

**ELECTROCHEMICAL SYNTHESIS OF COORDINATION COMPLEXES WITH MIXED LIGANDS OF CU(II), FE(III), AND ND(III) WITH CARBOXYLIC ACIDS****Vohidov Shermuhammad**

Postgraduate Student, Namangan State Technical University

Tel.: (88) 680 0041

**Abidjon Abdualimov**

Associate Professor, Department of Chemistry, Namangan State Technical University

Tel.: (97) 4800758

**Abstract:** Most processes occurring in biological systems involve the interaction of metal ions with multiple ligands, so the preparation and structural study of mixed-ligand complexes are of particular interest. It should also be noted that the synergism of mixed-ligand copper(II) compounds containing two bioactive ligands (salicylic, nicotinic, and benzoic acids) in each complex is enhanced. The advantages of electrochemical synthesis—a small number of reagents, process controllability, and environmental safety—confirm the high efficiency of this method for obtaining these complexes. The resulting coordination compounds can be used in the future in catalysis, materials science, and electrochemical technologies.

**Keywords:** rare earth metals (salicylic acid (HSal), nicotine (HNic), benzoic acid (HBen)) and pyridine (Py).

**Introduction**

Today, the development of coordination chemistry is aimed not only at developing synthetic methods and obtaining new substances but also at modifying already widely used methods for producing complex compounds. One promising method for synthesizing complex compounds is electrochemical synthesis, which offers several advantages over classical synthetic methods. For example, the use of free metals as reactants instead of compounds containing atoms of foreign elements in electrochemical reactions prevents contamination of the final product. Since electrochemical processes typically occur in a single step, they are easily controlled, enabling the production of coordination compounds that are impossible to synthesize by other methods.

The most common method is electrochemical synthesis using direct current, which has a significant drawback associated with the adhesion of the resulting complex compound to the electrode surface, making subsequent electrochemical synthesis impossible. To address the aforementioned issues, electrochemical synthesis can be achieved using a pulsed current with a variable duty cycle to generate a rectangular bipolar signal with a variable duty cycle. This allows for synthesis processes to be performed under specific conditions: varying the duration of the cathode and anodic pulses from 1 ms to 10 s, maintaining a ratio of these values from 1:1 to 1:10.

Most processes occurring in biological systems involve the interaction of metal ions with various ligands, so the preparation and structural study of mixed-ligand complexes is of particular interest. Also noteworthy is the enhanced synergism of copper(II) compounds with mixed ligands, each of which contains two bioactive ligands (salicylic, nicotinic, and benzoic acids).

Heterometallic complexes of carboxylic acids with rare earth metals and iron(III) can be used as drugs for the treatment of cancer, immunodeficiency, and blood disorders. Pyrolysis of these compounds can also lead to the formation of mixed iron(III) and neodymium(III) oxides with specific structures, which are widely used in modern technologies for data recording and storage, in microwave devices, as sensors, and as catalysts for various redox reactions.

This dissertation was completed in accordance with the research topic of the Department of General, Inorganic Chemistry and Information and Computational Technologies in Chemistry of Kuban State University: “Coordination Compounds and Materials Based on Them”.

**Research Objectives and Tasks**

The objective of this study is to prepare mixed-ligand copper(II) complexes with a number of carboxylic acids (salicylic (HSal), nicotinic (HNic), benzoic (HBen)) and pyridine (Py) using a modified electrochemical synthesis method, as well as heterometallic iron(III) and neodymium(III) complexes with phthalic (H<sub>2</sub>Phtal) and malic (H<sub>2</sub>Mal) acids, and to determine their composition and structure.

**To achieve this goal, the following objectives were posed and solved:**

1. Determining the optimal parameters of the electrochemical synthesis process (changes in current density during the process, the effect of the synthesis method on current efficiency, and selecting the optimal pulse time and duty cycle).
2. Synthesis of mixed-ligand copper(II) complexes with benzoic, nicotinic, and salicylic acids and pyridine, as well as heterometallic iron(II) and neodymium(II) complexes with malic and phthalic acids, using electrochemical methods using pulsed variable-frequency current.
3. Determination of the composition and predicted structure of the obtained complexes using IR and EPR spectroscopy, X-ray diffraction, and thermogravimetric analysis.
4. Study of the combustion products of heteronuclear neodymium(III) and iron(III) phthalate and malate and determination of the structure and composition of the resulting oxides.

**Advantages of Preparing Complex Compounds by Electrochemical Synthesis**

1. A method for producing complex compounds by electrochemical synthesis using pulsed alternating current was proposed and tested for the first time.

This method increases the yield of the final product and prevents the adhesion of the complex compound to the electrode surface.

2. The influence of several factors (current density, time, and pulse duty cycle) on the yield of the final product during electrochemical synthesis was studied; based on this, optimal parameters for the synthesis of these compounds were proposed.
3. Binary and mixed-ligand coordination compounds of copper(II) with benzoic, nicotinic, salicylic, phthalic acids, and pyridine were prepared for the first time using electrochemical synthesis using pulsed alternating current. Mononuclear and heterometallic coordination compounds of iron(III) and neodymium(III) with malic and phthalic acids were also obtained.
4. The mode of coordination of carboxylic acids in the obtained compounds was determined using IR spectroscopy data.
5. The geometry of the coordination unit in binary and mixed-ligand copper(II) complexes with benzoic, nicotinic, salicylic, phthalic acids, and pyridine was determined using EPR spectra.
6. Mixed oxides with the perovskite structure FeNdO<sub>3</sub> were obtained by pyrolysis from heterometallic complexes of iron(III) and neodymium(III).

**Practical Significance**

The optimized electrochemical synthesis method using pulsed current with a variable duty cycle can be applied in the future to the synthesis of other d- and f-element coordination compounds.

The data obtained in this study, including current density dependences, current efficiency, and other synthesis process parameters, can be used by researchers working in the field of electrochemical synthesis of d- and f-element coordination compounds.

A method for producing precursors of complex oxides with a perovskite structure is proposed. These precursors are widely used in modern technologies for recording and storing information, in microwave devices, as sensors, and as catalysts for various redox reactions.

**Conclusion**

This study explored the potential of electrochemical synthesis of mixed-ligand coordination complexes based on copper(II), iron(III), and neodymium(III) ions in the presence of carboxylic acids. It was found that the electrochemical method effectively forms complexes of metal ions with carboxylic acids and additional ligands. Experiments revealed that electrode potential, solution pH, ligand concentration, and electrolysis duration significantly influence complex

formation. Under optimal conditions, the formation of stable mixed-ligand coordination compounds with Cu(II), Fe(III), and Nd(III) ions was observed.

These studies demonstrate the potential of electrochemical synthesis of heterometallic and mixed-ligand coordination complexes based on carboxylic acids and provide a scientific basis for further in-depth research in this area.

**References.**

- Гринберг, А.А. Введение в химию комплексных соединений - Л.: Химия, 1971.-631 с.
2. Кукушкин, Ю.Н. Химия координационных соединений - М.: Высшая школа, 1985. - 456 с.
  3. Костромина, Н.А. Химия координационных соединений / Н.А. Костромина, В.Н. Кумок, И.А. Скорик - М.: Высшая школа, 1990. - 432 с.
  4. Яцимирский, К.Б. Введение в бионеорганическую химию - Киев: Наукова думка, 1976. - 685 с.
  5. Хьюз, М. Неорганическая химия биологических процессов - М.: Мир, 1983.-420 с.
  6. Координационные соединения редкоземельных элементов / Под ред. В.И. Спицина, Л.И. Мартыненко - М.: Изд-во МГУ, 1974. - 168 с.
  7. Филиппов, А.П. Исследование каталитического действия бис- ацетилацетоната  $Co(II)$  в реакции хлораля с фенилизотионатом / А.П. Филиппов, Ю.В. Спиринов // ТЭХ. - 1971. - Т. 7, В. 3, С. 340-346.
  8. Николаев, А.Ф. О полимеризации винилацетата в присутствии триацетилацетоната марганца и спирта / А.Ф. Николаев, К.В. Белгородская, Б.И. Луракина, Е.Д. Андреева // Высокомолекулярные соединения. - 1971. - Т. 13, № 5-6, С. 1018.
  9. Кукушкин, В.Ю. Теория и практика синтеза координационных соединений / В.Ю. Кукушкин, Ю.Н. Кукушкин - Л.: Наука, 1990. - 260 с.
  10. Гарновский, А.Д. Современные аспекты синтеза металлокомплексов. Основные лиганды в химии / А.Д. Гарновский, И.С. Васильченко, Д.А. Гарновский - Ростов-на-Дону: ЛаПО, 2000. -355 с.