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A REVIEW ON SYNTHESIS AND POTENTIAL APPLICATIONS OF NANOMATERIAL BASED BIO-NANOSENSORS

VIDIT KULSHRESTHA, SACHIN, ANKUR CHOURASIA & NAHID MASOOD SIDDIQUI

Amity Institute of Biotechnology,J-3 Block, Amity University, Sector-125, Noida, Uttar-Pradesh,India

ABSTRACT

The target is recognised by biological substances by means of biosensors, which then use output components that can transform the biorecognition event into electrical, optical, or mass-sensitive signals. Common examples of effective biosensors include blood glucose metres, home pregnancy strips, and COVID-19 fast testing. Nano-sensors are essential in the field of nanotechnology for (a) spotting physical and chemical changes, (b) keeping track of biomolecules and biochemical changes in cells, and (c) assessing harmful and polluting substances found in the workplace and the environment.One of these platforms that offer many benefits, such as being affordable, selective, particular, quick, and portable, is the electrochemical biosensor platform. The development ofhigh-sensitivity and decomposition power monitors has resulted from the simultaneous application of the benefits of electrical methods and nanostructures. Over the past few years, research on nanomaterials has evolved swiftly, and some of their potential applications have already been realized. In the foreseeable future, one of the major technologies is projected to be made possible by nanomaterials. The development of point-of-care diagnosis, the integration of diagnostics with therapies, and personalized medicine are all expected to be made possible by nanotechnologies, which promise to expand the capabilities of present molecular diagnostics. The development of nanosensors and nanotechnology must be vigorously pursued due to their importance.

KEYWORDS: Environment, Biorecognition, Nanomaterials, Covid-19.

INTRODUCTION

The first Industrial Revolution, which occurred at the end of the eighteenth century, was the catalyst for the advancement of technological study and the acquisition of new materials. The problems of today include the miniaturization of equipment and devices, which results in smaller volumes, lower power requirements, and higher performance(Hong, 2019). The evolution of science and technology throughout the cosmos has been greatly influenced by the nanoworld.The discipline of nanotechnology has undergone a revolution as a result of the discoveries of nanomaterials like carbon fullerenes in 1985, carbon nanotubes in 1991, and organised mesoporous materials in 1992. According to their dimensionality, nanomaterials can be divided into a variety of categories, including nanoparticles that are three dimensional (nanoparticles), two dimensional (nanosheets), and one dimensional (nanowire, nanotube). (Mehrotra, 2016).

The distinctive visual, magnetic, electrical, and mechanical properties that appear at the nanoscale make nanomaterials one of the most researched materials. Users in a variety of applications, including uses for a catalyst, gas sensors, batteries, optoelectronics, and biotechnology, have been interested in these emergent features(Hong, 2019). The capacity to make microscopic structures with extreme accuracy and the quest for new desired materials are both necessary for advancement. The process of development is not, however, that simple and un-complicated(Kübra Gençdağ & Mihrican, 2020).

Low-dimensional materials and architectures exhibit exceptional qualities. This enables these substances and structures to contribute significantly to the quick science and technology progress. Nanomaterials have taken the centerstage in science and technological development thanks to their extraordinary features(Zeng et al., 2016). These materials' unusual mechanical and chemical characteristics, which differ greatly from those of materials with the same composition at a millimetre scale, are what first sparked interest in them(Mehrotra, 2016).

Nanoproducts typically have dimensions that range from 1 to 100 nm in length. In order to dramatically improve the physical, chemical, physico-chemical, and biological characteristics of materials and devices, for a variety of uses, this developing technology fabricates, images, measures, models, and manipulates matter at the level of individual atoms, molecules, or particles(Su H et al., 2017). Since materials have significantly different characteristics in this range than in their bulk counterparts, the size range that attracts the most interest is generally from 100 nm down to the atomic level. An increasing importance of surface and interfacial area is the primary cause of this shift in behaviour(Wu et al., 2015).

Recent developments in nanotechnology have focused mostly on the creation of fast electronics, more effective catalysts, and sensors. For the upcoming years, this latter category of applications offers both exceptional importance and unheard-of development potential(Zeng et al., 2016). Making more sensitive, efficient, and focused sensing devices has been one of the key goals for the development of sensors thus far. It is obvious that these systems are becoming better and become more specific as the component sizes get smaller. This can result in actions being taken more quickly, nearly instantly(Hong, 2019).

For some time now, nanotechnology has been making the transition from the laboratory setting to applications and consumer goods. In reality, nanotechnology is a highly interdisciplinary area that integrates a variety of disciplines, including physics, chemistry, electrical and mechanical engineering, and biosciences(Noah, 2020). All of these disciplines and the areas in which they are used will be significantly impacted. Similar to the information technology and telecom industries, economic effect is anticipated. As a result, there is a huge increase in the need for a workforce that can support this promising technology(Mehrotra, 2016).

Sensors have so far been created to identify and measure gases, radiation, biomolecules, microbes, etc. The majority of the sensors created to date operate on the lock-and-key principle, where the selective receptor (lock) is specifically attached to the desired analyte. (or key)(Mehrotra, 2016). These limitations have been highlighted in this review article and future challenges related to it have been mentioned as well. The article has been prepared with the motive to provide some potential and plausible solutions that can provide a new direction to the application of biosensors in the scientific world. Additionally, it examines how the creation of these systems may be capable of previously unthinkable advancements thanks to nanotechnology and nanomaterials.

WHAT ARE NANOMATERIALS AND WHERE ARE THEY FOUND

Chemical substances or materials known as nanomaterials (NMs) have been created and developed in numerous industries, including sensors, electronics, biomedical engineering, optical communications technology, and a wide range of other disciplines. They are notable for their distinctive properties, small, tunable sizes, and high surface area to volume ratio. The NMs show brand-new, distinguishing characteristics including improved stronger, more sensitive, stable, chemically reactive or conductible, biocompatible, and less poisonous (Lahir et al., 2016). According to standards set by the American Association for Testing and Materials (ASTM) and the International Organization for Standardization (ISO), the diameters of the NMs vary from 1 to 100 nm with one or more dimensions (ISO). Within the nanoscale range, NMs are often categorised as elements with a carbon, inorganic, or organic basis, and their attributes were varied in relation to the greater size of the corresponding materials(Su H et al., 2017). The majority of NMs used for research and business reasons are created by chemical, physical, and mechanical methods.

Sensors are tools that monitor physical qualities like temperature, mass, electrical characteristics, or optical features and create a signal for recording or further post-processing. The development of sensors has a lengthy history. In the 1880s, the first thermostat was created, and in 1940, the first infrared sensor was created(Wu et al., 2015). Nanosensors can be used to measure signals that are available at that size and are comparable to macrolevel sensors in that they have at least one dimension in the nanoscale. With its recent fast progress, nanotechnology has demonstrated enormous potential in practically all industries. The nanosensor area has benefited from these advancements for its own growth. Various electronics companies have supported these innovations to suit their requirement for downsizing(Liyanage et al., 2021).

Nanomaterials, which have the potential to become one of the fundamental technologies of the future world, have recently emerged as one of the main study fields. Nanotechnology is the study and creation of objects or materials at the atomic or molecular level(Eivazzadeh-Keihan et al., 2022). However, using one of the aforementioned definitions can be overly limiting. It is beneficial to include everything and everything that has been labelled as nanotechnology in a comprehensive survey. A framework for categorising and comprehending the many kinds of nanomaterials might then be developed(Perdomo et al., 2021).

The size effect underlies the amazing characteristics of nanomaterials. When something shrinks, it develops a number of amazing qualities and phenomena that are not visible at the bulk level, which is the micron scale and above(Hong, 2019). The materials' characteristics underwent substantial modifications to what is seen at the bulk scale as a result of changes in their electronic properties.

Some nanoparticles occur naturally, but manufactured nanomaterials (EN), which are intended for, and the current state of affairs being business items and approaches, are highly persuasive(Eivazzadeh-Keihan et al., 2022). Currently available products include stain-resistant and wrinkle-free fabrics, beauty care goods, sunscreens, gadgets, paints, and stains. Innovative UV-impeding glass bottle coatings shield beverages from sun harm, and butyl-flexible/Nano-soil composite tennis balls are more durable(Kübra Gençdağ & Mihrican, 2020). Nanoscale titanium dioxide is used in sunblock and beauty care products, while numerous products use nanoscale silica as a filling., including those for women's skin (Javaid et al., 2021).

PROPERTIES AND NANOMATERIALS SYNTHESIS

In general, strategies that are top-down and bottom-up have been used to synthesize nanomaterials. Due to their distinct advantages, such as producing nanostructures with fewer flaws, more uniform chemical compositions, and various ordering ranges, both approaches have drawn a lot of attention. While the top-down method prepares nanomaterials from bulk materials, the bottom-up method synthesizes material atom by atom and molecule by molecule(Perdomo et al., 2021).

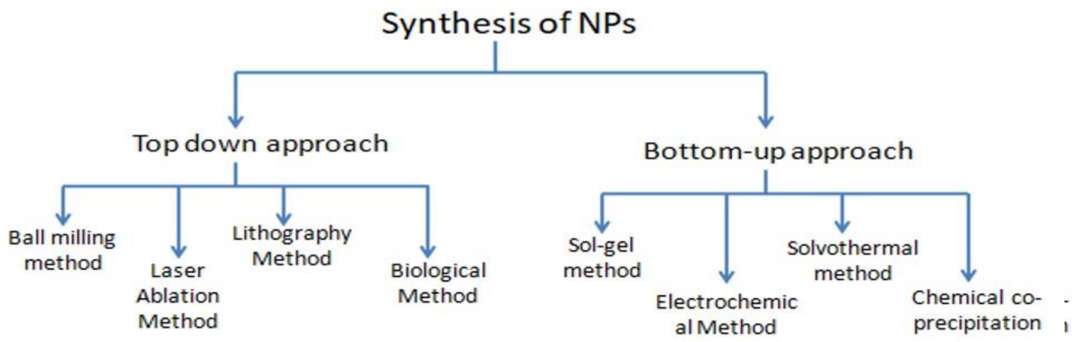

Figure 1: SchematicDepiction of Synthesis of Nano-Particles

For the most part, bottom-up rather than top-down approaches are chosen when manufacturing nanoparticles. It offers regulated particle size and homogenous nanoparticles at a reasonable cost(Noah, 2020).

Melting Point Depression is a term used to describe the fact that the melting point of materials at the nanoscale is lower than that of larger materials. Typically, a bulk material's melting point is independent of its size. However, as the size of the grain gets smaller, the melting point of materials at the nanoscale gets lower(Eivazzadeh-Keihan et al., 2022). The melting point of metals with nanometer-sized dimensions can fall by tens to hundreds of degrees. Because they all melt at lower temperatures than their bulk counterparts, nanowires, nanotubes, and nanoparticles all show melting point depression. (Singh, 2020).

It is well known that the size of nanostructures affects their optical characteristics. A semiconductor with a constant optical absorption at shorter wavelengths and an optical band gap of 0.41 eV is bulk lead sulphide (PbS) (Asha &Narain, 2020). The size effect causes changes in electronic and optical properties, which have a substantial impact on macroscopic features like optical band gap, conductivity type, carrier concentrations, electrical resistivity, and device characteristics (Hong, 2019).

A quantum mechanical phenomenon is known as giant magneto resistance (GMR). The thickness and quantity of the alternating layers affect the GMR effect. Induction coils were primarily employed in read-out heads because a shifting magnetic field causes an electric coil to produce a current(Su H et al., 2017). We still utilise induction coils for data storage because, despite rapid developments, this technology has not been able to keep up with the needs of hard drives that are getting smaller. Nanotechnology is the study of thin structures made up entirely of atoms. At this scale, the behaviour of the substance will alter, and the exceptional characteristics of nanoscale structures will set them apart from their bulk counterparts (Su H et al., 2017). GRM is thus one of the intriguing uses of nanotechnology at the nanoscale scale and could be used in future data storage devices. Hard drive size is steadily and quickly shrinking every day(Hong, 2019).

Applications extending from data accumulating to suggestive applications, including clinical imaging, have compared attractive nanoparticles(Hong, 2019). The use of an attractive field restricts these nanoparticles. For example, ferrite nanoparticles smaller than 128 nm exhibit supraparamagneticbehaviour. By modifying the surface of ferrite nanoparticles in a solution with surfactants, or compounds of phosphoric destructive or silicon, it is possible to increase their reliability(Abdel-Karim et al., 2020).

"Mechanical Properties of Nanoparticles" covers the effects of porosity, grain gauge, super versatility, filled polymer composites, and carbon nanotube-based composites. It also covers mass metallic and inventive materials(Singh, 2020). Two materials that cannot be produced through squeezing or sintering have attracted much more notable interest since they will undoubtedly be of contemporary significance. are indeed metals that have been altered by plastic, which exhibit remarkable qualities. In any event, the latter are typically not classified as nanomaterials due to their larger grain gauge(Abdel-Karim et al., 2020). There is an intriguing way that may be utilised to demonstrate the means of evaluation of the electrical stream at a constant applied voltage(Campuzano et al., 2020). The crucial distinction, in this case, is that, as the wire's cross-sectional area shrinks, the increase in electrical conductivity gradually becomes a more moderate advancement that is strongly quantified(Mehrotra, 2016).

BIONANOSENSORS

Sensors are tools that monitor physical qualities like temperature, mass, electrical characteristics, or optical features and create a signal for recording or additional post-processing. With its recent rapid progress, nanotechnology has demonstrated enormous potential in practically all industries(Wu et al., 2020). The nanosensor area has benefited from these advancements for its own growth. Various electronics companies have supported these innovations to suit their requirement for miniaturization. Nanomaterials have been the subject of extensive study over the past two decades for a range of applications, including nanosensors(Holzinger et al., 2014).

This technology has undergone significant advancements. Since there are numerous types of nanosensors accessible today, classification can be challenging. However, there are two main categories in which nanosensors can be put: (1) construction, and (2) application. Nanosensors can be further divided into two types based on structure: Nanooptical sensors Fluorescence's sensitivity is utilised by optical nanosensors for both qualitative and quantitative evaluation. Nanosensors that detect the electrical or chemical characteristics of a particular substance in order to generate a signal are called electrochemical nanosensors. Significant advancements in this type of nanosensor technology have recently occurred(Wu et al., 2015).In the area of biosensor engineering, the most well-known example is the biotin/avidin (or streptavidin) system(Holzinger et al., 2014).

As a result, the biosensors are made up of three components: an electronic device, a signal transducer for translating the binding event into electrical, optical, or thermal signals, and a biorecognition component for identifying the analyte(Wu et al., 2015).

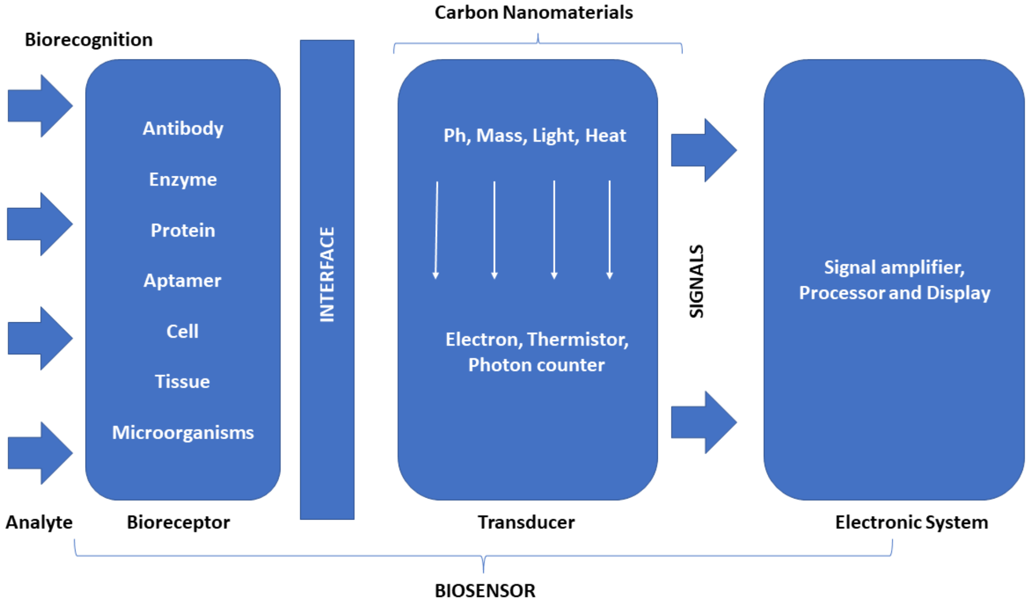

Figure 2: Components of a Biosensor

In the biorecognition procedure, the analyte is selectively linked to the biological recognition molecules. Either physically or chemically immobilising these biomolecules on the sensor substrate is required. In chemical attachment, the transducer surface and bioreceptor covalently connect when the proper chemicals are used(Su H et al., 2017). The transducer should be able to use electrochemical or fluorescent methods to transform the biorecognition events into a quantifiable signal. In many different sectors of application, including medicine, agriculture, food safety, bioprocessing, environmental monitoring, and industrial monitoring, biosensors have played a crucial analytical role(Lahir et al., 2016).

NANOMATERIALS THAT MAKE UP THE BIOSENSORS

The development of new early detection approaches has advanced significantly as a result of the excellent sensitivity and selectivity of biosensors based on nanomaterials. It permits straightforward and quick investigation in vivo because of its submicron dimensions. Their distinctive shape, size, and structure also affect their reactivity, toughness, and other characteristics. Additionally, the use of nanomaterials in biosensors offers various detection simplifies the process by setting limits based on the study data to modify the sensitivity level to suit requirements(Lahir et al., 2016).

Graphdiyne

A brand-new two-dimensional all-carbon allotrope called graphdiyne (GDY) is made up of benzene rings and alkyne units(Khalil et al., 2016).

Carbon-based nanomaterials are commonly used to create electrochemical biosensors due to their unique physical and molecular characteristics.GDY is said to have better carbon chemical bonds than traditional carbon nanomaterials, which are crucial for their practical uses(Khalil et al., 2016). GDY also features a typical 2D layout. When designing sensors, the porous structure of GDY is essential for the efficient transfer of the analyte to the sensor surface(Khalil et al., 2016).

Gold nanostructures

Gold and silver metal nanoparticles (NPs) have become quite popular in nano sensing and diagnostic applications.

Therefore, gold nanoparticles have a greater potential to be effective detection probes due to their simple production, adaptable surface functionalization, and long-term stability(Singh, 2020). Other forms of gold nanoparticles can be used in sensing applications, such as the detection of catechol and bacteria in human kidney infections using gold nanowires and nanocubes, respectively. According to reports, the gold nanorod-based nanosensor offers great selectivity and is very repeatable(Daraee et al., 2016). Additionally, it was stated that the nanosensing platform is dependable, simple, economical, and labor-intensive(Wu et al., 2020). The aspect ratio-tunable nanomaterial has the potential to be utilised in a variety of biomedical applications.

Inorganic novel nanomaterials

Due to their superb structural flexibility and other characteristics, inorganic nanostructured materials have recently received a lot of attention as potential electrode materials for electrochemical sensors. Binary metal oxides, often known as BMOs, are now regarded as one of the most advanced electrocatalyst materials for a variety of electrochemical applications(Javaid et al., 2021). Transition-metal phosphates/phosphides, or TMPs, have garnered the most interest among the many BMO types as a viable electrocatalyst. Electrocatalysts based on -zirconium phosphate (-ZrP) have been acknowledged as being essential for many electrochemical applications. It was successful to identify furazolidone using the sensitive electrochemical sensing probe and ZrP nanoplates(Perdomo et al., 2021).

Nanozymes

Artificial nanomaterials have been proven to be highly stable and inexpensive substitutes for enzymes in electrochemical biosensing over the past ten years due to their comparable qualities to those of enzymes(Noah, 2020).

Nanozymes, which combine the benefits of enzymes and chemical catalysts, outperform natural enzymes because they can typically be produced in large quantities at low cost and with ease and offer powerful catalytic performance with great operational stability. Furthermore, compared to normal enzymes, nanomaterials' smooth surface alterations provide for greater area for adjustments(Campuzano et al., 2020). Additionally, they have tunable and durable catalytic activity due to the inherent nanomaterial characteristics of these materials. The use of bioreceptors makes up for the lack of selectivity in nanozymes. However, it is crucial to be aware that there are currently few bio-ligands available for novel analytes, and that their application might jeopardize the stability and affordability of nanozymes. Nanozymes have been successfully used to create affinity ligand-based electrochemical biosensors, which offer a number of great advantages including better signal readout, reduced cost, higher selectivity, and sensitivity(Campuzano et al., 2020).

Hybrid nanocomposites

A brand-new and optimistic class of hybrid sensing probes called hybrid sensing materials has been developed. These materials are organised by the interaction of organic molecules with inorganic supports. In comparison to other hybrid materials like polymer, titania, and self-assembled monolayers, magnetic silica hybrid offers advantages including low toxicity, easy separation by durability, biocompatibility, thermal stability, and an external magnetic field (Noah, 2020). Environmental monitoring, forensic research, water characterization testing, defence and the food industry, biomedicine, defence, and medical diagnosis are a few examples of the diverse applications of biosensors.

Magnetic silica hybrids have been described as sensing devices that use surface-enhanced raman spectroscopy (SERS), electrochemistry, colorimetry, and fluorescence. One of the finest materials for molecular catalysts is inorganic mesoporous material because of its thermal stability, ease of production, and adaptability(Campuzano et al., 2020). It is employed in physicochemistry, electronics, and biomedicine. Thecharacteristics allow for the development of "electronic wires," which enhance the transmission of electrons between redox centres and electrode surfaces in proteins (Noah, 2020).

DNA nanomaterials

The widespread use of DNA nanoparticles in bioassays is a result of their hopeful potential for the sensitive and precise detection of biomolecules. Due to the electrochemical biosensor's high sensitivity, simple controllability, and cheap cost, it has attracted more attention in clinical diagnosis(Mokhtarzadeh et al., 2017). Due to this, it is still necessary to think about using an electrochemical platform for biomolecular identification and signal amplification to find miRNAs. Numerous nucleic acid nanostructures, such as DNA dendrimers, DNA gels, and DNA tetrahedrons, have been used for biological detection in recent years. As a continuous nanostructure with exceptional selectivity, Y-shaped DNA (Y-DNA) offers a reliable way to completely measure target molecules(Mokhtarzadeh et al., 2017). Three oligonucleotides that are partially hybridised to one another make up Y-DNA. Some older biosensors used this capability to identify DNA by adding target DNA to a DNA strand that is fixed to the surface, followed by another DNA stand, to create the desired structure (Chao et al., 2016).

In addition to rolling circle amplification, strand displacement amplification, catalytic hairpin assembly, and hybridization chain reaction are some of the signal amplification methods that have been developed (RCA). The two hairpin sensors can continue to hybridise independently once they have been activated (Mokhtarzadeh et al., 2017).

DNAzyme

A multitude of processes can be catalysed by DNAzymes, single-stranded DNA sequences, includingribonucleotide or deoxyribonucleotide spot, phosphodiester backbone cleavage. Metal ions have been shown to be essential for the bulk of known DNAzymes' catalytic activity and to be involved significantly in the catalytic process(Gong et al., 2015).

DNAzymes are the new metal ion sensing technologies that have an ideal metal-selective components for because it is possible to choose a DNAzyme with metal ion specific activity without prior chemical knowledge of the DNAzyme structure (Hu et al., 2020). A particularly helpful biomaterial for measuring metal ions is an RNA-cleaving DNAzyme, but it is difficult to distinguish between various metal ion concentrations because some DNAzymes can be cleaved by numerous metal ions. The fast development of nanomaterials and biomaterials over the past two decades has increased the possibilities for enhancing electrochemical sensor performance (Hu et al., 2020).

A minuscule ion called Cu(II) needs to be chelated before it can attach to an antibody. The ideal physiological parameters for both antibodies and enzymes limit their use in actual environments(Chao et al., 2016). DNA is a great biological functional substance in addition to being the genetic makeup of the majority of living things. This technique is used to detect metal ions. Single-stranded DNA can selectively bind with metal ions to create a stable metal-mediated DNA. Because of this, several investigations have concentrated on the recently developed biosensor that uses various DNA-based aptamers with nanoparticles added to increase sensitivity (Hu et al., 2020). Through in vitro selection, the generation of DNA-based enzymes that break down RNA has been shown to be a very useful platform for the detection of metal ions. After interacting with heavy metal ions, DNAzymes have been the focus of numerous biochemical and biophysical investigations because of their high catalytic efficiency and high metal ion selectivity (Chao et al., 2016).

Carbon nanodots

Nanomaterials with a size of less than 10 nm called carbon dots (CDs) have emerged as a new possible electrode modifier material. CDs have previously been used in electrochemical sensing systems, with the emphasis being more on their electrocatalytic capabilities toward target analytes than on electrode modifications. In order to boost the electrochemical sensor's sensitivity, it has been used to conduct study on carbon dots that have a significant potential for use as electrode modifiers in electrochemical techniques. (Garg & Bisht, 2016).

A novel CD member has recently gained attention due to their strong luminescence, fine characteristics, minimal cytotoxicity, and excellent conductivity. It is easier to immobilise biomolecules using CNDs because they are surrounded by a range of functional groups, such as hydroxyl, amide groups, and carboxyl, depending on the precursors used in theirproduction (Eivazzadeh-Keihan et al., 2022). Therefore, CNDs have been used in various biological applications, including the construction of solar cells and photocatalysis, due to their versatility in being changed with a wide range of biomolecules and in combination with the great qualities indicated above. Despite the benefits already indicated, there have been very few recorded when it comes to the use of electrodes, efforts to incorporate CNDs of CNDs for electrochemical biosensors. This nanomaterial's electrocatalytic properties for oxygen reduction, biomedical uses, including glucose biosensing and DNA sensing, are the main focus of reports on the use of CNDs in electrochemical sensors(Garg & Bisht, 2016).

Nanodiamonds

Due to their unique physical and chemical characteristics, nanodiamonds (ND), a novel member of the carbon nanoparticle family, have recently attracted a lot of attention in the fields of drug delivery, bio-imaging, and biosensor applications. Due to its many functional groups, nanodiamond (ND) is crucial in many fields of material science. (Zhang et al., 2014). An electrochemical detector will be used to determine the amino acids in Parkia seeds, made of copper, nanodiamonds, and carbon nanotubes was constructed (PS). With composite electrodes made with nanodiamond, PS was electrochemically reacted(Zhang et al., 2014).

Magnetic nanoparticles

High surface areas and a biocompatible environment are provided by nanomaterials for enzyme loading. Due to their ease of separation in solutions, magnetic particles have been used in numerous nano-sensing devices during the past ten years as a consequence of study(Wu et al., 2019).

Due to their electroconductivity, biocompatibility, and ease of synthesis, a variety of iron magnetic nanoparticles (MNPs) have demonstrated to be an excellent nanomaterial for electrochemical biosensing applications. They greatly advance electrochemical nanobiosensor development. Researchers have looked into iron and iron oxide nanoparticles as components of biosensing that enhance signals(Hong, 2019). Magnetite (Fe3O4), a complex oxide of Fe2+ and Fe3+, is one of these minerals and one of the most researched nanocrystals that are highly paramagnetic. It possesses special mechanical and physical properties at the mesoscopic scale and a wide range of possible applications, including microwave absorption and cell separation. For in vivo testing, Fe3O4 nanoparticles have been employed extensively. The attachment that is directforcholesterol oxidase to Fe3O4 magnetic nanoparticles as well as the kinetic behaviour, stability, and activity of bound cholesterol were investigated(Zhang et al., 2014). A wide linear range, excellent sensitivity, and quick response were all displayed by prepared biosensors. For the first time, Fe3O4 - Au nanoparticles were used successfully throughout the dual-mode recognition of carcino embryonic antigens (CEA) and satisfactorily validated the antigens' existence(Wu et al., 2019).

APPLICATIONS ON BIONANOSENSORS

Several sectors, including the food industry, the medical field, the marine industry, and others use biosensors. They offer more stability and sensitivity when compared to conventional approaches. Biosensors are employed in the management of psychiatric and diagnosis patient diagnoses, patient health monitoring, farming experimentation, forensic and biomedical testing, and water quality control(Welch et al., 2021). Historically, glucose biosensors in the medical industry have focused on controlling diabetes. Blood glucose levels, which continue to be an important indicator of diabetes, are streamlined using biosensors as well. Biosensors are still very significant since they enable individuals to control the goal blood sugar levels and assess the disease's ecological effects. Biosensors can identify diseases more quickly and track patients' conditions in addition to providing healthcare and therapy(Holzinger et al., 2014).

The many manufacturing industries, particularly those that provide medical, healthcare, or clinical services, are where biosensors found their best uses. Applications for biosensors include the detection of diseases, retinal prostheses, contrast MRI imaging, cardiac diagnosis, medical mycology, health tracking, and other significant elements or broadly categorised areas (Perdomo et al., 2021).

With their extensive capacities and top-notch social services, these capabilities raise healthcare to new heights. The most recent pandemic COVID-19 is extremely contagious and is brought on by a coronavirus that has been widely distributed worldwide (Mokhtarzadeh et al., 2017). Additional infectious diseases that have received a lot of focus recently include avian flu, SARS, Hendra, Nipah, etc. Therefore, biosensors have the ability and huge potential to detect the spread of any illness or virus. The biosensor's capacity to diagnose heart conditions is another important feature. With about 17 million deaths each year, cardiovascular illnesses are regarded as the leading cause of death worldwide. The development of cardiovascular disease diagnostics has been greatly aided by biosensors that use biomarkers(Mokhtarzadeh et al., 2017). For the accurate diagnosis of cardiac disorders, it is essential to design and develop extremely sensitive and specific biosensors using practical surface chemistries and nonmaterial. g. Blood glucose may now be monitored over a wide range of temperature concentrations even in the presence of multiple interfering chemicals thanks to advancements in biosensor technology. The market demand will rise in the upcoming years as a result of the increasing sensitivity and accuracy of biosensors within a tiny sample volume. Portable electronic devices have a huge amount of potential for surveillance, therapy, diagnosis, fitness, and well-being, and they have a major impact on the entire healthcare system (Eivazzadeh-Keihan et al., 2022). The factors driving market expansion include ongoing technological advancements and an increase in the use of biosensors in a variety of applications. Wearable biosensors have improved the standard of living. Wearable technology also lessens the financial burden of medical care. Expanding senior populations and rising youth interest in wearable technology would therefore create new segment prospects. Using biosensors is a great technique to recognise diseases, find hazardous bacteria, human, and environmental substances(Sharma et al., 2021).

Experts in medicine and biotechnology have focused on finding and comprehending diseases over the years. Recent advances in fundamental and clinical science have been made possible by the discovery of biomarkers at low concentrations and their prognosticative role in the onset and diagnosis of disease. Technology will be required for the identification of extremely precise, precise, quantitative, and multiplexed biomarkers(Topkaya et al., 2016). Electrochemical biosensors are utilised in cancer research to provide faster and more precise diagnosis. Optical transducer biosensors can capture changes in light that take place during the study and interaction of biological elements(Topkaya et al., 2016). This interesting feature is explained by the biological mechanism employed to identify the target molecule. High fundamental features are typically present in biological interactions such the binding of antibodies to antigens, the processing of a substrate by an enzyme, or the joining of two extra DNA strands. To prevent hyperglycemia, people with diabetes can control the amount of glucose in their homes. The biosensor equipment is mounted in a transportable unit, and medical professionals determine that the patient has an acute myocardial infarction(Topkaya et al., 2016).

Today, portable devices routinely incorporate biosensors for point-of-care monitoring. Biosensors can be found in devices that measure glucose, addiction, pregnancy, and many other things. To track and keep an eye on the joints' articular movementduring other healthful pursuits, several researchers have used biosensors(Haleem et al., 2021). Using a blood pressure monitor at home is one of the safest ways to maintain good health. Implantable biosensors have the potential to revolutionise patient care and the treatment of diseases, but there are still technological issues to be overcome and validated biomarkers to be developed. Implantable biosensor chips may hold great potential for the development of specialised medications. Due to their widespread use in healthcare applications, soft pressure sensors are essential(Mehrotra, 2016). Energy-harvesting hardware contains the main technologies that will enable the development of the next wave of biosensors. New medical diagnostics and tracking systems are now possible thanks to the low cost, comparatively straightforward production techniques, and tiny sensors. Health care providers find it particularly tempting because it lowers the possibility of contamination and the price of sterilising medical equipment. Because they are more suitable with the corporal curvature, flexible sensors are also advantageous from the perspective of the patient(Haleem et al., 2021).

Many biomarkers are now accepted for use in the medical and non-technological sectors, including myoglobin, B-type natriuretic peptide (BNP), cardiac troponin I (cTnI), C-reactive protein (CRP), interleukins, and interferons. These cardiac signature biomarkers made use of a variety of biosensor technologies, including magnetic, optical, acoustic, and electrochemical ones(Javaid et al., 2021). These diagnostic biosensors have uses in a variety of categories for allied and cardiovascular care services. Some of the biosensors used for the aforementioned uses include the cardiac marker system, stratus, alpha, and the triage cartridge. With readout periods ranging from 10 to 18 minutes, these biosensors use fluorescent microfluidics, machine analysis, disc readers, and tabletop readers. Modern modelling and forecasting methods for clinical use, including cardiac disorders, have been made possible by the creation of artificial intelligence (AI), which has opened up new areas and resources for bioscience(Kamel & A. Khattab, 2020).

Some of the approaches used to create unique uses in healthcare include optical, spinit, piezoelectric, etc. In inflammatory response research, uses for the treatment of human malignant tumours, breast and prostate cancer, and other diseases, these conceptualised biosensors were found to be effective(Topkaya et al., 2016). The main characteristics of complex biosensor applications are detecting antibodies, locating tumours, analysing volume, performing fast and precise detections, etc. Biosensors have the benefits of quicker detection and higher sensitivity. They are able to specifically differentiate between tumour cells and normal cells and have achieved targeted detection of localised tumour cells as well as circulating tumour cells. Therefore, there is a lot of promise for the application of biosensors in the identification and monitoring of cancer(Topkaya et al., 2016). Biosensors are also used to analyse biomolecular interactions because they can assess the affinities and kinetics for a broad range of molecular interactions in real time without the need for molecular labels or marks. The fastest growth has been seen in non-wearable biosensors over the anticipated time period. These are a popular substitute for scientific analysis since they are affordable and use little test media to produce valid findings. In addition, biosensors have excellent sensitivity, which produces accurate performance. Even biosensors have been created in the lab and integrated into mobile applications(Mehrotra, 2016).

CONCLUSION AND FUTURE RECOMMENDATIONS

Research on nanomaterials has advanced quickly over the past few years, and some of their prospective uses have already been realised. It is anticipated that one of the important technologies in the near future would be made possible by nanomaterials. The various nanomaterials that have been created so far represent a specific class of materials with distinctive features. This topic has a wide range of uses, from additives for solid rocket propulsion to the usage of nanoparticles in cosmetics. Biosensors are a rapidly developing technology that has both technical and practical applications. Therefore, the balance between technology's continually expanding boundaries and its benefits, which are becoming more tangible, varied, and in line with society demands, will determine how far it can go. The toxicity of nanomaterials is a critical problem that cannot be disregarded as nanotechnology develops. Nanotechnologists must continue to pay attention to these areas. For the full realisation of nanotechnology applications, these issues must be effectively resolved. A new breed of biosensors should be developed by utilising cutting-edge features and future studies should focus on elucidating the mechanism of interaction between nanomaterials and biomolecules on the surface of electrodes or nanofilms. Significant advancements must be made in surface functionalization techniques, assembly methods to minimise defects, and the growth of such materials (e.g., lower temperature, pressure, etc.) in order to increase the sensitivity, selectivity, and reproducibility of these nanomaterials for sensing uses. In order to control nanostructure size, crystal faces, and layer thicknesses, extra processes are required because high surface area materials are highly desired for sensing uses. These mechanisms could result in brand-new findings, unique material traits, surface functionalities, and a wide range of cutting-edge sensing techniques and applications.

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