# ANNOTATION

**for the degree dissertations on the topic "Synthesis of pectin and its application in the creation of organo-inorganic enterosorbents and metal-polymer catalysts" for the degree of Doctor of Philosophy (PhD) in the educational program 8D05301 -"Chemistry"**
**by Sandugash Nurbolkyzy Akhmetova**

**Research topic:** "Synthesis of pectin and its application in the creation of organo-inorganic enterosorbents and metal-polymer catalysts".

**The purpose of the study is to:** The aim of the study is to optimize the conditions for microwave extraction of pectin from domestic plant raw materials and to create organo-inorganic composites based on it for use as enterosorbents and catalysts for low-temperature hydrogenation and oxidation processes.

**Research objectives:**

1.Determination of the optimal conditions for pectin extraction from plant raw materials (sugar beet pulp, apple pomace) using microwave treatment;

2.Preparation and characterization of organo-inorganic composites based on isolated pectin and montmorillonite, as well as investigation of their sorption and protective properties in experiments on rats under lead ion intoxication and with the use of acetylsalicylic acid;

3.Synthesis of copper, cobalt, nickel, palladium, and palladium-silver catalysts based on pectin-inorganic composites and investigation of their catalytic properties in low-temperature hydrogenation of unsaturated compounds (2-propen-1-ol, phenylacetylene);

4.Synthesis of nickel, copper, and cobalt catalysts based on pectin/inorganic composites and their testing in liquid-phase oxidation of alkanes (cyclohexane, n-octane) with hydrogen peroxide.

**Research methods:** The studies were carried out using established scientific and experimental methods. The results were confirmed by a set of physicochemical analytical techniques on modern instruments: a gas chromatograph “Chromos GX-1000” with a flame-ionization detector, a Nicolet iS5 FT-IR spectrometer, a scanning electron microscope Jeol JSM-6610LV, a transmission electron microscope Jeol JEM-2100, an X-ray diffractometer DRON-4-0.7 using cobalt-monochromatized Kα radiation, a spectrophotometer SF-2000, and a thermogravimetric analyzer Labsys Evo (Setaram, France). The biological properties of the developed composites were investigated by staff of the RSE on PHS “Institute of Physiology of Humans and Animals, MES RK”. The activity, selectivity, and stability of the catalysts were studied using hydrogenation and oxidation catalytic setups in the Laboratory of Organic Catalysis of «D.V.Sokolsky Institute of Fuel, Catalysis and Electrochemistry» JSC.

**The main provisions (proven scientific hypotheses and other conclusions that are new knowledge) submitted for defense:**

1.The influence of microwave extraction conditions on the yield and quality characteristics of pectin (degree of esterification and uronic acid content) obtained from domestic plant raw materials (apple and sugar beet pulp) was demonstrated. The optimal microwave extraction parameters were: power - 520 W, pH - 2.0, extraction time for sugar beet pectin - 8 min, for apple pectin - 6 min, and the mass ratio of plant material to extractant - 10:150. The maximum pectin yield was obtained from apple pomace and amounted to 18.3%. The quality indicators of the obtained pectin, such as degree of esterification and uronic acid content, reached 39.3 % and 60.6 %, respectively.

2.The properties of pectin-montmorillonite composites, including sorption activity and protective effect, were studied in experiments on rats under lead ion intoxication and with the use of acetylsalicylic acid. It was established that the composite containing 10 % pectin was most effective in promoting the elimination of lead ions from the body, while the composite with 20 % pectin showed the highest efficiency in forming a protective barrier on the gastrointestinal mucosa.

3.The catalytic properties of synthesized Cu, Co, Ni, Pd, and Pd-Ag catalysts supported on pectin-modified inorganic carriers were investigated in low-temperature hydrogenation of unsaturated compounds (2-propen-1-ol, phenylacetylene). It was found that the effectiveness and selectivity of the catalysts in the hydrogenation of 2-propen-1-ol and phenylacetylene depend on both the nature of the metal (active phase) and the type of inorganic support. The optimal catalyst was 1 % Pd-Pectin/ZnO, with a reaction rate of $4.9 \cdot 10^{-6}$ mol/s and selectivity to propanol of 82.5 %.

4.The catalytic properties of nickel, copper, and cobalt catalysts based on pectin/inorganic composites were determined in the liquid-phase oxidation of alkanes (cyclohexane, n-octane) with hydrogen peroxide. The most active and selective catalyst was 3 % Cu-Pectin/MMT, for which the conversion of cyclohexane and n-octane was 14.6% and 7.1%, respectively.

**Justification of the novelty and significance of the results obtained and their compliance with the directions of scientific development or government programs:**

During the research, valuable new knowledge was gained on the production of pectin from plant waste and the synthesis of organo-inorganic composites (enterosorbents) and metal-polymer catalysts based on them. A simple method for the synthesis of new polysaccharide inorganic composites with sorption and protective properties and catalysts for liquid-phase oxidation and hydrogenation processes at a temperature of 40°C is proposed.With and atmospheric pressure. The synthesis of composites is carried out under environmental conditions without high-temperature calcination and reduction processes using non-toxic reagents. These advantages meet the requirements of the principles of "green" chemistry, which is the basis of a modern strategy for developing new and improving existing technologies and processes. The results obtained may be in demand by the country's agricultural sector, as new innovative environmentally friendly

approaches are currently needed to achieve a sustainable agricultural environment and reduce waste.

The dissertation work was carried out in accordance with the plans of scientific research conducted at the «D.V. Sokolsky Institute of Fuel, Catalysis and Electrochemistry» JSC within the framework of scientific grant financing projects: AP05133114 "Development of improved processes for obtaining polysaccharides from plant waste and the creation of nanocomposites and nanocatalysts based on them for "green" syntheses of biologically active substances" (2018-2020, state registration No. 0118RK00283), AP09259638 "Development of catalytic syntheses of biologically active substances for agricultural purposes" (2021-2023, state registration No. 0121RK00356), AP19678287 "Pectin from plant waste: improvement of the production method and application in polymer-stabilized low-percentage nanocatalysts of fine organic synthesis" (2023-2025, state registration No. 0123RK00288).

**Description of the doctoral student's contribution to the preparation of each publication:**

Based on the results of the dissertation, 7 scientific papers have been published, of which: 4 articles in peer-reviewed scientific publications included in the Web of Science and Scopus databases; 1 articles in publications recommended by the Committee for quality assurance in the field of education and science and the Ministry of education and science of the Republic of Kazakhstan; 1 abstracts of reports at international scientific and practical conferences of the RK; 1 patent for utility model 5216 of the RK published on 03/26/2021, Byul. No. 45.

4 articles in foreign publications included in the Scopus and Web of Science databases:

1. How the Chemical Properties of Polysaccharides Make It Possible to Design Various Types of Organic–Inorganic Composites for Catalytic Applications. Molecules. – 2024. – V. 29(14). − P. 3214. https://doi.org/10.3390/molecules29133214 (WoS: Q2, CiteScore percentile in Scopus - 83%). Co-authors: Zharmagambetova A., Talgatov E., Auezkhanova A., Malgazhdarova M., Zhurinov M., Abilmagzhanov A., Jumekeyeva A., Kenzheyeva A. Doctoral student's share 60%;

2. Synthesis of polymer protected Pd–Ag/ZnO catalysts for phenylacetylene hydrogenation. Journal of Nanoparticle Research. – 2022. –V. 24:236. https://doi.org/10.1007/s11051-022-05621-1 (WoS: Q3, процентиль по Cite Score Scopus - 61%). (WoS: Q2, CiteScore percentile in Scopus - 83%). Zharmagambetova A.K., Auyezkhanova A.S.,Talgatov E.T., Jumekeyeva A.I., Buharbayeva F.U., Myltykbayeva Zh., Lopes Nieto J.M. Doctoral student's share 60%;

3. Polysaccharide-Stabilized Nanocatalysts in Hydrogenation of Phenylacetylene. Theoretical and Experimental Chemistry. – 2020. – V. 56. – P. 39-45. https://doi.org/10.1007/s11237-020-09638-2 (WoS: Q4, CiteScore percentile

in Scopus - 32%). Co-authors: Zharmagambetova A., Auezkhanova A., Talgatov E., Tumabayev N., Rafikova Kh. Doctoral student's share 70%;

4. Synthesis and protective properties of pectin/montmorillonite composites against aspirin-induced enterocolitis. Periodico Tche Quimica. – 2023. – V. 17(35). –P.897-907.http://dx.doi.org/10.52571/PTQ.v17.n35.2020.74_AUYEZKHANOVA_pgs_897_907.pdf (WoS: Q4, CiteScore percentile in Scopus - 22%). Co-authors: Auezkhanova A., Talgatov E., Kapysheva U., Zharmagambetova A. Doctoral student's share 70%.

1 article published in publications recommended by the Committee for Quality Assurance in Science and Higher Education of the Ministry of Education and Science of the Republic of Kazakhstan:

1. Optimization of pectin extraction from sugar beet pulp using microwave treatment. Chemical Journal of Kazakhstan. – 2024. – V.3(87). – P. 103-113. https://doi.org/10.51580/2024-3.2710-1185.36 (Co-authors: Zharmagambetova A., Auezkhanova A., Kenzheyeva A., Dzhardimalieva G. Doctoral student's share 80%);

1 abstracts in the materials of international scientific and practical conferences, including those from far and near abroad:

1. Determination of optimal conditions for the release of pectin from processed vegetable raw materials. International Scientific and Practical Conference "Chemical Science and chemical education modern aspects of transfer: theory and practice". − 2021. − Pp. 89-93. (Co-authors: Zharmagambetova A.K., Zhanbekov Kh.N., Auezkhanova A.S., Talgatov E.T. Doctoral student's share 80%);

1patent for a utility model:

1. A catalyst for the hydrogenation of phenylacetylene. Utility model patent 5216 RK publ. 03/26/2021, Byul. No. 45. (Co-authors: Zharmagambetova A.K., Auezkhanova A.S., Talgatov E.T., Seitkalieva K.S., Tumabaev N.Zh.).

**Structure and Scope of the Dissertation.** The dissertation consists of an introduction, 3 chapters, a conclusion, and a list of references comprising 230 sources. The work is presented on 130 pages of typed text and includes 25 tables, 60 figures, and 12 formulas.