**REVIEW**

**the official reviewer for the dissertation work of**

**Kaliyeva Assem Mukhtarkhanovna on the topic ««Obtaining and investigation of composite materials for flameless heaters», submitted for the degree of Doctor of Philosophy (PhD) in the specialty «6D073900 – Chemical Technology of Explosives and Pyrotechnics».**

| №п/п | Criteria | Compliance with the criteria (it is necessary to mark one of the answer options) | Justification of the position of the official reviewer |
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| 1. | The topic of the dissertation (as of the date of its approval) corresponds to the directions of scientific development and/or state programs | 1.1 Compliance with priority areas of science development or government programs: | The dissertation work is devoted to obtaining optimal compositions of flameless heaters based on aluminum |
| | | 1) The dissertation was completed within the framework of a project or target program funded from the state budget (specify the name and number of the project or program)<br>2) The dissertation was completed within the framework of another state program (specify the name of the program)<br>3) The dissertation corresponds to the priority direction of science development approved by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan (specify the direction) | The work was done on an initiative basis |
| 2. | Importance to science | The work makes/does not make a significant contribution to science, and its importance is well disclosed /not disclosed | The research results show that the new powder mixture based on aluminum and calcium oxide has a high reactivity and can be used as a flameless heat source. The study of the influence of various parameters of the MA on the reaction process makes it possible to optimize the conditions of the exothermic reaction and increase its effectiveness. The results obtained can be used to develop new technologies in the field of energy, industry and other industries where high energy efficiency and the use of flameless heat sources are required. The work makes a significant contribution to science in the field of energy compositions and new composite materials of heat sources. |

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| 3. | The principle of independence | The level of independence:<br>1) High;<br>2) Average;<br>3) Low;<br>4) There is no independence | The results of the research presented in the dissertation were obtained by the author personally. In this regard, I consider the level of independence of this work to be high. |
| 4. | The principle of internal unity | 4.1 Substantiation of the relevance of the dissertation:<br>1) Justified;<br>2) Partially justified;<br>3) It is not justified. | The relevance of the dissertation is well-founded. The results obtained within the framework of this dissertation can be proposed for the manufacture of heating devices. The advantage of the proposed method for obtaining highly dispersed powders for flameless heaters by mechanochemical activation is that the process can be effectively controlled when forming new structural compositions, which ensures an increase in the energy capacity of the system. After all, poor mixing of solid components in energy systems, a small contact surface area, and strong diffusion resistance make it difficult for solid-phase reactions to occur, they proceed at a very low rate and require long-term maintenance at high temperatures. Therefore, the next important area of the doctoral dissertation is the use of the mechanochemical activation (MA). |
| | | 4.2 The content of the dissertation reflects the topic of the dissertation:<br>1) Reflects;<br>2) Partially reflects;<br>3) Does not reflect | The dissertation fully reflects the research topic. The dissertation contains an introduction, conclusion and 5 sections: 1 – A literary review on energy materials and on the creation of flameless heaters; 2 – Experimental methodology describes methods for the synthesis of compositions of flameless heaters; 3,4,5 – Experimental results and discussion. The dissertation is presented on 101 pages and includes 34 figures and 22 tables. The work consists of an introduction, a literature review, a description of the objects and methods of research, the results and their discussion, conclusion and of list of 161 literature sources used. |

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| | | 4.3. The purpose and objectives correspond to the topic of the dissertation:<br>1) correspond to;<br>2) partially correspond to;<br>3) do not match | The goals and objectives of the research are clearly formulated in the dissertation work. They fully correspond to the topic of the dissertation. |
| | | 4.4 All sections and provisions of the dissertation are logically interrelated:<br>1) completely interconnected;<br>2) the relationship is partial;<br>3) there is no relationship | All sections and scientific provisions in this dissertation work are logically interrelated. |
| | | 4.5 The new solutions proposed by the author (principles, methods) are reasoned and evaluated in comparison with known solutions:<br>1) there is a critical analysis;<br>2) partial analysis;<br>3) the analysis is not your own opinions, but quotes from other authors | The scientific novelty lies in the production of compositions of flameless heaters by mechanochemical activation and allowed to obtain aluminum-based compositions activated by air, which the maximum gorenje gorenje of the system is 886.4°C.<br>Also, a composite composition based on calcium oxide providing temperatures in the range of 28-55°C in the exothermic reaction, thermodynamic characteristics are calculated: combustion temperature (T=859K) and enthalpy (ΔG=21140.5 kJ/mol). |
| | The principle of scientific novelty | 5.1 Are the scientific results and provisions new?<br>1) Completely new;<br>2) partially new (25-75% are new);<br>3) not new (less than 25% are new) | Scientific results and provisions are new, which is confirmed by publication in rating scientific journals. |
| | | 5.2 Are the conclusions of the dissertation new?<br>1) Completely new;<br>2) partially new (25-75% are new);<br>3) not new (less than 25% are new) | The conclusions of the dissertation are new, compiled on the basis of the experimental results obtained, scientifically based and do not cause doubts about their reliability. |
| | | 5.3 Technical, technological, economic or managerial decisions are new and justified:<br>1) Completely new;<br>2) partially new (25-75% are new); | Technical and technological solutions are new and well-founded. |

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| | | 3) not new (less than 25% are new) | |
| 6. | Validity of the main conclusions | All the main conclusions are based/not based on scientifically significant evidence or are well-founded enough (for qualitative research and areas of study in the arts and humanities) | All the main conclusions are based on scientifically significant evidence and experimental results, are well-founded and compared with modern literary data. |
| 7. | The main provisions submitted for protection | It is necessary to answer the following questions for each provision separately:<br>7.1 Is the position proved?<br>1) proved;<br>2) rather proven;<br>3) rather not proven;<br>4) not proven<br><br>7.2 Is it trivial?<br>1) Yes;<br>2) no<br>7.3 Is it new?<br>1) Yes;<br>2) no<br>7.4 Level for application:<br>1) narrow;<br>2) average;<br>3) wide<br>7.5 Is it proved in the article?<br>1) yes;<br>2) no | Provision 1 on obtaining an air-activated composite material for a flameless heater by mechanochemical activation is justified and the results are published in scientific papers, including the articles:<br>1. A. Kaliyeva, L. Galfetti, Ye. Tileuberdi, Ye. Ongarbayev, Z. Mansurov. Effect of mechanical activation on the reactivity of composites for flameless heaters // The Eurasian Chemico-Technological Journal. –2022. –Vol.22. –P.141–147.;<br>2. Kaliyeva A. Kydyrali, L. Galfetti, E. Tileuberdi, E. Ongarbayev. Study of the effect of mechanochemical activation in the production of composite materials for flameless heaters // Combustion and Plasmachemistry. – 2019. –Vol.17. –P.173-177. (in Russian).<br>3. Kaliyeva A.M., Tileuberdi Ye., Galfetti L., Ongarbayev Ye.K, Mansurov Z.A. Al-based mixtures for flameless ration heaters / X International Symposium «The physics and chemistry of carbon and nanoenergetic materials», 12-14 september 2018, Almaty, Kazakhstan.<br>Provision 1 is new, is not trivial, and may have a wide range of applications.<br><br>Provision 2 to determine the optimal composition of flameless heaters with activated water is proved in the dissertation and the results are published in scientific papers, including in the article: |

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| | | | 1. Kaliyeva A., Tileuberdi E. Obtaining an exothermic composite using nanostructured metallic aluminum // Chemical Journal of Kazakhstan, -2020. No. 3 (71). – P. 181-188. (in Kazakh).<br>2. Shingisbek D., Kaliyeva A.M. Effect of mechanical activation on the reactivity of composites for flameless heaters / International Conference of students and young scientists "Farabi Alemi", April 8-11, 2019, Almaty, Kazakhstan (in Kazakh).<br>Provision 2 is new, is not trivial, and may have a wide range of applications.<br><br>Provision 3 to obtain a composite material for flameless heaters with the addition of silicon dioxide is proved in the dissertation and the results are published in scientific papers, including the article: Kaliyeva A., Tileuberdi E. Obtaining an exothermic composite using nanostructured metallic aluminum // Chemical Journal of Kazakhstan, -2020. No. 3 (71). – P. 181-188. (in Kazakh). Provision 3 is new, is not trivial, and may have a wide range of applications. |
| 8. | The principle of reliability Reliability of sources and information provided | 8.1 The choice of methodology is justified or the methodology is described in sufficient detail<br>1) Yes;<br>2) no | The methodology of the work is described in sufficient detail in the experimental part section. It includes a description of the methodology: obtaining highly dispersed powder compositions of flameless heaters based on aluminum using mechanochemical activation; physico-chemical methods for studying the obtained samples; investigation of the exothermic characteristics of manufactured samples based on aluminum and calcium oxide; methods of thermodynamic calculations of the obtained systems. |

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| | | 8.2 The results of the dissertation work were obtained using modern research methods and methods of data processing and interpretation using computer technology:<br>1) Yes;<br>2) no | All the methods of analysis used are considered to be fully sufficient for conducting this kind of research. |
| | | 8.3 Theoretical conclusions, models, identified relationships and patterns have been proven and confirmed by experimental research (for areas of training in pedagogical sciences, the results have been proven on the basis of a pedagogical experiment):<br>1) yes;<br>2) no | The theoretical conclusions, the revealed interrelations and patterns in the dissertation work are confirmed by experimental studies. |
| | | 8.4 Important statements are confirmed/partially confirmed/not confirmed by references to relevant and reliable scientific literature | Important statements are confirmed by references to reliable scientific literature. Links to domestic and foreign sources were taken from the international peer-reviewed databases Scopus and Web of Scince. |
| | | 8.5 The literature sources used are sufficient/not sufficient for a literary review | The literature sources used in the dissertation volume 161 are sufficient. The presented number of sources in the dissertation work allows the author of the dissertation to solve the tasks set. |
| 9 | The principle of practical value | 9.1 The dissertation has theoretical significance:<br>1) Yes;<br>2) no | This work is a scientific study that solves both theoretical and applied problems. |
| | | 9.2 The dissertation is of practical importance and there is a high probability of applying the results obtained in practice:<br>1) yes;<br>2) no | The dissertation work is of practical importance and there is a high probability of applying the results obtained in practice. The resulting highly dispersed energy powder compositions can be used as a heat source for various purposes. |
| | | 9.3 Are the suggestions for practice new?<br>1) Completely new;<br>2) partially new (25-75% are new);<br>3) not new (less than 25% are new) | The proposals for the practical study of the results obtained in the dissertation are completely new. They can be used in the development of new technologies for the synthesis of flameless heaters. |

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| 10. | The quality of writing and design | The quality of academic writing:<br>1) High;<br>2) average;<br>3) Below average;<br>4) Low. | The quality of academic writing is high. The dissertation work is designed in accordance with the requirements for dissertations. |

Decision: To award the degree of Doctor of Philosophy (PhD) or doctor of the profile

**Official Reviewer:**

Ph.D., Professor, School of Chemistry and Chemical Engineering,
Nanjing University of Science and Technology
Director of Micro-nano energetic devices key laboratory
of Ministry of Industry and Information Technology



Ruiqi Shen

