REVIEW

by the Local Scientific Supervisor
Doctor of Chemical Sciences, Professor Gulziya Seilkhanova

of the dissertation by Akmaral Bakhytzhankyzy Rakhym

titled "Sorbents Based on Aluminosilicate Raw Materials for Heavy Metal Ions, Bisphenol-A, and Propranolol Extraction from Aqueous Solutions", submitted for the degree of Doctor of Philosophy (PhD) in the specialty 6D060600 – Chemistry

Currently, one of the Sustainable Development Goals (SDG 6: Clean Water and Sanitation) is to ensure access to clean and affordable water for all, as it is a foundation for a sustainable world. Therefore, research in this area is highly relevant. Water is the source of life and one of the most important natural resources, used in nearly all aspects of human activity. Every year, large volumes of wastewater from industrial enterprises are discharged into the environment. Among the most common pollutants in wastewater are heavy metal ions and various organic compounds. Based on the literature review, it has been established that sorption methods are effective for water purification and promote the rational use of water resources by enabling the return of treated water into the production cycle.

The PhD dissertation by Rakhym A.B., titled "Sorbents Based on Aluminosilicate Raw Materials for Heavy Metal Ions, Bisphenol-A, and Propranolol Extraction from Aqueous Solutions," is devoted to the development of new, efficient sorbents based on natural aluminosilicate raw materials—zeolite (Z) and chamotte clay (C)—as well as to the identification of physicochemical patterns in the adsorption processes of heavy metal ions, bisphenol-A, and propranolol from aqueous solutions.

The dissertation presents new scientific findings, including:

Three series of sorbents based on zeolite and clay were synthesized:

The first series includes sorbents modified with surfactants—either the cationic surfactant didodecyldimethylammonium bromide (DDAB) or the anionic surfactant sodium laureth sulfate (SLES).

The second series consist of sorbents pre-treated with NaCl and subsequently modified with surfactants.

The third series involve sorbents that underwent acid activation using hydrochloric acid, followed by surfactant modification.

The physicochemical and textural properties of the obtained sorbent materials based on zeolite and chamotte clay were determined.

It was established that zeolite and chamotte clay modified with the anionic surfactant SLES extract Cd^{2+} and Sr^{2+} ions with 90–97% efficiency, while the unmodified raw minerals almost completely (98–99%) adsorb Pb^{2+} ions, indicating their potential applicability for water purification processes.

It was shown that zeolite and chamotte clay modified with the cationic surfactant DDAB exhibit higher sorption capacity toward inorganic anions (MnO_4^-, $Cr_2O_7^{2-}$) and organic pollutants (BPA and PRO). This is due to the surface recharging of aluminosilicates, resulting in an excess of positive charge. In the case of organic compounds, enhanced hydrophobic interactions between BPA/PRO and DDAB also contribute to adsorption.

The potential application of the synthesized sorbents for targeted delivery of pharmaceutical compounds such as BPA and PRO was demonstrated.

Based on the analysis of adsorption patterns and the effect of material modification on the physicochemical characteristics of the studied processes, a new approach was proposed for evaluating the contribution of physical adsorption in pores and ion exchange in the interaction mechanism within aluminosilicate sorbent–pollutant systems.

The results of the dissertation possess both theoretical and practical significance. From a scientific standpoint, the obtained findings are of interest in the field of physical chemistry, particularly in establishing the kinetic and thermodynamic patterns of adsorption processes involving inorganic and organic substances on aluminosilicate minerals. Additionally, the proposed new method for evaluating the contributions of physical adsorption in pores and ion exchange to the overall mechanism of the process is noteworthy. The acquired knowledge can be recommended for integration into academic curricula, especially in the study of elective courses. It should also be noted that zeolite and chamotte clay modified with surfactants exhibit high sorption capacities toward both cationic and anionic forms of inorganic and organic pollutants, which is of practical value for water purification applications.

A significant contribution to the completion of this dissertation was made by the international consultant, Professor Yitzhak Mastai, who provided Rakhym A.B. with the opportunity to work in the laboratories of Bar-Ilan University (Israel), which are equipped with modern instrumentation. During the research internship, the PhD candidate obtained physicochemical characteristics of the sorbent materials and studied the kinetics of organic compound adsorption using spectrophotometric methods. It is also worth noting that access to the university's library resources was provided. The results obtained were discussed at scientific seminars held in the laboratory led by Professor Yitzhak Mastai.

The results of the dissertation were repeatedly presented and discussed at international and national conferences and seminars.

The goal of the research was successfully achieved through the completion of all the stated objectives. The main findings of the dissertation were published in 14 scientific works, including: 2 articles in journals indexed in the Web of Science database (Q1, IF = 5.876; Q4, IF = 0.447); 2 articles in proceedings journals indexed in Scopus (38%) and Web of Science; 4 articles in journals recommended by the Committee for Quality Assurance in Education and Science of the Ministry of Higher Education of the Republic of Kazakhstan; and 7 publications in the proceedings of international and national conferences.

During her dissertation work, Rakhym A.B. demonstrated a high level of independence, as well as excellent theoretical knowledge and practical skills in the field of chemistry. She carried out a large volume of experimental research using various physicochemical methods, and the obtained results were interpreted based on modern principles of thermodynamics and the kinetics of sorption processes.

The dissertation "Sorbents Based on Aluminosilicate Raw Materials for Heavy Metal Ions, Bisphenol-A, and Propranolol Extraction from Aqueous Solutions" meets all the requirements for PhD dissertations in terms of relevance, novelty, and practical significance of the results. Its author, Rakhym A.B., fully deserves the awarding of the PhD degree in the specialty 6D060600 – Chemistry.

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