For the dissertation of Arshyn Zhengis, submitted for the degree of Doctor of Philosophy (PhD) in Chemistry (8D05301), titled "Preparation of a Novel Multifunctional Zwitterionic Polymeric Membrane"

Review

Arshyn Zhengis has submitted the dissertation for defense in the format of a series of scientific articles. The submitted materials fully comply with the requirements and regulations approved by the Ministry of Science and Higher Education of the Republic of Kazakhstan.

The research topic pursued by Arshyn Zhengis is currently highly relevant from both environmental and scientific perspectives. The work addresses the challenge of efficient and selective removal of heavy metal ions and synthetic dyes from wastewater. The main objective of the study is to develop a new multifunctional zwitterionic polymer membrane with high water permeability, selectivity, and antifouling stability, and to comprehensively determine its structural and functional properties.

In the course of the study, a nanocomposite membrane was fabricated by integrating sulfobetaine methacrylate (SBMA) and zeolitic imidazolate framework-8 (ZIF-8) into a polyacrylonitrile–polyvinylpyrrolidone (PAN–PVP) matrix. The resulting membrane provided a pure water flux of 71.96 $L \cdot m^{-2} \cdot h^{-1}$ and demonstrated high removal efficiencies for heavy metal ions: Cd^{2+} – 95.6%, Cu^{2+} – 93.3%, Pb^{2+} – 97.8%. The rejection of organic dyes was also very high: methyl orange – 98.9% and methylene blue – 98.4%. After 10 repeated cycles, the membrane maintained approximately ~93% of its performance, confirming its high stability and reusability.

Key scientific results and publications:

Paper 1 — ACS Applied Materials & Interfaces (CiteScore: 14.5)

"Zwitterion–MOF Functional Interface Enabling Robust Ion and Dye Rejection in Water Filtration"

This study examines the effective separation of heavy metal ions and synthetic dyes using a PAN–PVP-based nanocomposite membrane containing SBMA and ZIF-8. The author substantiated the membrane's structural features and stability using FTIR, SEM, XRD, XPS, and ζ-potential analyses, and further explained the interaction mechanisms between pollutants and the membrane interface through DFT and MD simulations.

Paper 2 — Polymer (CiteScore: 7.7, Elsevier)

"Zwitterionic SBMA-based Nanofiltration Membranes: Synthesis Techniques, Antifouling Mechanisms, and Future Perspectives"

This review provides a systematic analysis of synthesis methods for SBMA-based nanofiltration membranes, their antifouling mechanisms, and future development directions. The author convincingly shows that the high hydrophilicity and electrically neutral nature of zwitterionic materials reduce surface fouling and contribute to stable membrane operation.

• Paper 3 — Nanomaterials (CiteScore: 9.2)

"Preparation of Zwitterionic Sulfobetaines and Study of Their Thermal Properties and Nanostructured Self-Assembling Features"

In this work, four different sulfobetaine-type zwitterionic polymers were synthesized, and their thermal properties and nanostructured self-assembly features were evaluated. It was found that variations in structural fragments (methacrylamide, imidazole, pyridine) significantly influence thermal stability and self-assembly behavior.

Overall, the author has published 4 scientific papers: three in high-impact international journals (ACS Applied Materials & Interfaces, Nanomaterials, Polymer) and one in a national scientific journal. In two of the international publications, the author is listed as the first author.

Conclusion

The dissertation research by Arshyn Zhenis entitled "Preparation of a New Multifunctional Zwitterionic Polymeric Membrane" is a well-structured study with strong theoretical and experimental foundations, and the obtained results demonstrate high scientific novelty and practical significance. The content is logically consistent, the structure is concise, and the research methods are conducted at a modern level.

Therefore, I consider that the dissertation fully meets the requirements set by the Ministry of Science and Higher Education of the Republic of Kazakhstan, and that the author is fully deserving of the degree of Doctor of Philosophy (PhD) under the educational program "8D05301 – Chemistry." The dissertation may be recommended for consideration by the Dissertation Council.

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