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DEAN

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To the
Department of Chemistry and Chemical Technology
Al-Farabi Kazakh National University
Almaty
Republic of Kazakhstan

Review letter for PhD thesis of Saparbek Tugelbay

I am providing a review letter for Mr Saparbek Tugelbay PhD candidate for his PhD defense. I serve an external co-advisor of the PhD thesis entitled:

"Mechanochemical synthesis of silver phosphate nanocomposites and their photocatalytic and antibacterial properties".

Mr. Saparbek Tugelbay presented a series of three publications in high-ranking international journals. His research focuses on the mechanochemical synthesis of silver-based nanocomposites and the study of their photocatalytic and antibacterial properties.

The research chosen as the topic of the Doctoral (PhD) Dissertation is very actual, state of the art is good. Recently, significant research has been launched worldwide to develop new, environmentally friendly technologies in mechanochemical synthesis of novel advanced materials.

The results of the research was published in the following articles:

The first research, *"Scalable synthesis of AgX (Cl, Br, I, PO_4) nanophotocatalysts for efficient visible-light degradation of persistent antibiotics from aqueous environments,"* was published in *Journal of Photochemistry & Photobiology A: Chemistry* **Q2, Impact Factor: 4.7**

This work demonstrates a green, solvent free synthesis of silver-based nanophotocatalysts and their quantitative performance metrics in degrading recalcitrant pharmaceutical pollutants, offering a promising approach for solar-driven water purification. This article demonstrates the potential of mechanochemical engineered Ag-based photocatalysts for sustainable pharmaceutical remediation. It introduces AgX systems as effective materials for degrading persistent antibiotic pollutants and advances green, light-driven strategies for water purification.

This work reports the systematic mechanochemical synthesis of silver halides and silver phosphate in high-energy ball mills. The study demonstrates their efficiency in degrading persistent nitrofuran antibiotics such as Nitrofurazone and Furagin under visible light. Particularly, Ag_3PO_4 and AgCl exhibited outstanding activity, achieving up to 95–99% removal within 90 minutes, with stability over repeated cycles.

The second article, *"Ag_3PO_4-based composites as next-generation antibacterial nanomaterials: A review of light induced synergistic effects,"* appeared in the *Chemical Engineering Journal* **Q1, Impact Factor: 13.2**

By unifying current progress and critical knowledge gaps, this review highlights Ag_3PO_4 as a next-generation antimicrobial platform with high potential for clinical, environmental, and industrial applications.

Authors revealed that future work must balance mechanistic understanding with clinical and environmental realism. This includes validating performance in vivo, ensuring safety across physiological conditions, and engineering responsive systems that adapt to infection dynamics. With continued interdisciplinary innovation.

It was concludede that Ag_3PO_4 based composites may evolve from laboratory materials into next-generation antimicrobial tools for combating bacterial infections and antibiotic resistance in real world settings.

The third paper, *"Enhanced photocatalytic antibacterial Ag_3PO_4/AgCl nanocomposites for water purification from organic and microbial contaminants,"* was published in the *Journal of Environmental Chemical Engineering* **Q1, Impact Factor: 7.2**
In the current paper, a scalable and sustainable technology for the solid-state synthesis of multifunctional hybrid Ag_3PO_4/AgCl nanocomposites for water treatment from organic pollutants and microorganisms has been successfully developed. This method relies on a solution-free, mechanochemical synthesis of nanocomposites in planetary ball mill.
The study shows not only high photocatalytic activity toward organic pollutants but also strong antibacterial and antifungal effects against *E. coli, S. aureus, P. aeruginosa,* and *Candida albicans*. Mechanistic analysis confirmed the synergistic role of ROS generation and Ag^+ release, while electron microscopy visualized membrane damage of microbial cells.
Their findings highlight the potential of this novel solid-state synthesis technology in tackling pressing issues related to water pollution and microbial contamination which are sustainable solutions in environmental remediation.

I conclude that the all the three papers are careful, high-quality works that satisfy the formal and content requirements, which contains a number of new and novel finding, which are well-supported by experimental investigation, therefore the results gained new knowledge and it contributes to further development of science and technology in nanotechnology, photocatalysis, and environmental chemistry. It is very important to emphasize that the basis of the dissertation is a large number of experimental work done by the Candidate.

Considering the above, the dissertation work of Tugelbai Saparbek entitled "Mechanochemical Synthesis of Silver Phosphate Nanocomposites and Their Photocatalytic and Antibacterial Properties" fully meets the requirements for dissertations submitted for the degree of Doctor of Philosophy (PhD) in the specialty **8D05301 – Chemistry**, in terms of scope, content, and the level of research performed.
The author has demonstrated a high level of theoretical knowledge, proficiency in modern experimental methods, and the ability to conduct independent scientific research.
As the scientific supervisor, I consider it appropriate to recommend this dissertation for defense for the degree of Doctor of Philosophy (PhD).

Sincerely,



Prof. Dr. Gábor Mucsi
Professor, Dean of the Faculty of Earth and Environmental Sciences and Engineering,
University of Miskolc, Hungary