VITALITY OF ELECTRODES IN THE MODERN ERA

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Abstract

A conductor or semiconductor that directly contacts the electrolyte solution is called an electrode. An electrode is used to realize both the input and the output in an electrochemical system. Noble metals (platinum, gold, silver, etc.), mercury, various types of carbon materials, and semiconductor materials are some of the substrate materials for regularly used electrodes.

Keywords: Electrode, Polymer, conductor, etc.,

Mercury Electrodes

A traditional electrode material is mercury. The cathodic potential window can be extended with a strong hydrogen overvoltage. Mercury electrodes, on the other hand, have a flat surface that is extremely repeatable, renewable, and helpful in electrochemical investigation. As a result, several types of mercury electrodes, such as mercury film electrodes and electrodes that drop mercury have been developed [1].

The falling mercury electrode is the type of mercury electrode that is most frequently employed. The primary benefit of using a mercury electrode is that it can be self-renewing, eliminating the requirement for maintenance prior to each experiment. Furthermore, the surface of every mercury drop is uniformly clean. However, the application of the dropping mercury electrode and the other mercury electrodes in the study for biologic species has been constrained by the toxicity of mercury and the constrained anodic range.

Metal Electrodes

Platinum, gold, and silver have all been utilized extensively as electrode substrates. Noble metal electrodes can provide a broad anodic potential range and extremely favorable electron transfer kinetics. Other metals have also been used as electrode substrates in addition to noble metal electrodes. Additionally, alloy electrodes with bifunctional catalytic mechanisms, such as platinum-ruthenium and nickel-titanium electrodes, have been identified and are frequently utilized in the construction of fuel cells [2].

Carbon Electrodes

Various electrodes have been created using a range of carbon-based compounds as electrode substrates. These electrode surfaces can be easily renewed for electron exchange because of the soft characteristics of carbon. Broad potential window, low background current, rich surface chemistry, and comparative chemical inertness are other characteristics of carbon materials.

Carbon-based materials are also relatively inexpensive. As a result, carbon electrodes are frequently utilized nowadays. Pyrolytic graphite electrodes (PGE), glassy carbon electrodes (GCE), carbon paste electrodes, carbon fibre electrodes, and electrodes made of carbon composites are some of the frequently used carbon electrodes [3].

Conducting Polymer–Modified Electrodes

Organic polymers with metallic conductivity or semiconductor characteristics are referred to as conducting polymers. Various well-characterized and ordered conducting polymers have been used since the discovery of high conductivity in doped polyacetylene in 1977 [4]. As a result, various conducting polymer-modified electrodes have been created for the investigation of proteins and cells.

Conducting polymer-modified electrodes have various benefits. One the one hand, non-aqueous mediums with high activity can support the functioning of the majority of proteins [5]. The electrochemical measurements of analysis for proteins and cells can be made easier by conducting polymers, which often have electronic states that can be reversibly occupied and emptied with electrochemical procedures [6].

Chemically Modified Electrodes

Proteins under study are frequently immobilized on the surface of an electrode in research studies. However, the conformational shift caused by this immobilization process could denaturalize most proteins, which could have an impact on future protein analyses. Because of this, bare electrodes are not the best interfaces for obtaining direct electrochemistry of the majority of proteins; therefore, CMEs are being created to help.

CMEs first appeared in 1973 after Lane and Hubbard used chemisorption to modify several olefin molecules on a pristine platinum electrode, which drastically altered the electrode's electrochemical response [7].

Self-Assembly Monolayers

Self-assembly is a phrase used to describe processes in which a collection of spatially disorganised objects arranges itself through small-scale interactions. Ionic, covalent, metallic, and weak interactions (such as hydrogen bonds, van der Waals forces, and π–π interactions) are among the interactions.

The assembling system can't stand alone. It needs a strong foundation, thus an electrode is a great support that can also serve other purposes. SAM has many benefits. The monolayer is chemically stable and biocompatible for electrochemical examination, for instance, and the production of a SAM only necessitates a straightforward method [8].

Mediator-Modified Electrodes

A appropriate electron transfer mediator can speed up redox processes on the surface of an electrode [9]. The following benefits of mediator-modified electrodes over naked electrodes are listed.

First off, it can lower the analyte's overpotential and any potential background current interference. Second, by improving the current signal's responsiveness, a lower detection limit can be attained. Thirdly, it is possible to avoid product and analyte adsorption. As a result, by utilizing electrodes designed to hold mediators, the analyses' sensitivity and selectivity can be considerably increased.

Nanomaterial-Modified Electrodes

Nanomaterials have at least one dimension that is between 1 and 100 nm in size . They have distinct geometrical, mechanical, electrical, chemical, as well as quantum, surface, and other macroscopic-materials-unique features, such as the influence of small size, surface tension, etc. The wide spectrum of uses for nanomaterials in medicine, electronics, biomaterials, environmental science, energy production, and biosensors has been strongly influenced by these features.

Electrodes made of nanomaterials provide a number of benefits over electrodes made of conventional materials. First off, nanoparticles provide a significant amount of surface area that can be used to immobilize more useful molecules on electrodes. Second, some semiconductor nanomaterials might encourage electrochemical interactions by increasing the pace at which electrons move from electrodes to proteins. Thirdly, certain biocompatible nanomaterials can support cells or proteins in continuing to function on an electrode for an extended amount of time [10].

In order to undertake electrochemical analysis, a number of nanomaterials have been synthesised and characterised. Metal nanomaterials, particularly gold nanoparticles (AuNPs), metallic oxide/sulfide nanomaterials, carbon nanotubes (CNTs), particularly multiwalled carbon nanotubes (MWCNTs), and graphene are some of the frequently used nanomaterials.

Conclusion

Electrodes are mostly used to create electrical current and transfer it through non-metal things to essentially change them in various ways. Conductivity can also be measured using electrodes. Other applications for electrodes include electroplating, electrolysis, welding, cathodic protection, membrane electrode assembly, chemical analysis, and Taser electroshock weapons, to name a few. Electrodes are also utilised in defibrillators, electroconvulsive therapy, and other medical devices. In biomedical research, electrodes are also employed for electrophysiological methods.

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