MODERN ELECTRODE SYSTEMS FOR VOLTAMMETRIC DETERMINATION

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Introduction. Voltamperometric methods is a group of electrochemical methods, that are widely used in quantitative and qualitative analysis of substances, including medicinal, in a wide range of concentrations. Some inverted variants of voltammetry allow to obtain the lower limits of concentration of the substance at 10^{-9}-10^{-11} M. The method of amperometric titration is included in the first edition of the State Pharmacopoeia of Ukraine (SPhU).

Aim. The aim of our study was to research a wide variety and the attempt to make a classification of modern of electrode systems that are used for voltamperometric determination.

Materials and methods. Before 40s of the 20th century theoretical electrochemistry was developed mainly as an electrochemistry of the mercury electrode. In 1942 a famous scientist from Kharkiv V.G. Levich, one of the student of the L.D. Landau group, mentioned, that rotating disk electrode (RDE) differs from the others, as its surface is equally accessible in a diffusion ratio. This feature makes RDE be a unique tool for electrochemical researches over solid electrodes, because it allows to research fast electrochemical reactions. The amount of electrons that are involved in a reaction can be determined using the rotating disk electrode, that is important for establishing the mechanism of the reactions that involve organic substances. If the coefficient of diffusion of a reacting substance is known, the amount of electrons can be determined by the value of the current diffusion limit.

As the current diffusion limit on the rotational disk electrode is proportional to the concentration of the substance, thus the electrode can be used for analytical purposes. Rotational disk can be made of any solid conductive material, such as precious metals or glassy carbon that are stable at anode area and give the opportunity to research the potential anodic processes.

In 1952 the first edition of the monograph "Physicochemical hydrodynamics" was published by V.G. Levich that had been reissued in 1959. In 1958 two remarkable scientists A.N. Frumkin and L.N. Nekrasov suggested a method of the ring-disk electrode. The monograph “Rotating ring-disk electrode” by M. P. Tarasevich, E. I. Hrusheva, V. Yu. Filinovsky was published in 1987.

Three types of electrodes – an indicator (working) electrode, a reference electrode and a counter electrode – classification of the electrodes by their functions are typically used in electrolyzers for measurements. The main characteristic feature for the counter electrode is a bigger surface, compared to the indicator one. Platinum, glassy carbon and graphite are the materials that are often used for a counter electrode.

One of the most important classifications of the electrodes is by the material it’s made of. Inert electrodes that are used as a reference or a counter usually are metallic, carbon-

bearing or composite. Among metallic there are specific advantages and disadvantages that some metals have, for example mercury and a group of precious metals (such as gold, platinum, silver and others) and basic metals. Among carbon-bearing graphite, glassy carbon, pyrographite, carbositall, from carbon fiber and diamond electrodes are often used.

Composite electrodes consist of a dispersed phase and liquid medium such as carbon paste electrodes and epoxy resins or polymer - solid paste electrodes.

Saturated calomel, potassium chloride and silver chloride electrodes are often used in analytical practice as reference electrodes. A lot of efforts to increase sensitivity, selectivity and reproducibility of voltammetric measurements and attempts to avoid the toxicity of metallic mercury led to the creation of so-called disposable electrodes.

In the late 20^{th} century a huge interest was attracted to the creation of screen-printed electrodes that were printed on polymer or ceramic tapes on inkjet printer, while the dye had a trace of particles of carbon-bearing materials, silver and etc.

Results and discussion. Recently the creation of a new generation of electrodes is connected with works that are based on modifications of the electrode surface. In this case, the surface is covered with a chemical substance in a one or a few layers, polymer membrane or oxides formed of the electrode material. As a result, the ability of the electrode for voltampermetric response changes with the introduction of new specific properties. Specificity or selectivity response of the electrode increases greatly. The most important results of these studies were summarized and presented in the publication "Modified electrodes for voltamperometry in chemistry, biology and medicine" by G. K. Budnikov, G. A. Evtyugin, V. N. Maystrenko.

Currently, the amperometric biosensors are widely used as enzyme biosensors in medicine, environmental and analytical control, DNA sensors, imunosensory, microbial fabric, and sensors, and so on. Inorganic ions and organic compounds, biologically active compounds that are used in HPLC, flow-injection analysis, capillary zone electrophoresis, the microfluidic systems with electrochemical detection as gas detectors and others are determined using modified electrodes.

Another perspective direction of research is a creation of the ultra-micro electrodes. These electrodes are based on nanocomposites, nanostructures and nanoparticles. The invention of micro electrodes allows to analyze very small volumes, also making analysis possible in vivo – in a single cell of biological organism.

Conclusions. Thus, we can assume that electrochemical analysis and voltammetric methods is an important tool than can solve many problems of common chemistry, pharmaceutical, biochemical, environmental, toxicological analysis. The future pharmacist, analyst and researcher should master this powerful arsenal of modern methods of electrode systems.