DETERMINATION OF BISPHENOL A AND URID ACID BY ZINC HYDROXIDE-SODIUM DODECYL SULFATE-BISPYRIBAC MODIFIED CARBON PASTE ELECTRODE

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UNIVERSITI PENDIDIKAN SULTAN IDRIS

2026

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DISSERTATION PRESENTED TO QUALIFY FOR A
MASTER'S IN SCIENCE
(RESEARCH MODE)

UNIVERSITI PENDIDIKAN SULTAN IDRIS

2026

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ACKNOWLEDGEMENTS

Alhamdulillahirabil'alamin, all praise to Allah SWT for His blessing until I can complete this thesis. First and foremost, I would like to express my deep and sincere gratitude to my supervisor, Prof. Dr. Illyas bin Md Isa in particular has been a constant source of support and encouragement throughout my time in University Pendidikan Sultan Idris and me deeply indebted to him for his guidance, understanding, patience and boundless knowledge.

My acknowledgement also goes to Assoc. Prof. Dr. Norhayati binti Hashim, Dr. Norlaili binti Abu Bakar and Dr. Mohamad Idris bin Saidin great efforts to explain things clearly and simply.

I especially thank to all staff and laboratory technicians, Mr. Farhan, Mr. Hashimi, Mr. Isa and Mr. Supian with their help and guidance for the use of advanced equipments such as potentiostat, SEM and TEM, as well as HPLC instrument. Regarding my time at laboratory, I wish to extend my warmest thanks to my friends and to all those who have helped me with my work.

Finally, I would like to express my deepest gratitude to my father, Iriyanto who is fully financially supported me throughout my entire study at this university, my mother, Dasnawati, and all my families for their constant support, understanding and love that I received.

ABSTRACT

This study aims to develop a voltammetric sensors for the detection of bisphenol A (BPA) and uric acid (UA) using chitosan zinc hydroxide-sodium dodecyl sulfate-bisyribac (ZHN-SDS-BP/Chi/MWCNT) modified multiwalled carbon nanotubes paste electrode and zinc hydroxide-sodium dodecyl sulfate-bisyribac (ZHN-SDS-BP/MWCNT) modified multiwalled carbon nanotubes paste electrodes. Transmission and scanning electron microscopes were used to examine the surface morphology of these nanocomposites. Cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS) and square wave voltammetry (SWV) were used to study the electrochemical properties of these electrodes. Electrodes performance was optimized by evaluating the effects of composition ratio, pH of solution, type of supporting electrolyte and SWV parameters. The effective electrode surface area was determined using chronocoulometry. Under optimal condition, the ZHN-SDS-BP/Chi/MWCNT demonstrated a linear range of 3.0 μM to 0.3 mM for a determination of BPA with a detection limit of 1.0 μM. Meanwhile, ZHN-SDS-BP/MWCNT shows a linear range of 5.0 μM to 0.7 mM for simultaneously determination of UA and BPA of with detection limits of 0.4 μM and 0.8 μM. Both electrodes display a good reproducibility, repeatability and stability. The electrodes were successfully applied in the determination of BPA and UA in lake water samples. As implication, the developed electrodes serve a cost-effective device for determination of BPA and UA in aqueous samples.

PENENTUAN BISFENOL A DAN ASID URIK OLEH ELEKTROD PES KARBON TERUBAHSUAI ZINK HIDROKSIDA-NATRIUM DODESIL SULFAT-BISPIRIBAS

ABSTRAK

Kajian ini bertujuan untuk membangunkan penderia voltammetri bagi pengesanan bisfenol A (BPA) dan asid urik (UA) menggunakan elektrod pes karbon nanotiub berbilang dinding terubahsuai kitosan zink hidroksida-natrium dodesil sulfat-bispiribas (ZHN-SDS-BP/Chi/MWCNT) dan elektrod pes karbon nanotiub berbilang dinding terubahsuai zink hidroksida-natrium dodesil sulfat-bispiribas (ZHN-SDS-BP/MWCNT). Mikroskop elektron penghantaran dan pengimbasan digunakan untuk mengkaji morfologi permukaan nanokomposit ini. Voltammetri berkitar (CV), spektroskopi impedans elektrokimia (EIS) dan perlucutan gelombang segiempat sama, (SWV) digunakan untuk mengkaji sifat elektrokimia elektrod-elektrod ini. Prestasi elektrod telah dioptimumkan dengan menilai kesan nisbah komposisi, pH larutan, jenis elektrolit sokongan dan parameter SWV. Luas permukaan efektif elektrod ditentukan menggunakan kronokoulometri. Di bawah keadaan optimum, ZHN-SDS-BP/Chi/MWCNT menunjukkan julat linear 3.0 μM hingga 0.3 mM untuk penentuan BPA dengan had pengesanan 1.0 μM. Sementara itu, ZHN-SDS-BP/MWCNT menunjukkan julat linear 5.0 μM hingga 0.7 mM untuk penentuan UA dan BPA secara serentak dengan had pengesanan 0.4 μM dan 0.8 μM. Kedua-dua elektrod menunjukkan kebolehasilan, kebolehulangan dan kestabilan yang baik. Elektrod berjaya digunakan dalam penentuan BPA dan UA dalam sampel air tasik. Sebagai implikasi, elektrod yang dibangunkan berfungsi sebagai alat yang kos efektif untuk penentuan BPA dan UA dalam sampel akueus.

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CHAPTER 1

INTRODUCTION

1.1 Chemical Sensor

The rapid advancement of industrialization, urbanization, and modern healthcare systems has intensified the demand for reliable analytical tools capable of detecting chemical substances with high sensitivity and selectivity. In this context, chemical sensors have emerged as indispensable devices for monitoring, controlling, and analyzing chemical species across a broad spectrum of applications. A chemical sensor can be defined as an analytical device that converts chemical information—ranging from the concentration of a specific analyte to its chemical activity—into a measurable and processable signal (Janata & Josowicz, 2013). By enabling real-time, on-site detection, chemical sensors offer significant advantages over conventional laboratory-based analytical techniques, which are often time-consuming, costly, and require sophisticated instrumentation.

Fundamentally, a chemical sensor consists of two primary components: a molecular recognition element and a physicochemical transducer. The recognition

element is responsible for selectively interacting with the target analyte through chemical or physical mechanisms such as adsorption, redox reactions, complex formation, or biomolecular binding. The transducer subsequently converts the chemical interaction into a quantifiable output signal, typically electrical, optical, thermal, or mechanical in nature (Borisov & Wolfbeis, 2018). The integration of these components into a functional sensing platform determines the overall analytical performance of the device, which is commonly evaluated in terms of sensitivity, selectivity, response time, stability, reproducibility, and detection limit.

Chemical sensors are generally classified according to their transduction mechanisms. Among the most extensively studied and widely applied are electrochemical, optical, mass-sensitive, and thermal sensors. Electrochemical sensors operate by measuring changes in current (amperometric), potential (potentiometric), or impedance (impedimetric) resulting from chemical reactions occurring at an electrode interface. Owing to their relatively simple instrumentation, portability, and cost-effectiveness, electrochemical sensors have found widespread use in environmental monitoring and clinical diagnostics (Wang, 2006). A prominent example is the glucose biosensor, which revolutionized diabetes management through rapid and accurate blood glucose measurements.

Optical chemical sensors, in contrast, detect variations in optical properties such as absorbance, fluorescence, phosphorescence, or refractive index induced by the interaction between the analyte and the sensing material. These sensors are particularly advantageous due to their high sensitivity, capability for remote sensing, and resistance to electromagnetic interference (Borisov & Wolfbeis, 2018). Meanwhile, mass-

sensitive sensors, including quartz crystal microbalance (QCM) and surface acoustic wave (SAW) devices, measure frequency shifts resulting from analyte adsorption on a sensing surface. Thermal sensors detect temperature changes associated with exothermic or endothermic chemical reactions. The selection of a specific sensor type depends largely on the intended application, operational environment, and analytical requirements.

In recent decades, the field of chemical sensing has experienced transformative progress driven by advances in material science and nanotechnology. The incorporation of nanostructured materials—such as metal oxide nanoparticles, carbon nanotubes (CNTs), graphene, and quantum dots—has significantly enhanced sensor performance. Nanomaterials offer a high surface-to-volume ratio, tunable surface chemistry, and unique electronic properties that facilitate improved analyte interaction and accelerated charge transfer processes (Comini et al., 2015). For instance, semiconducting metal oxides such as SnO_2, ZnO, and TiO_2 have been extensively employed in gas sensing applications due to their pronounced changes in electrical conductivity upon exposure to oxidizing or reducing gases. Similarly, graphene-based materials have demonstrated remarkable sensitivity in detecting gaseous molecules and biomolecules because of their exceptional electrical conductivity and two-dimensional structure (Yang et al., 2015).

The application domains of chemical sensors are broad and continually expanding. In environmental monitoring, these sensors are essential for detecting air pollutants, including carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2), and volatile organic compounds (VOCs), as well as water contaminants such as

heavy metal ions and organic pollutants. Rapid detection of these substances is critical for mitigating environmental hazards and ensuring public safety. Compared with conventional analytical methods such as gas chromatography and mass spectrometry, chemical sensors provide portable and real-time alternatives that are better suited for field deployment (Comini et al., 2009).

In the biomedical and healthcare sectors, chemical sensors play a pivotal role in disease diagnosis, therapeutic monitoring, and point-of-care testing. Biosensors a specialized subset of chemical sensors that employ biological recognition elements such as enzymes, antibodies, or nucleic acids—have significantly expanded diagnostic capabilities. The development of enzyme-based and immunosensors has enabled the detection of biomarkers at extremely low concentrations, facilitating early disease diagnosis and personalized medicine approaches (Wang, 2006). Moreover, the integration of chemical sensors into wearable devices has opened new avenues for continuous health monitoring, reflecting the growing convergence between sensor technology and digital healthcare systems.

Despite substantial advancements, several challenges persist in the development and practical implementation of chemical sensors. Achieving high selectivity in complex matrices remains a significant obstacle, as interfering species may compromise measurement accuracy. Sensor drift, limited long-term stability, and environmental susceptibility also present technical challenges that must be addressed to ensure reliable performance. To overcome these limitations, researchers have explored strategies such as molecular imprinting, surface functionalization, and the fabrication of sensor arrays combined with advanced data processing algorithms. The

concept of electronic noses and electronic tongues systems that utilize pattern recognition to analyze complex chemical mixtures illustrates the innovative approaches being adopted to enhance selectivity and analytical reliability (Janata & Josowicz, 2013).

The ongoing integration of chemical sensors with microelectronics, wireless communication, and data analytics has further expanded their capabilities. Microelectromechanical systems (MEMS) technology has enabled the miniaturization of sensing devices, reducing power consumption and facilitating mass production. In parallel, the incorporation of wireless connectivity and Internet of Things (IoT) frameworks allows real-time data transmission and remote monitoring. Such developments are particularly relevant in smart environmental monitoring systems, industrial automation, and precision agriculture.

Looking ahead, the future of chemical sensor technology lies in the development of highly selective, ultra-sensitive, and multifunctional sensing platforms capable of detecting multiple analytes simultaneously. Emerging trends include flexible and wearable sensors, printable electronics, and the application of artificial intelligence (AI) and machine learning for signal processing and pattern recognition. These innovations are expected to significantly enhance analytical performance and broaden the scope of practical applications. As global concerns regarding environmental sustainability, public health, and industrial safety continue to intensify, the role of chemical sensors will become increasingly central to technological progress and societal well-being. Chemical sensors represent a dynamic and interdisciplinary field that integrates principles of chemistry, physics, materials science, and engineering to

enable the detection and quantification of chemical species. Advances in nanomaterials, fabrication technologies, and digital integration have significantly improved their performance characteristics, positioning chemical sensors as vital tools in modern analytical science. Continued research efforts aimed at overcoming existing challenges and enhancing sensor capabilities will undoubtedly drive further innovation and expand their impact across diverse scientific and industrial domains.

1.2 Voltammetric Sensor

As voltammetric sensors were first invented, their working electrodes were inert metals, carbon compounds, and mercury. Because noble metals are expensive and mercury is hazardous, its usage has long been prohibited. Because of its narrow anodic potential range and problematic handling, the mercury electrode is practically out of the picture. Many kinds of carbon electrodes, including glassy carbon, diamond, fullerene, graphite, nanotubes, graphene, and graphene oxide, are still in use (Power, 2021).

Since carbon paste electrodes can be mass-produced through screen printing, they have become more and more popular as functional electrodes in recent years. Screen printed electrodes are an additional type of electrode that can be employed in commercial technologies since they are a reliable miniature form. The voltammetric sensors hold promise for such diagnostic methods as they are fast, simple in operation, offer real time analysis and can be mass-produced for portable use as they can be miniaturized compared to other existing diagnostic methods (Kim, 2020).

Carbon based electrodes are more popular owing to their biocompatibility, stability and good electron transfer kinetics. The bare electrodes often lack sensitivity and selectivity needed for the analysis due to poor charge transfer at the electrode surface. This requires modification of electrode surfaces to enhance charge transfer kinetics and avoid interferences. In this light, the nanomaterials are paving the way for smart electrochemical sensors as they provide enhanced electrochemical surface area with large surface area to volume ratio allowing improved interfacial kinetics exhibiting electrocatalytic activity for sensitive and selective determination of analytes (Gupta, 2020).

The synergistic effect of nanomaterials is also being actively pursued by combining two or more nanomaterials to form a composite which would derive advantages from all individual components based on the sensing need. Although nanomaterials have proved to be beneficial, there are certain challenges yet to overcome like handling sophisticated instruments and the stability of nanoparticles utilizing stabilizers or capping agents in certain cases to avoid agglomeration which will disrupt electrode-electrolyte interfacial kinetics (Meng LA, 2019).

There are mainly three major hurdles encountered in the development of electrochemical sensors: the attainment of a low limit of detection (LOD); limiting the interaction of unwanted interfering species; maintaining sensor stability and achieving reproducibility in complex real matrices. The LOD indicates the lowest concentration/quantity that could be detected for an analyte and is a major criterion for a sensor performance as many times we are dealing with analytes that are present at trace levels in real samples. With the advancement of nanomaterial modified surfaces,

picomolar level of detection has been achieved. These modified surfaces still pose the challenge of stability and reproducibility. Moreover, the sensor needs to be validated for real samples otherwise it does not hold importance in the market. The test of an electrochemical sensor as a diagnostic tool is only validated if it is stable and functional in a real matrix. Real matrices involve interferences that hinder electrode performance.

1.3 Introduction of Bisphenol A and Urid Acid

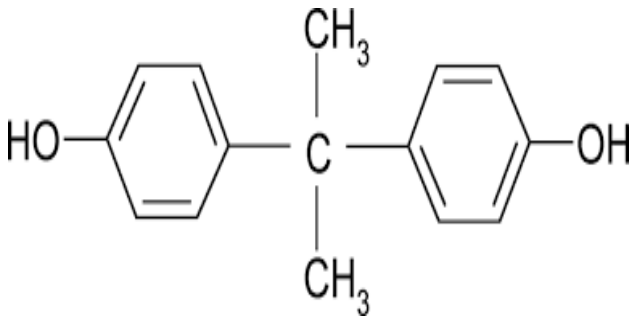
The chemical formula for bisphenol A (BPA), a colourless crystalline solid that is a member of the organic compound family, is $C_{15}H_{16}O_2$. The most well-known applications of BPA are in the production of epoxy resins and polycarbonate plastics, which are mostly used in water bottles, baby bottles, and other food and drink containers. It is also well-known for its propensity to leak from those goods, which has raised concerns about it in relation to the environment and public health (Dodds & Lawson, 2018).

In the modern world, bisphenol A (BPA) is a material that is almost universal. It is extensively utilised in the production of epoxy resins, which are used to line steel drums, pipes, plastic food containers, and medical equipment as protective linings. Since BPA is a substance that comes into touch with food, it can be found in almost all canned foods and home equipment. Epoxy resins based on BPA are also commonly employed because of their sticky qualities. Additionally, BPA plays a significant role in the manufacturing of polycarbonate polymers, which are used in eyeglasses, optical devices, and medical equipment. Additionally, BPA is added to polyvinyl chloride

polymers, which are widely used in construction materials, pipelines, wire insulation, and healthcare supplies (Johnson and Sahu, 2015).

Figure 1.1

The structure of Bisphenol A (Cousins et al., 2002)



BPA was first synthesized in 1891, by Russian chemist Aleksandr P. Dianin, who combined phenol with acetone in the presence of an acid catalyst to produce the chemical. In the 1950s scientists discovered that the reaction of BPA with phosgene (carbonyl chloride) produced a clear hard resin known as polycarbonate, which became widely used in the manufacture of plastics.

The highest permissible (or "reference") dosage established by the U.S. Environmental Protection Agency (EPA) is 50 micrograms per kilogramme of body weight per day, although BPA levels in humans have typically been found to be far below this level. The majority of nations have not placed restrictions on the production, import, or distribution of BPA products, despite the material's ubiquity in human populations and its link to animal reproductive and developmental damage. This has mostly been caused by contradictory scientific data showing a link between low-level

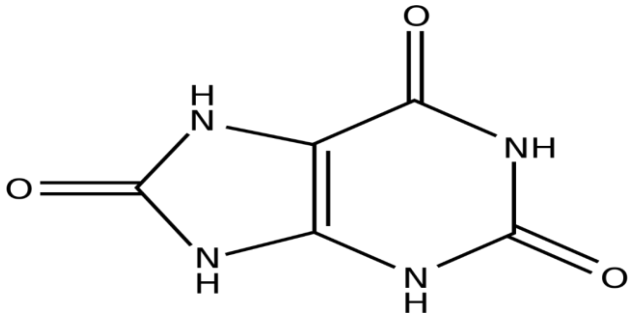
exposure and detrimental consequences on human health. On the other side, a number of nations and areas, including the US, Canada, Europe, and Sweden, have officially outlawed the use of BPA in infant and kid items, which include, among other things, baby bottles, sippy cups, and formula cans (Huang et al, 2015).

Uric acid is a heterocyclic compound of carbon, nitrogen, oxygen, and hydrogen with the formula $C_5H_4N_4O_3$. It creates urates—salts and ions—including acid urates like ammonium acid urate. Urine naturally contains uric acid, which is a byproduct of purine nucleotide metabolism. Elevated uric acid levels in the blood are linked to various health issues, such as kidney stones caused by ammonium acid urate and diabetes, and can cause gout (Hilippa D. Darbre, 2015).

Purine metabolism, which uses purine from both endogenous and exogenous sources, ultimately produces UA, primarily in the liver, kidneys, gut, and vascular endothelium (El Ridi & Tallima, 2017). Nucleic acids from both live and dying cells make up the majority of the endogenous purine sources, whereas exogenous purine comes from food, fructose catabolism, and animal proteins (Cortese et al., 2019). Many distinct enzymes are needed to catalyse the conversion process in the pathway leading to the synthesis of UA from nucleic acids like adenine and guanine. The conversion of hypoxanthine to xanthine and the subsequent conversion of xanthine to UA are the two fundamental processes for the synthesis of UA. The flavoenzyme xanthine oxidoreductase is the one that contributes most to this conversion (Harrington, 2002).

Figure 1.2

The structure of Urid Acid (Thomas, 2013)



UA has a PKa value of 5.8, placing it in the weak acid category. It is primarily found as the salt urate. The rise in UA crystals is directly correlated with blood urate levels. According to studies, men's levels of UA range from 2.5 to 7.0 mg/dl, while women's levels are slightly lower, ranging from 1.5 to 6.0 mg/dl. Humans and apes are known to have 3 to 10 times higher levels of UA than other mammals, which have levels between 10 and 20 ug/ml. This is because they lack uricase activity (Corriveau & Popovic, 2009).

1.4 Carbon Paste Electrode (CPE)

Adams created the carbon paste electrode (CPE) at the close of 1958. The narrow anodic potential window of the mercury electrode led to the development of the carbon paste electrode, which is a fluid composed of dispersed carbon particles that can be employed as a substitute for the dropping mercury electrode (DME) (Adams, 2019). Carbon (graphite) powder and a binder (pasting liquid) are combined to create carbon paste. Low volatility, high viscosity, electroinactivity, chemical inertness, limited solubility in aqueous solution, and immiscibility with organic solvents are the

requirements for a carbon paste binder (Svancara et al., 2009). Low cost, extremely low background current, easily renewable, and customisable surface electrode are all provided by carbon paste electrodes (Wang, 2000). Consequently, carbon paste has emerged as one of the most popular electrode material used for various sensor and detector (Svancara et al., 2009).

For the past fifty years, carbon paste a blend of powdered carbon, or graphite and pasting liquid the binder has been referred to as the classical carbon paste electrode. It has grown to be one of the most widely utilised electrode materials for creating different electrodes, sensors, and detectors in laboratories. Graphite particles and a binder (pasting liquid) make up the traditional carbon paste electrodes. Approximately 75% of the carbon paste used can be found in this electrode (Svancara et al., 2009). The composition of the pasting liquid and carbon has a significant impact on the reactivity of the traditional carbon paste electrode (Wang, 2000).

Organic substances such silicone fluids, paraffin oil, bromonaphtalene, and Nujol (mineral oil) are included in the pasting liquid (Svancara et al., 2009). The interaction between graphite microparticles in a conventional carbon paste electrode produces electronic conductivity, while the binder keeps the mixture compact. When graphite and electrolyte solution come into contact on the electrode surface, the electrode reaction takes place (Scholz, 2002). According to Kalcher (1990), there are two types of traditional carbon paste electrodes: unmodified carbon pastes (CPEs) and chemically or biologically modified carbon pastes (CMCPEs). The most common usage of the term "carbon paste biosensor" is in reference to carbon paste electrodes that have been biologically modified (Gorton, 1995).

Olson and Adams (2016) said that most carbon paste electrode may achieve background currents of about 200 nano-ampere or else lower than that based on the adsorbed electroactive species or analytes. In addition, carbon paste electrode is becoming increasingly popular and advised due to its broad electrochemical potential window. It appears that the conventional carbon paste electrode's normal potential range is inherently dependent on the kind of medium or supporting electrolyte that is utilised. The measurements can be conducted in the following potential ranges: alkaline electrolyte between -1.2 V and +1.2 V, neutral electrolyte between -1.3 V and +1.4 V, and acidic electrolyte between -1.0 V and +1.5 V against Ag/AgCl (Olson C & Adams, 2013).

The binder, sometimes referred to as the pasting liquid, is the second important purpose of carbon paste that influences the properties of the carbon paste electrode. The following binding agents are commonly employed when creating carbon pastes: silicon oil, paraffin oil, mineral oil (such uvasol or nujol), ceresin wax, bromoform, or bromonapthalene. The extended lifespan, mechanical stability, chemical inertness, insolubility in the aqueous solution under measurement, and electro-inactivity of the binder are what make it useful in practical applications. The presence of binder at the surface frequently causes a bigger over-potential, a lowering of the kinetics, and a decrease in transfer rates as compared to homogenous electrodes. However, the binder class that exhibits success has attractive features like good ion-pairing capability but has abnormal signal-to-noise properties (Metelka, 2009).

A number of carbon materials, ranging from highly oriented pyrolytic graphite and carbon nanotubes to glassy carbon, carbon black, carbon fibre, and other kinds of

graphite powder, have been extensively employed in the creation of solid electrodes. Carbon paste electrodes are the most widely utilised types of functional electrodes due to their ease of creation. Carbon nanotube paste is mushy and non-compact, so it needs to be kept in a holder. Glass tubes, short Teflon tubes, and polyethylene syringes are common types of holders. A conducting wire is required to establish an electrical connection between these holders. It takes a reservoir or doesn't require one to refill the carbon paste holder (Vytras et al., 2009).

Carbon paste electrodes come in two varieties: modified carbon paste electrodes and unmodified carbon paste electrodes, sometimes called naked electrodes. The low selectivity and sensitivity problems with the bare electrode are intended to be fixed by the modified carbon paste electrode. Using an unchanged electrode would not always be possible for analysis. The trace amount of analyte cannot always be determined using the unaltered electrode due to the fouling effect and infrequently insufficient signal-to-noise. The modified and unmodified carbon paste electrodes can be compared based on their manufacturing processes. Unmodified carbon paste electrodes are typically made by mixing carbon powder with a binder; however, modified carbon paste electrodes are made by adding one or more electroactive compounds, also referred to as modifiers, into the the bare electrode (Sajid et al., 2016).

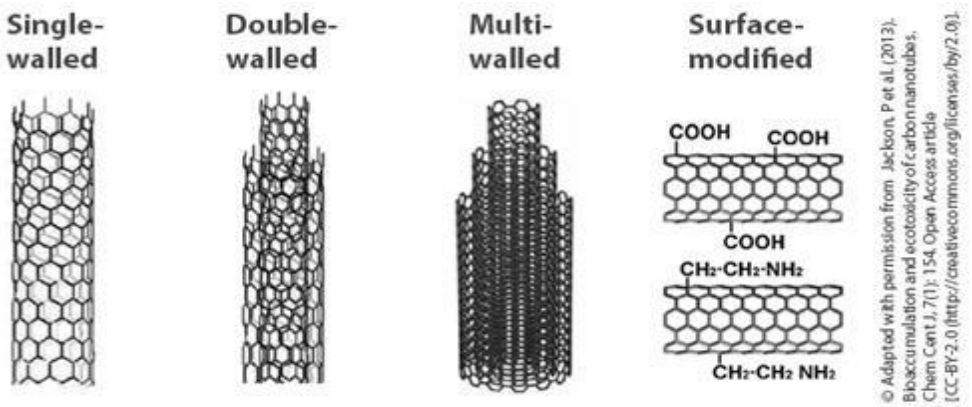
Because the modifier's incorporation into the bare electrode can lower the redox potential required for the electrochemical process and provide the ability to promote electron-transfer process, the modified carbon paste electrode can be used to lower the magnitude of the detection limit as compared to the bare carbon paste electrode. A modified electrode can also increase the sensitivity and selectivity of the detection

technique to show electrocatalytic activity towards the analyte. (Beitollahi & Khabazzadeh, 2008).

As a result of topology flaws on the tube surface and dimensions related to electronic structure, carbon nanotubes (CNTs) possess electrocatalytic activity properties (Rivas et al., 2007). Single-wall (SWCNT) and multi-wall (MWCNT) carbon nanotubes (CNTs) can both be used as constituents of the carbon paste electrode. Carbon paste can benefit from the addition of carbon nanotubes (CNTs), usually in the form of a modifier component. Graphite powders, carbon nanotubes (CNTs), and a pasting liquid known as carbon nanotube-modified carbon paste electrodes (CNT-CPEs) make up the carbon electrode (Svancara & Walcarius, 2012).

Figure 1.3

An overview of the many architectures of carbon nanotubes, including single-walled (SWCNT), double-walled (DWCNT), multi-walled (MWCNT), and potential surface alterations in nanotechnology (Jackson, P et al., 2013)



Two components of carbon nanotubes (CNTs) and a pasting liquid known as carbon nanotube paste electrodes (CNTPEs) can also be used in place of graphite powder. Carbon nanotubes (CNTs) can be combined with mineral oils (Raoof et al.,

2003), bromoform (Britto & Ajayan, 2016), or an electroactive binder (Kachoosangi et al., 2007) to create carbon nanotube paste electrodes, or cNTPEs. There has been a lot of interest in the chemically modified carbon nanotube paste electrodes (CMCNTPEs) and the biologically modified carbon nanotube paste electrodes (CNTP-biosensor). Carbon nanotubes (CNTs), pasting liquid, and modifier make up chemically carbon nanotube paste electrodes (CMCNTPEs) (Svancara et al., 2012). Chemically bonded carbon nanotube paste electrodes (CMCNTPEs) have a voltammetric response for multiple molecules that demonstrates reduced overvoltages and increased peak current (Rivas et al., 2007). The presence of modifier on CNTs was increasing highly sensitive detection for analytical measurements.

1.5 Problem Statement

Purine metabolism produces UA, a species that is thought to be very significant for human diagnosis. UA is important for the detection of abnormal level of UA in the human body. Extreme abnormalities of UA level may accumulate in human body, and excessive amount in body fluid may form solid state urate and lead to gout or kidney stones, hyperuricemia as an independent risk factor for the development of cardiovascular and renal disease and Lesh-Nyhan syndrome. Meanwhile, lower UA concentration had been linked to multiple sclerosis, Parkinson's disease, Alzheimer's disease and optic neuritis. Gout occurs when sodium urate crystals are deposited in the joints, soft tissue, bursae and tendons (Lakshmi et al., 2011).

The main form of UA is urate, or UA salt. The production of UA crystals rises with blood urate content. In human blood, the typical reference range for UA is 1.5 mg/dL to 6.0 mg/dL in women and 2.5 to 7.0 mg/dL in men. UA has a limited solubility in water, and its average blood values in humans are almost exactly equal to the 6.8 mg/dL solubility limit. When UA levels are more than 6.8 mg/dL, UA crystals known as monosodium urate (MSU) develop. However, because humans lack the uricase enzyme, they are unable to oxidise UA to the more soluble molecule allantoin. The kidneys dispose of most UA on a daily basis. Consequently, it's critical to keep an eye on the amount of UA in biological fluids so that it can be used as an early warning of the presence of the UA in urine (M.Jin et al., 2012).

The most widely used chemical industry substance in the world is BPA, which is utilised in the manufacturing of epoxy resin and polycarbonate. Exposure to BPA has detrimental impacts on the environment and is a serious cause for concern because it has a harmful impact on human health. One of the reasons why BPA is unintentionally released into the environment and contaminates rivers and ground water through effluent is the manufacturing of BPA goods. Conversely, BPA has been detected leaking into the environment through plastic plants, bottles, and packaging, as well as landfill leachates when exposed to specific conditions including excessive heat, harsh detergent cleaning, or acidic cleaning agents. As a result, BPA can enter food and water through a range of food contact materials, such as when people swelled the food or drink water that containing BPA, BPA will accumulate in the human body system and thus routinely ingest trace amount of BPA (Shi Liang et al., 2016).

But a great deal of recent in vitro research has revealed that BPA exposure is mediated by both non-genomic and genomic estrogen-response pathways. Research has indicated that excessive levels of BPA exposure can have deleterious effects on humans because of their estrogen-like properties. BPA can impair cell function even at low concentrations of 1 pM (0.23 ng -1), which has been related to sperm quality reduction, cardiovascular disorders, endometrial hyperplasia, recurrent miscarriages, neurotoxicity issues, polycystic ovarian syndrome, aberrant development, and a number of cancers, including testicular, prostate, and breast cancer. Consequently, BPA has been classified as a hazardous material (Deng, Xu & Feng, 2013).

1.6 Significance of the Study

As the electrochemical method used in this work is rapid, easy, affordable, and doesn't require any extra equipment, it is particularly interesting for in vivo practical applications. The electrode's design and development also don't take much thought. Given that the electrode may quickly be employed for widespread monitoring of a variety of illnesses, hazardous materials, and environmental components. Applying such electrode progress to solve the actual problem is hence desirable (Jadon Jain & Sharma, 2016).

Electrochemical sensors greatly benefit from electrode modification since it can alleviate the sluggish kinetics of many bare or simple electrodes. Because it produces the desired performance of the electrochemical sensor in the analytes, a thoughtful selection of electrode modification adds benefits for regular analysis. Because CNT

contributes to electrochemical sensors, analytes' electron-transfer processes are facilitated, which makes them an ideal option for electroactive species detection platforms. However, by overcoming the analytes' weak response, the inclusion of LDH shows improved performance in electro-catalysis and provides compact detection in analytes. In electrochemical study, LDH can undoubtedly be a desirable material for the modified electrode (Amiri Aref et al., 2016).

1.7 Objectives of Study

The objectives of this study are as follow:

1. To modify MWCNT paste electrode with ZHN-SDS-BP-Chi and ZHN-SDS-BP .
2. To characterize the development of MWCNT/ZHN-SDS-BP Chi and MWCNT/ZHN-SDS-BP.
3. To evaluate the development of MWCNT/ZHN-SDS-BP Chi and MWCNT/ZHN-SDS-BP for determination of uric acid and bisphenol A.