

REVIEW
of the official reviewer for dissertation work
Zhumagaliyeva Assem Nurbergenovna on the theme «Production and testing of carbonized rice husk-based nanocomposites for capturing of carbon dioxide»
presented for the degree of Doctor of Philosophy (PhD) in the specialty «6D074000 - Nanomaterials and nanotechnology».

№	Criteria	Eligibility (one of the options must be checked)	1.	The topic of the thesis (as of the date of its approval) corresponds to the directions of development of science and/or state programs	Justification of the position of the official reviewer
1.	<p>1.1 Compliance with priority areas of science development or government programs:</p> <p>1) The thesis was completed within the framework of a project or target program financed from the state budget (indicate the name and number of the project or program)</p> <p>2) The thesis was completed within the framework of another state program (indicate the name of the program)</p> <p>3) The dissertation corresponds to the priority direction of the development of science, approved by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan (indicate the direction)</p>	<p>The dissertation work devoted to data about CO₂ adsorption by nanocomposite materials of the Fe₃O₄-C system was tested in a laboratory static micro-reactor under the conditions of flue gases after combustion</p> <p>This work was carried out on the applicant's own initiative without grant funding, the final applied results of the work could be aimed at fulfilling the priority direction of the development of science approved by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan, such as "Rational use of water resources, flora and fauna, ecology"</p>			
2.	Importance for science	The work makes a significant contribution to science, and its importance is well disclosed	3.	The principle of independence	The candidate performed a new approach to the production and testing of nanocomposites based on renewable rice husk and magnetic nanoparticles by co-precipitation method. Fundamental investigations of carbon dioxide gas sorbents have been studied.
	Self-reliance level:	The work is related to the production of nanomaterials based on carbonized rice husks and iron precursors and their possible application for carbon dioxide sorption.			

	4) No independence	Nanocomposites and nanoporous materials obtained by leaching and further coprecipitation have been tested in a laboratory-scale microreactor. Carbonized rice husk served as a matrix under an argon atmosphere and was filled with magnetite nanoparticles. Based on the results of the work, articles were published and the results were presented at international conferences.
4.	<p>The principle of inner unity</p> <p>4.1 Justification of the relevance of the thesis:</p> <ol style="list-style-type: none"> 1) <u>Justified</u>; 2) Partially justified; 3) Not justified. <p>4.2 The content of the thesis reflects the topic of the thesis:</p> <ol style="list-style-type: none"> 1) <u>Reflects</u>; 2) Partially reflects; 3) Does not reflect <p>4.3. The purpose and objectives correspond to the topic of the thesis:</p> <ol style="list-style-type: none"> 1) <u>correspond</u>; 2) partially correspond; 3) do not correspond <p>4.4 All sections and provisions of the thesis are logically interconnected:</p> <ol style="list-style-type: none"> 1) <u>completely interconnected</u>; 2) the interconnection is partial; 3) there is no interconnection 	<p>Carbon dioxide emissions are the main factor influencing global warming and the importance of preventing this factor is obvious. To reduce greenhouse gas emissions, the use of gas capture technologies at coal-burning plants, electricity generation, large industrial facilities is the one of advantageous CO₂ capture strategies. The effectiveness of production a new nanocomposite sorbent is primarily driven by economics because it did not implicate significant modifications to the combustion process technologies currently used.</p> <p>Content of the thesis fully reflects and corresponds to the research topic</p> <p>The purpose and objectives corresponded to the topic of the thesis</p> <p>Sections and provisions of the dissertation work are logically interconnected. In addition, a widely studied comparative analysis was carried out with previous works in the field of</p>

	<p>4.5 The new solutions (principles, methods) proposed by the author are reasoned and evaluated in comparison with the known solutions:</p> <p>1) there is a <u>critical analysis</u>;</p> <p>2) partial analysis;</p> <p>3) the analysis does not represent one's own opinions, but quotes from other authors</p>	<p>investigation.</p> <p>The candidate proposes a new approach to the synthesis of nanocomposite sorbents based on renewable plant biomass and human-friendly magnetite. A new technological method based on optimal conditions was authorized by the National Institute of Intellectual Property of the Republic of Kazakhstan.</p>
<p>5. Scientific novelty principle</p>	<p>5.1 Are the scientific results and provisions new?</p> <p>1) <u>completely new</u>;</p> <p>2) partially new (25-75% are new);</p> <p>3) not new (less than 25% are new)</p> <p>5.2 Are the dissertation findings new?</p> <p>1) <u>completely new</u>;</p> <p>2) partially new (25-75% are new);</p> <p>3) not new (less than 25% are new)</p> <p>5.3 Technical, technological, economic or management decisions are new and reasonable:</p> <p>1) <u>completely new</u>;</p> <p>2) <u>partially new</u> (25-75% are new);</p> <p>3) not new (less than 25% are new)</p>	<p>The scientific results and provisions are completely new mainly due to using nanostructured composite materials based on carbonized rice husk supported with iron oxide obtained by the co-precipitation method. Materials estimated in typical post-combustion flue-gas conditions for determination CO₂ adsorption capacity (1 atm, 3-15% volume CO₂). All synthesized materials exhibit stable adsorption/desorption kinetics under vacuum at 250 °C.</p> <p>The findings in the thesis are completely new in the discovery of the increasing CO₂ sorption properties of composite material with carbon matrix and nanoparticulate magnetite, bounded with enhancing specific surface area of the material up to 431 m²/g. These indicators have strengthened the physisorption process</p> <p>Basic research on CO₂ sorbents has been considered since the start of Climate change. For the sorption of gases, solid sorbents have several advantages, which have long been known. If we consider a narrow profile of sorbents for carbon dioxide based on renewable sources and used as a nanocomposite material,</p>

		<p>tested under normal conditions without additional manipulations, it can be concluded that in this work technical, technological and economic solutions are new.</p>
6.	<p>The validity of the main findings</p>	<p>All main conclusions are based on scientifically significant evidence or well-grounded</p>
7.	<p>The main provisions for the defense</p>	<p>It is necessary to answer the following questions for each provision separately:</p> <p>1. Carbonized rice husk (cRH) has high CO₂ uptake up to 11.26 mg/g under post-combustion flue-gas conditions. The sorption capacity of cRH significantly increases to 29.2 mg/g by leaching with an increase in the concentration of the base NH₄OH to 28% in the aqueous solution.</p> <p>7.1 Is the provision proven? 1) <u>proven</u>; 2) rather proven; 3) rather not proven; 4) not proven</p> <p>7.2 Is it trivial? 1) <u>yes</u>;</p> <p>7.3 Is it new? 2) <u>no</u> 1) <u>yes</u>; 2) <u>no</u></p> <p>7.4 Application level: 1) narrow; 2) medium; 3) <u>wide</u></p> <p>7.5 Is it proven in the article? 1) <u>yes</u>;</p> <p>Provision 1 is new, non-trivial, and has a wide range of applications for investigations of CO₂ solid sorbents, obtained by carbonized material matrix and checked under post-combustion flue-gas conditions. The position was fully proven and published in the rating journal Combustion Science and Technology (Q2, percentile 62%).</p>

	<p>2) no</p> <p>2. Prevention of agglomeration of iron oxide particles in a composite material based on cRH and nanoporous magnetite nFM, in a ratio of 67:33 co-precipitated with TMAOH, effectively increased the sorption capacity to 15.6 mg/g, which exceeds individual indicators of the components by 38% and 13%, respectively. This effect is due to an increase in the volume of microspores up to $3.81 \cdot 10^{-2} \text{ cm}^3/\text{g}$ and a good synergism between the chemisorption of iron oxide nanoparticles and the physical adsorption of carbon in cRH.</p> <p>7.1 Is the provision proven? 1) proven; 2) rather proven; 3) rather not proven; 4) not proven</p> <p>7.2 Is it trivial? 1) yes; 2) no</p> <p>7.3 Is it new? 1) yes; 2) no</p> <p>7.4 Application level: 1) narrow; 2) medium; 3) wide</p> <p>7.5 Is it proven in the article? 1) yes; 2) no</p> <p>3. cRH treated with NaOH solution increases the carbon content up to 80% and the specific surface area of the material up to $431 \text{ m}^2/\text{g}$, which enhances physical sorption and increases the sorption capacity up to 21.9 mg/g.</p>	<p>Provision 2 is new, non-trivial, determines the optimal parameters in $\text{Fe}_3\text{O}_4\text{-C}$ system, where nanosized magnetite particles effectively enhanced the uptake capacity of sorbents due to synergism chemisorption with physical sorption. Obtained data was fully proven and published in the Proceedings of Tenth Mediterranean Combustion Symposium – Naples, Italy (2017), International Conference on Applied Mechanics, Mechanical and Materials Engineering – Xiamen, China (2017)</p> <p>Provision 3 is new and non-trivial. Nanoporous material based on carbonized rice husk and precipitated with sodium hydroxide was analyzed and proven by BET analysis,</p>
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8.	<p>The principle of reliability of sources and information provided</p> <p>8.1 Choice of methodology - is justified or the methodology is described in sufficient detail 1) yes; 2) no</p> <p>8.2 The results of the thesis were obtained using modern methods of scientific research and methods of processing and interpreting data using computer technologies: 1) yes; 2) no</p> <p>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): 1) yes; 2) no</p> <p>8.4 Important statements are confirmed by references to current and reliable scientific literature</p>	<p>Choice of methodology is justified in accordance with modern research requirements, the methodology is described in the experimental part of the thesis in sufficient detail.</p> <p>Experimental high-tech methods used in the thesis are digitalized. The candidate provided XRD, SEM, FTIR, AFM, TGA, EDX, ICP-MS, and BET analysis of produced materials. Interpreting data using computer program is noticed.</p> <p>All theoretical conclusions, identified relations, patterns, and any interpretation have been made or reasoned on the basis of proven and confirmed experimental data</p> <p>All statements in the thesis are consistent with results and analyses of current research are made up of comparative analysis with literature published in competent scientific journals of the corresponding field.</p>
	<p>2) no 7.3 Is it new? 1) yes; 2) no</p>	
	<p>7.4 Application level: 1) narrow; 2) medium; 3) wide</p>	
	<p>7.5 Is it proven in the article? 1) yes; 2) no</p>	

		8.5 <u>Used literature sources are sufficient for a literature review</u>	The list of references contains 163 sources. All reliable references to the scientific literature are sufficient enough for completed reviews.
9	Practical value principle	9.1 The thesis has theoretical value: 1) <u>yes</u> ; 2) no	The theoretical significance of the investigation relies in the determination of the optimal parameters for the production of alkali treated sorbents and composite materials based on carbonized rice husk and magnetite with CO ₂ capture performances suitable for practical application.
		9.2 The thesis is of practical importance and there is a high probability of applying the results obtained in practice: 1) <u>yes</u> ; 2) no	The practical significance lies in the fact that the developed composite materials based on carbonized rice husk have the prospect of being used in practical applications as adsorbents for carbon dioxide capture and sequestration technology as low-cost solid sorbents in post-combustion conditions.
		9.3 Are the practice suggestions new? 1) <u>completely new</u> ; 2) partially new (25-75% are new); 3) not new (less than 25% are new)	Previously, the practical use of carbon sorbents for the CO ₂ sorption were known. However, the proposed nanocomposites based on carbonized rice husk and nanoparticulate magnetite have been developed and applied under flue-gas conditions for the first time.
10.	The quality of writing and design	Academic writing quality: 1) <u>high</u> ; 2) average; 3) below average; 4) low.	Academic writing quality is high. There are grammar and negligible stylistic mistakes in the dissertation work, but this remark does not have a fundamental character

Decision: Based on the above relevance, scientific novelty, practical and theoretical significance, I consider that the dissertation work of Zhumnagaliyeva Assen Nurbergenovna «Production and testing of carbonized rice husk-based nanocomposites for capturing of carbon dioxide»

corresponds to the requirements «Rules for awarding degrees» and the author deserves the PhD degree in the specialty «6D074000 - Nanomaterials and nanotechnology».

Official Reviewer:

**Candidate of Technical Sciences,
Associate Professor of the Chemical
and Biochemical Engineering Department
of the Geology and Oil-Gas Business Institute
named after K. Turysova,
Sathayev University**



Sana Kanatbekovna

(signature)

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