* 2018). As a result, the fabrication of special instruments for low-level measurement of 1, 2-dihydroxy benzene in sediment samples has received a lot of interest. Many analytical techniques have been utilized to detect 1, 2-dihydroxy benzene sensitively, including spectrophotometry, chemiluminescence, flow injection evaluation, high concert fluid chromatography, vapor chromatography, concentration spectrometry and other electrochemical approaches (Davis *et al.* 1998). Electrical and chemical approaches were proven to be more undemanding and cost-effective than other statistical techniques (Branzoi *et al.* 2015). Due to their excellent discrimination, low oxidation possibility and great responsiveness, the methodologies adopted have contributed a significant role in creating sensitive 1, 2-dihydroxy benzene sensors.

On the other hand, the unaltered conductors had low specificity and sensitivity, as well as signal degradation, when it came to detecting 1, 2-dihydroxy benzene. Because of its great hydrophilic nature and abundance of functional groups, graphene oxide (GO) has sparked much interest in the research world (Silah *et al.* 2021). Furthermore, because of the existence of molecules, GO has been frequently employed for surface modification.

Here On the surface, there are functioning groups. Alternatively, because of its high thermal stability, excellent adhesion to the electrolyte interface, and abundance of nitrogen and amides, polycyanurotramine (PM), is also recognized as a classy polymer that has frequently been employed for cathode alteration. Additionally, PM-augmented membranes have been used for electrochemical detection of several sample matrices, including dihydroxy benzene isomers, gallic acid and neurotransmitters. Given the qualities of PM and GO, it is rea

It is reasonable to believe that a cathode enhanced with PM and GO can give strong electrocatalysts; though there are only a few publications available about PM-based electrochemical sensors (Pifer *et al.* 1995).

The GO/PM combination reference electrode has not yet been applied to assess 1, 2-dihydroxy benzene for our information. The development of a basic and accurate 1, 2-dihydroxy benzene electrochemical detector based on the PM/GO composites adapted trans-carbon cathode is described in this study (GCE). The reaction rate of PM/GO compound modified cathode for the combustion of 1, 2-dihydroxy benzene is higher than that of PM and GO customized electrodes. The sensor's sensitivities, discrimination, durability and applicability were assessed and discussed in depth.

2. REVIEW OF LITERATURE

Given their harmful impacts on health, the contemporaneous identification of resorcinol (RS), 2-hydroxybenzene isomer (DHB) and especially catechol (CC) and hydroquinone (HQ), is concerned. Nonetheless, due to its adaptability, it is projected that global DHB synthesis will keep going up rapidly, exposing the community to high levels of DHB through such a variety of routes, including aquatic and contaminated foods, environmental smog and cosmetic use. For instance, HQ is utilized in a wide variety of trade operations, including the biosynthesis and manufacture of rubbers and plastics, food, and skin bleaching treatments owing to HQ's ability to restrict melanin formation (Tse *et al.* 2010; Monisha *et al.* 2021).

As a result, maintaining DHB dose below the suggested limits released by regulatory agencies such as the World Health Organization (WHO) (TANAKA *et al.* 1985) is critical to mitigate its detrimental effects on human health. As a result, a fundamental problem for situational assessment is the exact and rapid identification of DHB. An electrochemical approach that provides detectors can be an accurate and convenient option for a quick and efficient real-time measurement of DHB. Bio-sensors built on polyphenol oxidized enzyme have been previously developed to detect phenol, with impressive specificity and sensitivity (Rodríguez *et al.* 2002). But, disadvantages like limited biochemical and thermal immovability and expensive costs have pushed for non-enzymatic monitoring (Yuan *et al.* 2012). Multi-detection of CC, RS and HQ using standard conductors such as glassy carbon electrodes (GCE) is impossible because their structure, near redox potential and surface morphology are required. Metal-organic software packages (MOF) (Ye *et al.* 2019; Zheng *et al.* 2020), conductor polymers (Lu *et al.* 2021), metallic nanoparticles (Yin *et al.* 2020), phthalocyanine (Yang *et al.* 2011) and carbon-oriented nanomaterials such as carbon nanotubes (CNTs) and grapheme (Chen *et al.* 2019; Butwong *et al.* 2020) – all have been the focus of many studies for innovative chemically-modified electrodes (CME) for multianalyte diagnosis. Given their increased resistance, huge surface region and catalytic characteristics comparable to either pristine CNTs or GO/graphene (Mani *et al.* 2013), hybrids of carbon and

graphene have demonstrated significant promise for identifying oxidoreduction chemicals (Torrinha *et al.* 2020). The health benefits with increased mechanical, visual, electrical and electrochemical capabilities are enabled by the firm-assembling interaction established by the 3D system molded by the reaction of high responsibility density graphite and other relatively large areas of CNTs (Dang *et al.* 2016).

3. INVESTIGATIONAL SETUP

3.1 Resources and Procedures

Sigma Aldrich provided natural graphite, which was utilized just as it was. Sigma Aldrich provided all of the chemicals, including formaldehyde and catechol. The underneath electrolyte, 0.1 M phosphate, pH 7, was equipped with specially purified water using 0.1 M Na_2PO_4 and 0.1 M NaH_2PO_4 . The other pH was prepared by regulating the phosphate barrier with thinned H_2SO_4 and NaOH. All compounds were trained using ultrapure twice distilled water (resistivity >18.2M cm at 25°C) from the LOTUN Ultra-pure Watery System. The CHI1205B and CHI750A electrolytic effort stations were used to perform cyclic potentiometer and differential pulse voltammetry (DPV) analyses. For electrolytic testing, a standard three-electrode setup was employed. A modified GCE with an optically total area of around 0.079 cm^2 was used as an electrolytic system for the experiments. Correspondingly, the reference and counter terminals were made of saturating Pt wire and Ag/AgCl. Using a Hitachi S-3000H, an SEM picture of the composite electrocatalyst was captured. The composite customized electrode's chemical analysis and elemental composition were used using a Hitachi S-3000 H SEM charge-coupled detector mounted to a HORIBA EMAX X-ACT. Thermo SCIENTIFIC Nicolet iS10 was used to examine Fourier transform infrared (FTIR) spectra.

3.2 Manufacture of GO/PM Compound Revised Electrode

Our previous procedures were used to create GO/PM dispersal (5.0 mg mL⁻¹ in double condensed water). About 10 L (optimum) of GO dispersed was encrusted over pre-cleaned GCE and dried in an air oven to make the GO/PM modified electrode. The resultant GO reference electrode was submerged in an electrochemical cell containing 1mM melamine and 0.01 M HCl and cycled 10 times at a scanning speed of 50 mVs^{-1} in a potential range of 0 to 1.5 V. Finally, while not in use, the GO/PM combination was produced on the working electrode, baked in an air oven and maintained under dry circumstances. The GO and PM modification electrodes were made in the same way as the melamine and GO electrodes. Fig. 1 displays a graphic illustration of all construction of a GO/PM composite electrocatalyst. All electrochemical tests were associated with the presence of nitrogen gas of high quality.

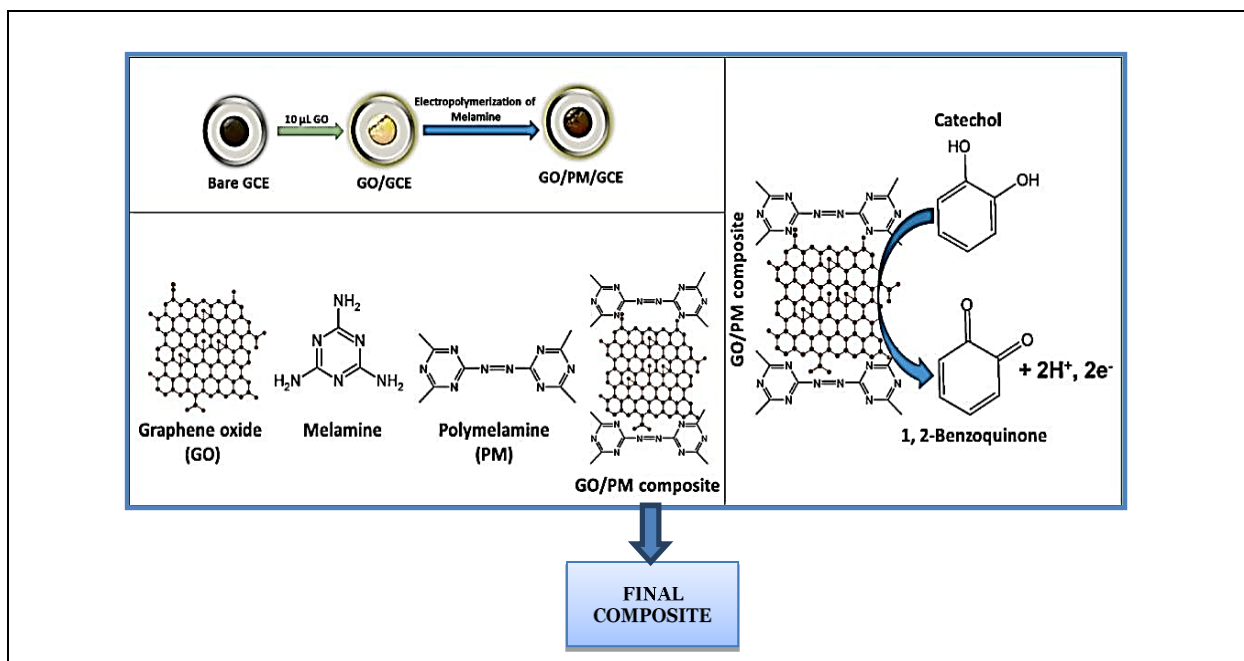


Fig. 1: PM/GO revised electrode

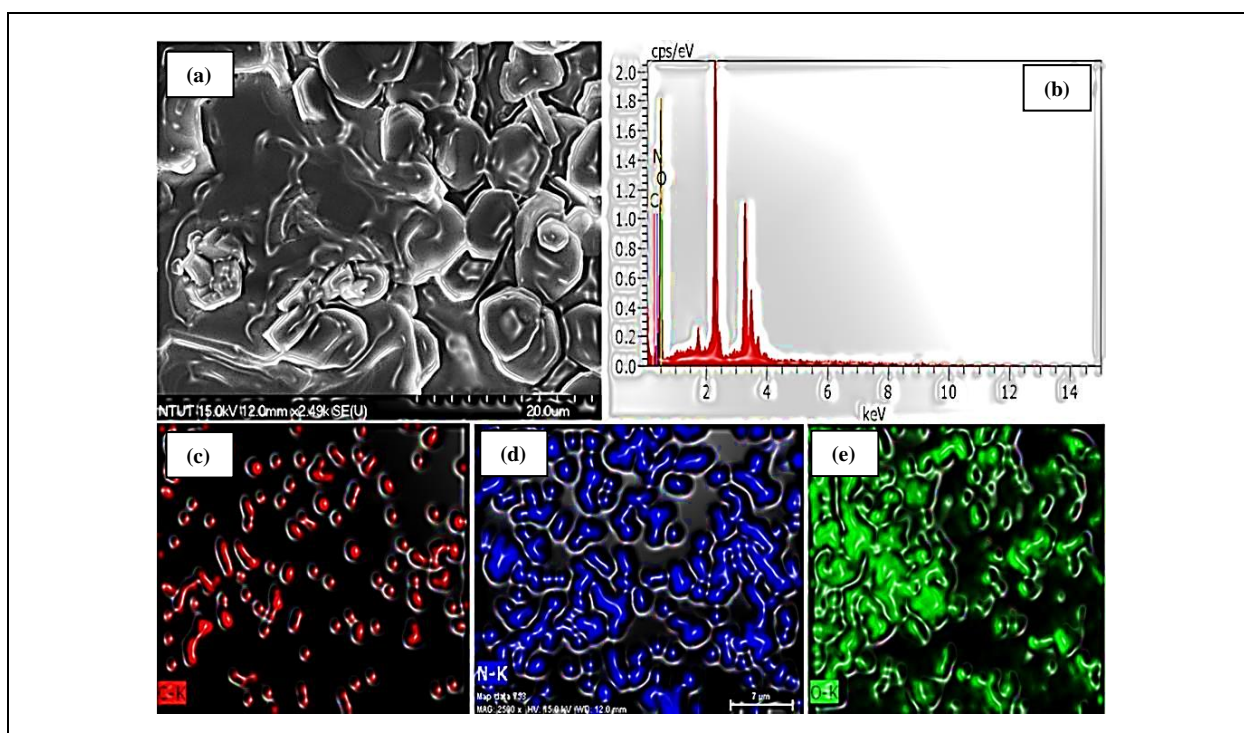


Fig. 2: SEM images of: (a) PM/GO (b) Carbon equivalent (c) Nitrogen (d) Oxygen and (e) Primary binding of PM/GO

4. RESULTS AND DISCUSSION

4.1 Categorizations

Analytical chemists are interested in expanding consistent and straightforward tools for detecting 1, 2-dihydroxy benzene. On carbon electrode materials, 1, 2-

dihydroxy benzene is extremely electroactive, although it has low affinity, responsiveness and repeatability. Due to the characteristics of GO and PM, the GO and PM composites have been chosen for sensitivity and selectivity measurement of 1, 2-dihydroxy benzene in this study. GO's plentiful oxygenated functional group is more suitable than PM's stable composition.

Furthermore, the numerous amine groups, nitrogen, and PM may interact with a greater number of 1, 2-dihydroxy benzene molecules, resulting in increased reactivity, low electron propensity and a lower detection limit for 1, 2-dihydroxy benzene on the GO/PM combination. Furthermore, compared with the previously described carbon system that has been designed. 1, 2-dihydroxy benzene sensors are more simple, affordable and has adequate analytical characteristics.

Fig. 2a shows an SEM picture of a GO/PM composite electrode surface, revealing that the PM film's symmetrical rectangular type structures were equally dispersed all through the interface of the GO nanosheets. It was also discovered that the PM is interconnected and tightly enfolded by GO nanosheets, owing to the significant contact between the groups of amino from PM

and GO. When evaluated to GO and PM, the distinctive shape of the GO/PM carbon fiber electrode material provides a greater electrocatalyst region. The composite surface is equivalent to the PM, and GO external morphologies were observed. Figure 2b–e shows the results of using the EDX and the accompanying scanning electron analysis to show the identity of PM composite. The existence of GO and PM in the combined modified electrode was verified by EDX and elemental mapping, which revealed particular areas of carbon, nitrogen, and oxygen. It's also worth noting that the surface shape of PM on GO matches that of prior studies. The results of the FTIR and Raman spectra corroborated the creation of the GO/PM composite, and comprehensive explanations are included in the supplementary electronic material (ESM).

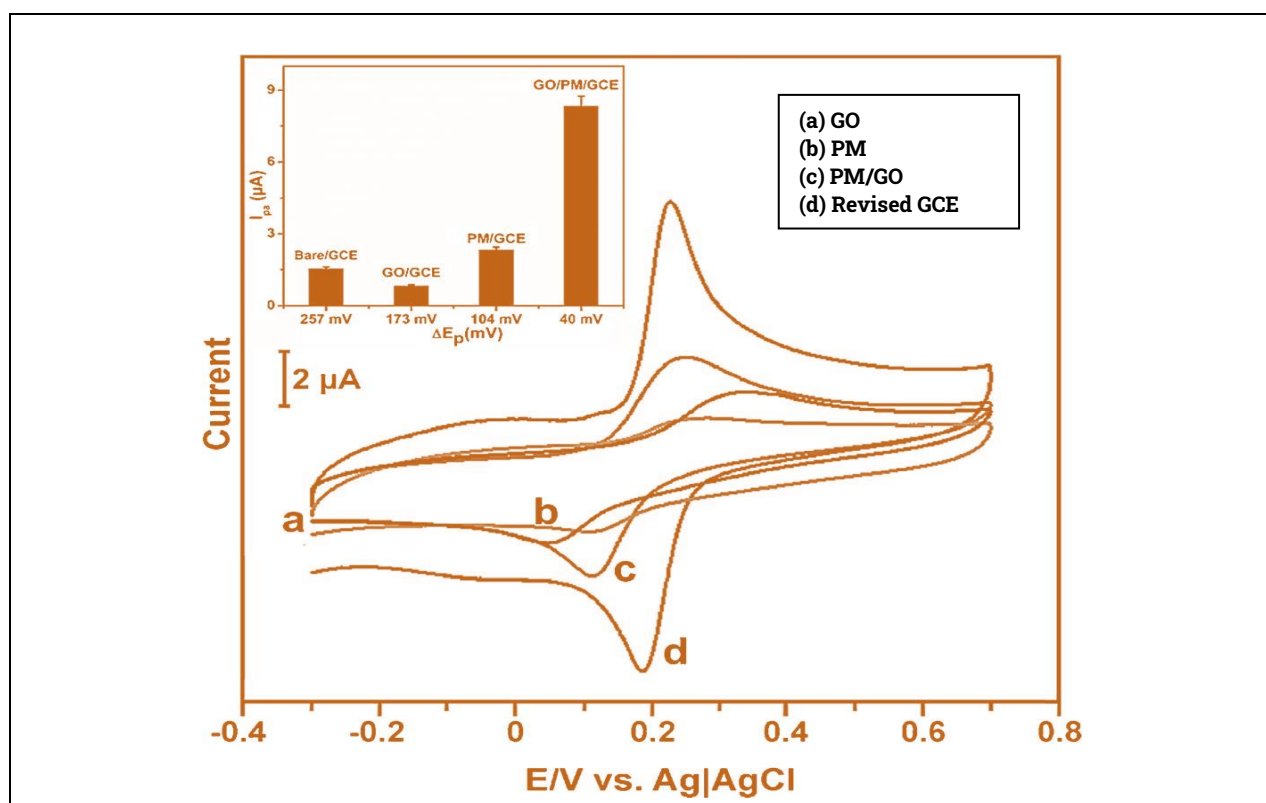


Fig. 3: Recurrent voltammetric retort of bare

4.2 Electrochemical Performance of 1, 2-Dihydroxy Benzene over Diverse Revised Electrodes

Using aluminum electrodes on several electrocatalysts, the electrochemical performance of 1, 2-dihydroxy benzene was investigated. At a search rate of 50 mVs^{-1} , Fig. 3 illustrates the cyclic voltammeter's responsiveness of bare conductors in 100 M 1, 2-dihydroxy benzene possessing pH 7. The sensor that had not been changed had a faint signal at 0.305 V, with an

amplitude partition (EP) of 0.257 V, oxidation peak current responsiveness to 1, 2-dihydroxy benzene. As illustrated in Fig. 1, the weak oxidation signal is due to the reaction of 1, 2-dihydroxy benzene to the equivalent quinone. The oxidative peak of 1, 2-dihydroxy benzene is seen at a lesser point (0.234 V) on the GO electrode material than on the unaltered cathode. Furthermore, the EP of 1, 2-dihydroxy benzene was 84.0 mV lesser than the modified cathode and an oxidation-reduction crowning current was reduced. Furthermore, GO is well-known as an insulating material with low electrocatalysts.

The oxidizing peak current to 1, 2-dihydroxy benzene is higher in the PM electrocatalyst than in the untreated and GO modified electrodes, indicating that PM has strong adsorption properties to 1, 2-dihydroxy benzene. The EP of 2-dihydroxy benzene was 69 and 153 mV lesser than those of naked and GO-treated electrodes, respectively. The GO/PM composites electrocatalytic, on the other hand, exhibits a well-defined ion concentration with a three-fold greater oxidation maximum peak response for 1, 2-dihydroxy benzene than the PM electrocatalyst. The 1, 2-dihydroxy benzene oxidation peak potential was found to be 0.223 V. The EP of 1, 2-dihydroxy benzene was 64 and 217 mV lesser than bare, GO and PM customized electrolyte, as illustrated in Fig. 4 (inset). The results show that the electrochemical behavior of 1, 2-dihydroxy benzene on GO/PM

combination electrochemical sensors is significantly better than on other based electrodes. When coupled, the specific characteristics of GO and PM result in increased enzymatic performance for the oxygenation of 1, 2-dihydroxy benzene. The hydrogen bond connection between PM and GO with 1, 2-dihydroxy benzene might be the reason for the improved electrocatalyst of the particles.

Scheme 1 depicts a proposed electro-oxidation procedure for 1, 2-dihydroxy benzene at a GO/PM composite electrocatalyst. The authority of scan velocity (Fig. 4 a) and pH investigations (Fig. 4 b) on the electrochemical behavior of 1, 2-dihydroxy methane at GO/PM electrode material, as well as their accompanying comments, can be found in ESM.

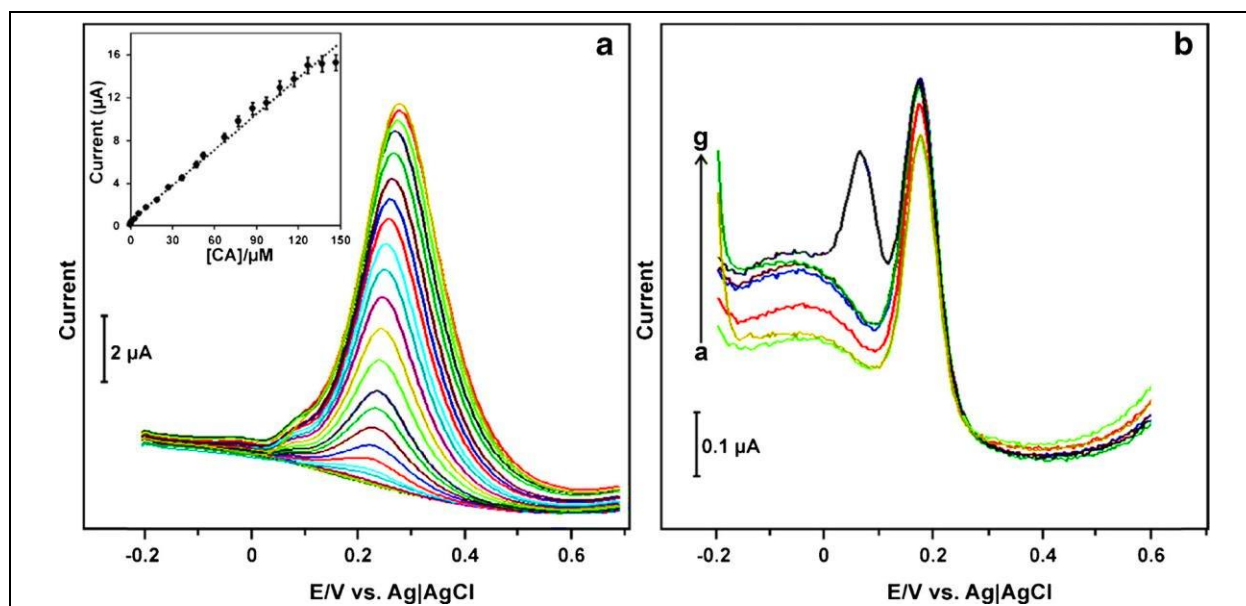


Fig. 4: (a) Disparity pulsation voltammograms for GO/PM (b) The outcome of 100 μM accumulation

4.3 Determination of 1, 2-Dihydroxy Benzene in Water Samples

We measured 1, 2-dihydroxy benzene in several samples taken using GO/PM modified electrodes to test the sensor's practicability. The 1, 2-dihydroxy benzene was detected using the DPV technique and the experimental conditions were identical to those shown in Fig. 3 a. The sample preparation technique was used to calculate 1, 2- dihydroxy benzene recovered in samples taken. The ground and valve irrigate samples did not provide an adequate signal on the electrode material, indicating that 1, 2-dihydroxybenzene was absent in the water sample. The recovered were measured after a known quantity of 1, 2-dihydroxy benzene, including underground and valve water samples having pH 7. Using a GO/PM composite customized electrode, median recoveries of 1, 2-dihydroxy benzene were 95.5 % and

94.2 % in-ground and valve dampen samples, respectively.

Furthermore, the composite changed electrode's realistic aptitude is equivalent to the spectrometric findings. According to the findings, the constructed detector may be utilized to detect 1, 2-dihydroxy benzene in water samples. Using cyclic voltammetry, the accuracy and reliability of the detector (not shown) were evaluated; the experimental circumstances were identical to those in Fig. 3. The relative standard deviation (RSD) for five different independently manufactured GO/PM composite electrocatalysts is around 4.5 percent. 100 mM 1,2-dihydroxy benzene was detected.

A single GO/PM composite electrocatalytic, on the other hand, displays an RSD of 3.9 percent when used to detect 100 M 1, 2-dihydroxy benzene containing 8 sets

of pH 7.0. The results show that the GO/PM composite electrocatalytic has adequate accuracy and consistency for 1, 2-dihydroxy benzene detection. We also looked at the storage space stability (not shown) of the manufactured GO/PM combination electrode material for detecting 100 M 1, 2-dihydroxy benzene by CV for up to 4 weeks. The experimental system is identical to that shown in Fig. 2. After four weeks of storage, the sensor retains 90.1 percent of its original oxidative short pulse responsiveness to 1, 2-dihydroxy benzene, indicating the compound upgraded electrode's excellent durability and renewability in the sensing of 1, 2-dihydroxy benzene. As a result, the manufactured detector is extremely constant throughout the instance.

5. CONCLUSION

In conclusion, an electrochemically produced GO/PM composite photoanode was used to construct a sensitive and selective 1, 2-dihydroxy benzene sensor. Compared to initially disclosed nanomaterial-based 1, 2-dihydroxy benzene sensors, the detection has less LOD (8 nM) and adequate investigative properties (linear response range). The detector was also successfully employed for the detecting of 1, 2-dihydroxy benzene in various water samples as a proof of concept and the recover of 1, 2-dihydroxy benzene were extremely comparable with the basic approach. In the presence of probable active conflicting chemicals, the sensor demonstrated a strong selectivity for 1, 2-dihydroxybenzene. However, the detector has several drawbacks, such as sensitivity in the context of strong HQ quantities. In the future, the GO/PM composite might be employed to detect 1, 2-dihydroxy benzene urate in ambient samples.

FUNDING

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

COPYRIGHT

This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC-BY) license (<http://creativecommons.org/licenses/by/4.0/>).



REFERENCES

- Branzoi, F., Branzoi, V., The Electrochemical Behaviour of PEDOT Film Electrosynthesized in Presence of Some Dopants, *Open J. Org. Polym. Mater.*, 5(4), 89–102 (2015).
<https://doi.org/10.4236/ojopm.2015.54010>
- Butwong, N., Kunawong, T., Luong, J. H. T., Simultaneous Analysis of Hydroquinone, Arbutin, and Ascorbyl Glucoside Using a Nanocomposite of Ag@AgCl Nanoparticles, Ag₂S Nanoparticles, Multiwall Carbon Nanotubes, and Chitosan, *Nanomaterials.*, 10(8), 1583-1589 (2020).
<https://doi.org/10.3390/nano10081583>
- Chen, T.-W., Simultaneous Determination of Dihydroxybenzene Isomers using Glass Carbon Electrode Modified with 3D CNT-graphene Decorated with Au Nanoparticles, *Int. J. Electrochem. Sci.*, 7037–7046 (2019).
<https://doi.org/10.20964/2019.08.58>
- Dang, V. T., Nguyen, D. D., Cao, T. T., Le, P. H., Tran, D. L., Phan, N. M., Nguyen, V. C., Recent trends in preparation and application of carbon nanotube–graphene hybrid thin films, *Adv. Nat. Sci. Nanosci. Nanotechnol.*, 7(3), 033002-033012 (2016).
<https://doi.org/10.1088/2043-6262/7/3/033002>
- Davis, J., Vaughan, D. H., Cardosi, M. F., Modification of catechol polymer redox properties during electropolymerization in the presence of aliphatic amines, *Electrochim. Acta*, 43(3–4), 291–300 (1998).
[https://doi.org/10.1016/S0013-4686\(97\)00086-8](https://doi.org/10.1016/S0013-4686(97)00086-8)
- Lu, J.-Y., Yu, Y.-S., Chen, T.-B., Chang, C.-F., Tamulevičius, S., Erts, D., Wu, K. C.-W., Gu, Y., Fabrication of an Extremely Cheap Poly(3,4-ethylenedioxythiophene) Modified Pencil Lead Electrode for Effective Hydroquinone Sensing, *Polymers (Basel).*, 13(3), 343 (2021).
<https://doi.org/10.3390/polym13030343>
- Mani, V., Chen, S. M., Lou, B.-S., Three Dimensional Graphene Oxide–Carbon Nanotubes and Graphene–Carbon Nanotubes Hybrids, *Int. J. Electrochem. Sci.*, 8, 11641–11660 (2013).
- Monisha, S., Mary Saral, A., Senthil Kumar, A., Electrochemical investigation of a tulsi-holy basil-crude plant extract on graphitized mesoporous carbon nanomaterial surface: Selective electrocatalytic activity of surface-confined rosmarinic acid for phenyl hydrazine-pollutant oxidation reaction, *J. Electroanal. Chem.*, 901, 115757 (2021).
<https://doi.org/10.1016/J.JELECHEM.2021.115757>
- Nellaiappan, S., Kumar, A. S., Selective amperometric and flow injection analysis of 1,2-dihydroxy benzene isomer in presence of 1,3- and 1,4-dihydroxy benzene isomers using palladium nanoparticles-chitosan modified ITO electrode, *Sensors Actuators B Chem.*, 254, 820–826 (2018).
<https://doi.org/10.1016/j.snb.2017.07.176>

- Pifer, J. W., Hearne, F. T., Swanson, F. A., O'Donoghue, J. L., Mortality study of employees engaged in the manufacture and use of hydroquinone, *Int. Arch. Occup. Environ. Health* 67(4), 267–280 (1995).
<https://doi.org/10.1007/BF00409409>
- Rodríguez, M. C., Rivas, G. A., Glassy carbon paste electrodes modified with polyphenol oxidase, *Anal. Chim. Acta* 459(1), 43–51 (2002).
[https://doi.org/10.1016/S0003-2670\(02\)00088-0](https://doi.org/10.1016/S0003-2670(02)00088-0)
- Silah, H., Erkmen, C., Demir, E., Uslu, B., Modified indium tin oxide electrodes: Electrochemical applications in pharmaceutical, biological, environmental and food analysis, *TrAC Trends Anal. Chem.*, 141, 116289 (2021).
<https://doi.org/10.1016/J.TRAC.2021.116289>
- TANAKA, K., Resorcinol, *J. Synth. Org. Chem. Japan* 43(3), 262–262 (1985).
<https://doi.org/10.5059/yukigoseikyokaishi.43.262>
- Torrinha, Á., Oliveira, T. M. B. F., Ribeiro, F. W. P., Correia, A. N., Lima-Neto, P., Morais, S., Application of Nanostructured Carbon-Based Electrochemical (Bio)Sensors for Screening of Emerging Pharmaceutical Pollutants in Waters and Aquatic Species: A Review, *Nanomater.*, 10(7), 1268 (2020).
<https://doi.org/10.3390/NANO10071268>
- Tse, T. W., Hydroquinone for skin lightening: Safety profile, duration of use and when should we stop?, *J. Dermatolog. Treat.*, 21(5), 272–275 (2010).
<https://doi.org/10.3109/09546630903341945>
- Yang, J., Deng, S., Lei, J., Ju, H., Gunasekaran, S., Electrochemical synthesis of reduced graphene sheet–AuPd alloy nanoparticle composites for enzymatic biosensing, *Biosens. Bioelectron.*, 29(1), 159–166 (2011).
<https://doi.org/10.1016/J.BIOS.2011.08.011>
- Ye, Z., Wang, Q., Qiao, J., Xu, Y., Li, G., In situ synthesis of sandwich MOFs on reduced graphene oxide for electrochemical sensing of dihydroxybenzene isomers, *Analyst*, 144(6), 2120–2129 (2019).
<https://doi.org/10.1039/C8AN02307G>
- Yin, D., Liu, J., Bo, X., Guo, L., Cobalt-iron selenides embedded in porous carbon nanofibers for simultaneous electrochemical detection of a trace of hydroquinone, catechol and resorcinol, *Anal. Chim. Acta*, 1093, 35–42 (2020).
<https://doi.org/10.1016/J.ACA.2019.09.057>
- Yuan, D., Chen, S., Hu, F., Wang, C., Yuan, R., Non-enzymatic amperometric sensor of catechol and hydroquinone using Pt-Au-organosilica@chitosan composites modified electrode, *Sensors Actuators B Chem.*, 168, 193–199 (2012).
<https://doi.org/10.1016/j.snb.2012.03.085>
- Zheng, X., Hu, Y., Li, H., Han, B., Lin, R., Huang, B., N-doped carbon nanotube frameworks modified electrode for the selective sensing of hydroquinone and catechol, *J. Electroanal. Chem.*, 861, 113968 (2020).
<https://doi.org/10.1016/J.JELECHEM.2020.113968>