RESEARCH
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COPPER OXALATE SYNTHESIS AND CHARACTERIZATION FOR BIOSENSING APPLICATION

RUNNING TITLE : Analyzing the biosensing application of the synthesized compound copper oxalate .

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Abstract
INTRODUCION: Biosensing is a rapidly advancing field that combines biological components with sensing technologies to detect and quantify target analysis in various applications
such as health care, environmental monitoring. One of the critical aspects of biosensing is the development of suitable sensing materials that exhibit high sensitivity and stability. Copper oxalate has emerged as a promising material for biosensing due to its unique properties including its ability to interact with various biomolecules and exhibit redox activity.
AIM: The aim of this research is to synthesize copper oxalate and characterize its properties for application in biosensing. By achieving this aim , the research intends to contribute to the development of naval biosensing platforms that utilize copper oxalate as a sensing material
MATERIALS & METHODS: Two grams of SDC was added to 2.5grams of copper nitrate . The mixture was added to 100 ml of distilled water. The solution was maintained at 70 degree and allowed for 5 hours of steering until it is fully dissolved .Finally the formed precipitate was collected and dried.
RESULT: The successful synthesis of copper oxalate is a significant achievement. The XRD analysis interprets the purity and crystalline nature of the sample. It depicted JCPDs card number 21- 297. The characterization technique employed FE-SEM, provided the morphology of the copper oxalate as a rectangular shape. The EXD results proved the purity of the mixture, only desired materials O, C , CO were present. CV - dopamine sensors were used , the optimal ph value was between 6to10. DPV - different concentrations of analyte were applied and current response is recorded.
DISCUSSION: A noteworthy accomplishment is the efficient synthesis of copper oxalate.Future investigations can be carried out by exploring different surface modification strategies, and modifications can also focus on integrating copper oxalate - based biosensors with advanced sensing technologies. Conducting field trials and validation studies of copper oxalate based biosensors in real world forensic scenarios would be more valuable . Copper oxalate biosensing in forensic domains continues to advance , leading to improved analytical tool and methodologies for forensic investigations.
CONCLUSION: Copper oxalate for biosensing application offers promising prospects for the field of biosensors. The advancement of biosensors, selective platforms for the detection and qualification of various analytes, and the development of analytical tools are all made possible by the potential effects of copper oxalate-based biosensors on forensic investigations.

KEY WORDS: copper oxalate , biosensors, bio sensing applications, forensic analysis.

INTRODUCTION:

A crucial step in the production of novel materials in many branches of science and technology, including ceramics, medicine, electronics, pigments, and cosmetics, is the synthesis of inorganic materials with high quality, specified size, and morphology. With its distinct characteristics and flexible production techniques, copper oxalate has become an attractive contender for biosensing applications. Its qualities, including easy synthesis, affordability, and programmable characteristics, make it an appealing option for the creation of biosensors. An inorganic substance with a peculiar anti-ferromagnetic characteristic is copper oxalate.(1). Additionally, copper oxalate is a probable precursor for the creation of Cu and CuO particles.(2). One class of crucial inorganic materials is copper oxide, which is widely employed in the fields of catalysis, superconductors, and ceramics. It can be utilized as a catalyst and catalyst support, as well as electrode active materials for nitrous oxide degradation with ammonia and carbon monoxide, hydrocarbon, and phenol oxidation in supercritical water.(1,3).

Biosensing has become a transformative topic with broad implications for healthcare, environmental monitoring, and biotechnology in an era marked by remarkable advances in science and technology. The core of biosensing is the capacity to quickly and precisely identify and quantify biomolecules or analytes of interest, enabling crucial advancements in illness diagnostics, drug discovery, and customized medicine. Because electrochemical detection is inexpensive, portable, and easily used, it is the transducer used in the majority of biosensors. (4).

Electrochemical biosensors constitute a sophisticated subclass of biosensor technologies renowned for their exceptional ability to transmute intricate biological data , particularly the concentration of analytics, which are often governed by highly specialized biochemical receptors, into discernible and quantifiable electric currents or voltage signals , thereby facilitating precise and real-time analysis in diverse application..(4,5).

Electrochemical biosensors emerged as promising diagnostic innovations, capable of discerning critical biomarkers present in bodily fluids like perspiration, blood , excrement , or urinary samples. The synergistic integration of adept immobilization methodologies with highly efficient transduction mechanisms of biosensors celebrated for their exceptional efficacy. Their versatile development spans a gamut of sectors. Encompassing the realms of medical sciences, defenses , the exploration of plant biology and beyond.(6).

The electrochemical methodology employed stands out as a distinctive facet of electrochemical biosensors. Furthermore, the realm of pathogen detection, the manner in which samples are handled and the format in which sensor signals are interpreted also serves as discerning characteristics of biosensor-based approaches. (7).

Forensic investigations encompass a wide array of scientific disciplines , all working in concert to fulfill the primary aim of supplying solutions to inquiries of significance linked to criminal or civil matters. (8). Due to their tremendous benefits of specificity, speed, and minimal sample modification, biosensors have emerged as the best tools in this field for sensitive determination of worrisome compounds as well as for quick initial screening in the field of forensic. The quantitative examination of chemical or biochemical species, such as genetic material, blood, saliva, urine, sweat, or semen, which are typical samples in forensic investigation, is another application for which biosensing detection is particularly suitable. For the majority of target substances of interest in forensic analysis, electrochemical biosensors have been described for the detection and quantification at this time.(9).

The search for novotel materials with improved performance , accessibility , and adaptability is ongoing in the field of biosensing technology. The need for innovative materials to match the ever-increasing demands for precision and sensitivity has been sparked by the crucial role that biosensors play in a variety of industries. One such promising material is copper oxalate , a compound that holds significant potential as a precursor for the development of advanced biosensors.

Hence the aim of this research is to synthesize copper oxalate and characterize its properties for application in biosensing.

MATERIALS AND METHODS:

A chemical reaction was conducted to synthesize a material, and the steps were meticulously followed for its successful completion. To initiate the process, precisely 2 grams of strontium-doped cerium oxide (SDC) were combined with 2.5 grams of copper nitrate. This initial mixture was then carefully introduced into 100 milliliters of distilled water, creating a solution. To maintain optimal conditions for the reaction, the solution was consistently kept at a controlled temperature of 70 degrees Celsius. This temperature setting was chosen to facilitate the dissolution process while preventing excessive or premature reactions.

Over the course of five hours, the solution was continuously stirred to ensure thorough mixing and dissolution of the components. This extended stirring period allowed the SDC and copper nitrate to react and form a new compound, leading to the creation of a precipitate. Once the reaction was complete, the formed precipitate was diligently collected from the solution. To obtain the final desired product, the collected precipitate was carefully dried, ensuring the removal of any remaining moisture or solvents. This systematic procedure aimed to synthesize a specific material with precise control over reaction conditions, ultimately yielding a high-quality product for further applications.

RESULTS:

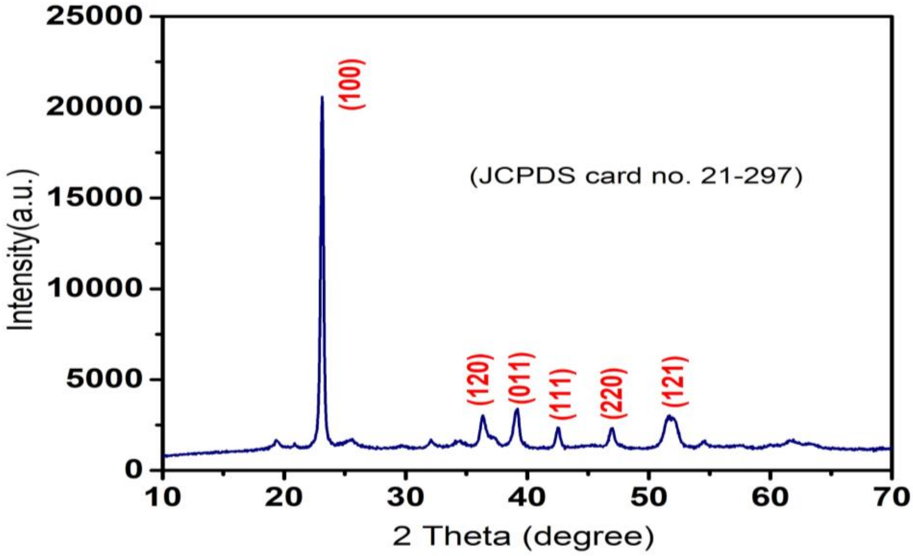

FIG 1 : XRD- The XRD analysis interpreted the purity and crystalline nature of the sample. It depicted JCPDs card number 21-297.

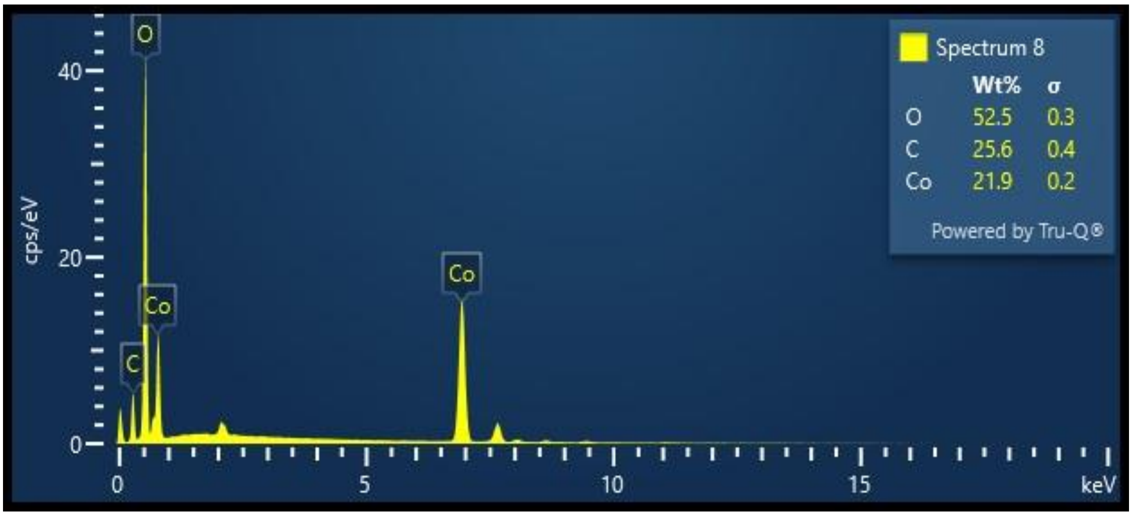

FIG 2 : EDX - The EXD results proved the purity of the mixture, only desired materials O, C , CO were present.

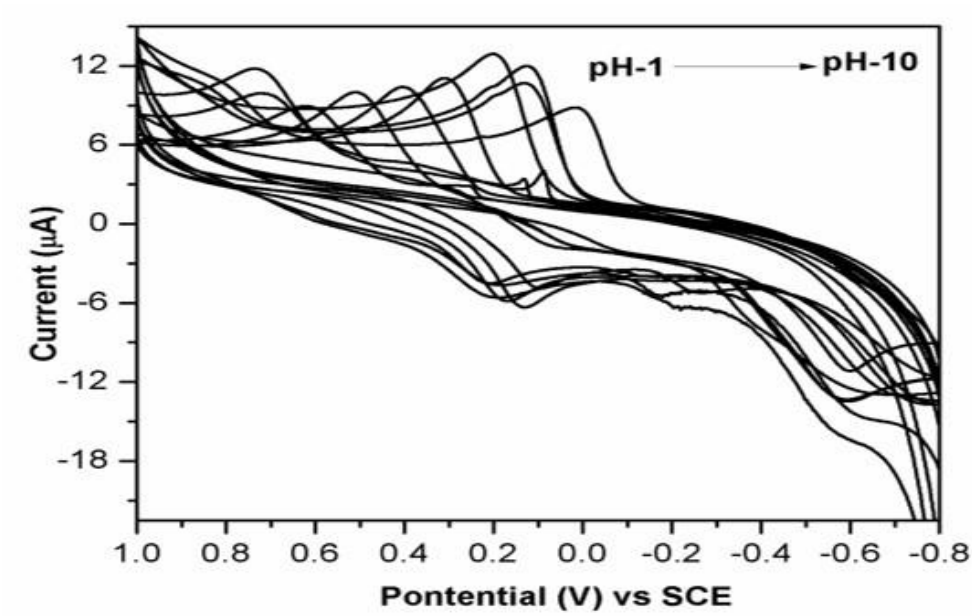

FIG 3 : Cyclic volumetric response of GCE modified with copper oxalate towards dopamine at 50 mV/s.

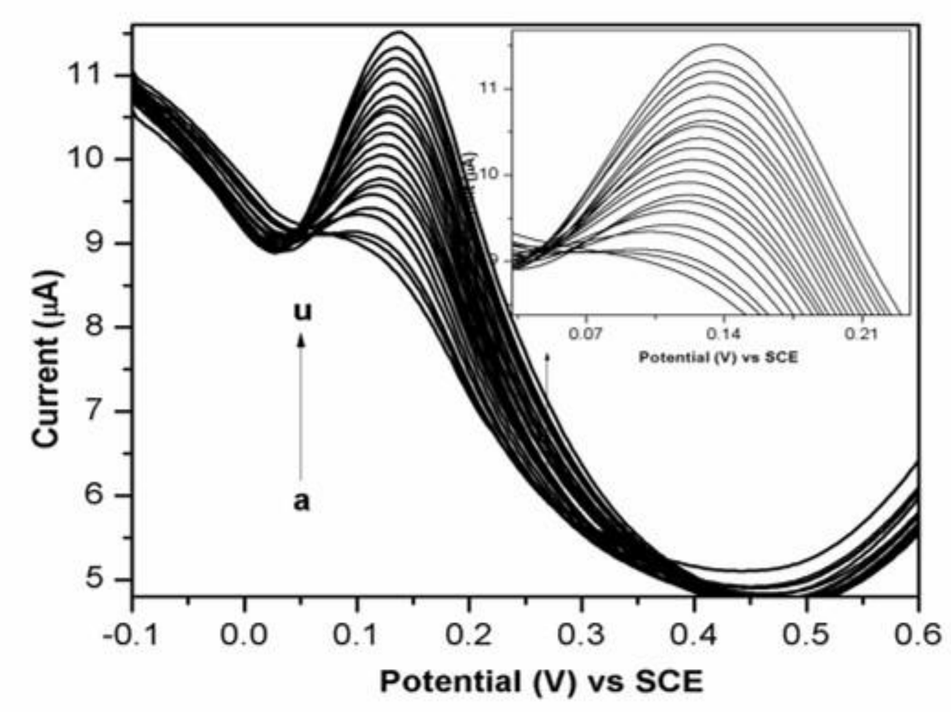

FIG 4 : DVP ANALYSIS - different concentrations of analyte were applied and current response is recorded.

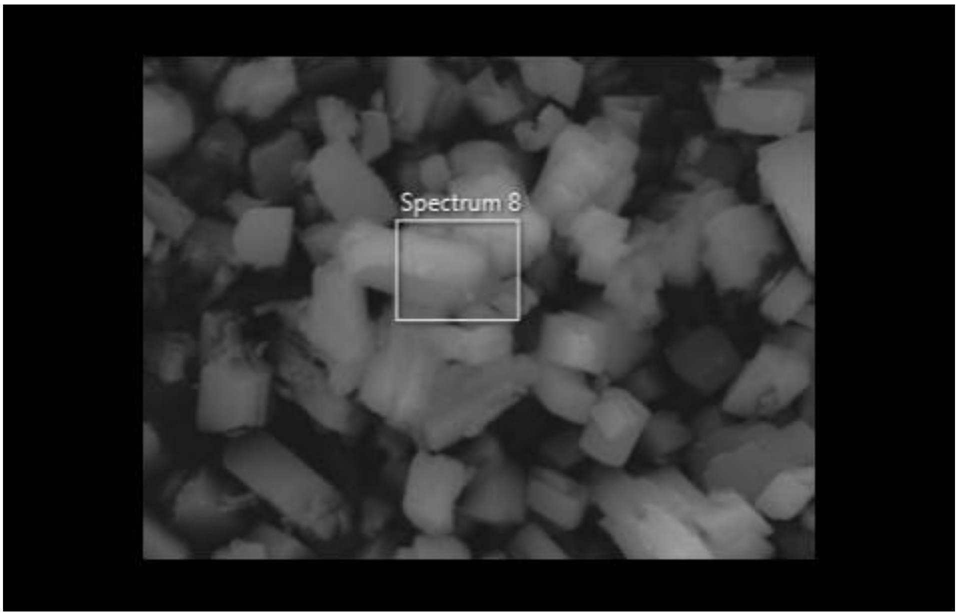

FIG 5 : FE-SEM - provided the morphology of the copper oxalate as a rectangular shape , ribbon shaped.

The successful synthesis of copper oxalate stands as a noteworthy accomplishment in this research endeavor. An essential aspect of this achievement was the utilization of X-ray Diffraction (XRD) analysis, a powerful technique that elucidates both the purity and crystalline characteristics of the synthesized sample. Remarkably, the XRD analysis revealed a pattern matching JCPDs card number 21-297, affirming the fidelity of the copper oxalate sample.

To further comprehensively characterize the copper oxalate material, Field Emission Scanning Electron Microscopy (FE-SEM) was employed, revealing distinctive rectangular morphological features. Additionally, Energy-Dispersive X-ray (EDX) analysis substantiated the purity of the sample, confirming the presence of only the intended elements—oxygen (O), carbon (C), and carbon monoxide (CO). In the subsequent stages of this study, the copper oxalate was harnessed for the development of electrochemical sensors for dopamine detection. An optimal pH range between 6 to 10 was determined, ensuring the sensors' peak performance. Differential Pulse Voltammetry (DPV) was employed to assess the sensors' sensitivity, applying various analyte concentrations and recording the resultant current responses, providing valuable insights into their analytical capabilities.

DISCUSSION:

The success of the copper oxalate synthesis was crucially confirmed by the XRD examination. The purity and crystalline structure of the sample were indicated by the detection of JCPDs card number 21-297 in the XRD pattern. In biosensing applications, this is crucial since the material's structural integrity can affect its electrochemical properties and, as a result, the effectiveness of biosensors. The accuracy and repeatability of biosensor measurements are guaranteed by a crystal structure that has been well described.The copper oxalate material has a characteristic rectangular shape, which was revealed by the FE-SEM characterization, which offered useful insights into the material's morphology. Which were similar to the research(10) depicting that the structure of copper oxalate was ribbon like and rectangular shaped. Materials' surface area and reactivity, which are key components in biosensing applications, can be considerably influenced by their shape. This knowledge directs the design and improvement of sensor materials, improving their functionality and sensitivity.

The EDX examination confirmed the presence of only the necessary elements (oxygen, carbon, and carbon monoxide), reiterating the purity of the copper oxalate. For biosensing applications, this purity is crucial because any impurities could affect the sensor's specificity and sensitivity. The possibility of false readings is decreased by using a pure substance, which guarantees that the biosensor reacts solely to the target analyte. The study's shift from material production and characterization to biosensing applications shows how applicable it is in real-world settings. A crucial discovery is the determination of the copper oxalate-based biosensors' ideal pH range (between 6 and 10). It emphasizes how crucial pH environment regulation is for precise and trustworthy biosensor measurements. This knowledge will be especially helpful in the future for applications requiring exact pH settings.

A crucial phase of the investigation involves using DPV to evaluate the sensors' sensitivity at various analyte concentrations. The current answers that were recorded offer quantitative information about the sensors' performance. The detection limitations of sensors, which are crucial factors in biosensing applications, must be understood in order to optimize sensor design.

Since nanomaterials obviously improve the performances in terms of sensitivity and detection limits down to single molecule detection, nanomaterials have become significant components in bioanalytical instruments.(11). In respect to which our research proved that copper oxalate for biosensing provides promising results .

Electrochemical sensors are a component of an electrochemical cell, which can have two or three electrodes. A typical three electrode electrochemical cell consists of a working (or indicator) electrode made of a solid, chemically stable conductor like platinum, gold, or carbon (such as graphite); a reference electrode, which is typically made of silver metal covered in a layer of silver chloride (Ag/AgCl); and an auxiliary electrode made of platinum wire.(11,12). In this current research dopamine sensors were used as a working electrode.

CONCLUSION:

A significant development in the field of biosensors can be seen in this study on the synthesis and characterisation of copper oxalate. It offers an all-inclusive strategy for sensor development by fusing fundamental material research with real-world biosensing applications. The discoveries have the potential to advance the creation of biosensors for a variety of uses, from medical diagnostics to environmental monitoring, in addition to adding to our understanding of copper oxalate. With the potential to have an impact on a variety of industries and enhance the quality of life for people, this research provides the foundation for upcoming advancements in biosensing technology.

ACKNOWLEDGEMENT:

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CONFLICT OF INTEREST:

There are no conflicts of interests in the present study.

SOURCE OF FUNDING :

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ETHICAL CLEARANCE:

Since it is an in vitro study, an ethical clearance number is not required.

DURATION OF THE STUDY :

The study was done for a period of three months.

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