REVIEW

of the official reviewer for dissertation work

Amanzholkyzy Arailym on the theme «Hydrogel forms of hydroxypropylmethylcellulose and bentonite clay based on plant extract *Tamarix Hispida*» presented for the degree of Doctor of Philosophy (PhD) in the educational program «8D05301 - Chemistry».

№	Criteria	Eligibility (one of the options must be checked)	Justification of the position of the official reviewer
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	1.1 Compliance with priority areas of science development or government programs: 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)** 2) The thesis was completed within the framework of another state program (indicate the name of the program) 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)	The thesis was carried out under the programme "Zhas galym", grant funding of the Committee of Science of the Ministry Science of Higher Education of the Republic of Kazakhstan, AP22684531 'Development of hydrogel forms of plant extracts based on HPMC', 2024-2026 under the priority "The science of life and health".
2.	Importance for science	The work **makes**/does not make a significant contribution to science, and its importance is well disclosed/not disclosed	This dissertation **makes** a significant contribution to the field of science, and its importance is thoroughly substantiated. The key findings related to the development of hydrogels with *Tamarix hispida* extracts, the optimization of extraction yields, and the identification of patterns in composite carrier formation effectively address a relevant research problem. These results advance our understanding of macromolecular and natural product chemistry, as well as the design principles of composite biomedical

			materials.
3.	The principle of independence	Self-reliance level: 1) **High;** 2) Medium; 3) Low; 4) No independence	The degree of the author's independence is demonstrated through the critical analysis of scientific literature and preparation of a comprehensive review on hydrogel and polymer composite systems, the independent execution of the experimental part, and the subsequent interpretation and generalization of the research findings. The PhD student also showed her skills of experimental work on chromatograph, study of rheological characteristics and carrying out analyses to establish antioxidant, anti-inflammatory activity. The author prepared materials for publication in scientific journals and presented them in the form of reports at scientific conferences.
4.	The principle of inner unity	4.1 Justification of the relevance of the thesis: 1) **Justified;** 2) Partially justified; 3) Not justified.	**Justified.** The literature review provides a solid rationale for the research direction, focusing on relevant areas such as cellulose ether hydrogels, pharmaceutical applications, plant-based bioactive complex immobilization, and Tamarix hispida constituents.
		4.2 The content of the thesis reflects the topic of the thesis: 1) **Reflects;** 2) Partially reflects; 3) Does not reflect	The content of the thesis **reflects** the topic of the thesis.
		4.3. The purpose and objectives correspond to the topic of the thesis: 1) **correspond;** 2) partially correspond; 3) do not correspond	The purpose and objectives fully **correspond** to the topic of the thesis, focusing on solving the important problem of creating phytoextracts with anti-inflammatory and antioxidant activities and polymeric hydrogel

			systems characterized by improved physicochemical properties.
		4.4 All sections and provisions of the thesis are logically interconnected: 1) **completely interconnected;** 2) the interconnection is partial; 3) there is no interconnection	All sections and arguments of the thesis are **completely interconnected**, and the conclusions accurately reflect the main results. The findings logically follow from the experiments and analyses conducted and align with the stated goals and objectives.
		4.5 The new solutions (principles, methods) proposed by the author are reasoned and evaluated in comparison with the known solutions: 1) **there is a critical analysis;** 2) partial analysis; 3) the analysis does not represent one's own opinions, but quotes from other authors	The dissertation demonstrates sound **critical analysis**. The author proposes novel solutions to key objectives, particularly in HPMC gel formulation, composite development. These solutions are well-reasoned, justified through comparative analysis with authoritative literature, and informed by recent scientific advances in the relevant field.
5.	Scientific novelty principle	5.1 Are the scientific results and provisions new? 1) **completely new;** 2) partially new (25-75% are new); 3) not new (less than 25% are new)	The dissertation puts forward novel scientific findings, not previously described in the scientific literature. In particular, this study is the first to demonstrate notable antioxidant and anti-inflammatory effects of *Tamarix hispida* aerial part extracts for water extraction and immobilization of the extract in HPMC and HPMC–bentonite composite hydrogels
		5.2 Are the dissertation findings new? 1) **completely new;** 2) partially new (25-75% are new); 3) not new (less than 25% are new)	This research offers novel experimental results. Key innovations include: 1) Use of ultrasound for enhancing active component extraction; 2) Identification of antioxidant and anti-inflammatory activity in a specific aqueous-ethanol extract; 3) Development and optimization of

			novel HPMC/bentonite gels. The novelty is validated by a patent (RK) and Scopus-indexed publications.
		5.3 Technical, technological, economic or management decisions are new and reasonable: 1) **completely new;** 2) partially new (25-75% are new); 3) not new (less than 25% are new)	Research findings support novel and justified technical and technological solutions, including a green ultrasonic extraction method that improves BAS yield and bioactivity while decreasing extraction time, with novel gel developments.
6.	The validity of the main findings	All main conclusions **are**/are not based on scientifically significant evidence or well-grounded (for qualitative research and areas of training in the arts and humanities)	All main conclusions are based on scientifically significant evidence. The reliability of the thesis conclusions is based on comprehensive experiments using spectrophotometric, rheological, and biomedical methods. The results are well interpreted and confirmed.
7.	The main provisions for the defense	It is necessary to answer the following questions for each provision separately: 7.1 Is the provition proven? 1) **proven;** 2) rather proven; 3) rather not proven; 4) not proven 7.2 Is it trivial? 1) yes; 2) **no** 7.3 Is it new? 1) **yes;** 2) no 7.4 Application level: 1) **narrow;** 2) medium; 3) wide 7.5 Is it proven in the article?	All three provisions presented in the dissertation work are logically follow from the conducted research, are confirmed experimentally and are not trivial. The novelty and practical significance of the provisions are proved by publications in peer-reviewed journals and a patent for a utility model. **Provition 1** is not trivial and proved in the experimental part of the work, novelty is determined by the establishment of optimal conditions for obtaining plant extracts from the aerial part of plant *Tamarix Hispida,* which were 25 minutes for a single extraction with aqueous ethanol at a temperature of 20-40°C at a ratio of 1:6 raw material to extractant. The application level is "narrow", as the optimal conditions are

		1) **yes;** 2) no	determined only for plant extracts from the aerial part of the *Tamarix Hispida* plant by ultrasonic extraction. **Provision 2** is not trivial and proved by assaying for anti-inflammatory and antioxidant activity by DPPH radical inhibition level with gallic acid and quercetin standards, at the end of the assay the extract showed inhibition level from 400 μg/mL and above (% DPPH inhibition 96.08±0.48). The level for application is narrow, the extracts can be used as anti-inflammatory and antioxidant components of various medical materials. **Provition 3** is not trivial, the results are new and proved by the results of the conducted research, for the first time proposed compositions of hydrogels based on HPMC, bentonite clay and their compositions containing plant extracts. The complex of physicochemical and rheological methods was used to select optimal composition and show the intercompatibility of components. The level of application of the obtained gels is narrow and can be used to create gel wound coatings.
8.	The principle of reliability Reliability of sources and information provided	8.1 Choice of methodology - is justified or the methodology is described in sufficient detail 1) **yes;** 2) no	The choice of research methodology is well justified, methods and approaches are used based on the analysis of world practices. The author's analysis of approaches and methodology is given in the analytical literature review, the

			selected methods are used in the experimental part.
		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	In the dissertation work of the applicant the scientific results of the thesis were obtained using modern analytical and experimental approaches, including ultrasonic extraction, biological activity tests of DPPH, analysis of rheological properties, desorption characteristics.
		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	The theoretical conclusions, models, identified relationships and patterns are proved and confirmed by experimental research, which include instrumental study of isolated extracts, establishing the main characteristics of gels, conducting biotesting of extracts and revealing immobilisation patterns.
		8.4 Important statements are **confirmed** / partially confirmed / not confirmed by references to current and reliable scientific literature	Important statements are confirmed on the basis of analyses of modern scientific achievements and confirmed by references to current and reliable scientific literature. The sources used are published in peer-reviewed publications of scientometric databases, included works both on the chemical composition and biological activity of plant extracts and on hydrogel systems with plant components.
		8.5 Used literature sources are **sufficient**/not sufficient for a literature review	The literature sources used are sufficient for the literature review, includes a list of 193 titles from reliable and relevant literature.
9	Practical value principle	9.1 The thesis has theoretical value: 1) **yes;** 2) no	This dissertation studies timely issues in the area of material science. The creation of composite hydrogels using green methods, and novel extraction

			techniques for *Tamarix Hispida* water-soluble extract further the underlying understanding in this field.
		9.2 The thesis is of practical importance and there is a high probability of applying the results obtained in practice: 1) **yes;** 2) no	The thesis is of practical importance and there is a high probability in the possibility of developing transdermal forms with prolonged action and proposals can be used in pharmaceutical practice.
		9.3 Are the practice suggestions new? 1) **completely new;** 2) partially new (25-75% are new); 3) not new (less than 25% are new)	Water-soluble extracts and gels based on HPMC and its clay compositions are proposed for practical application, which can be used in medicine as agents with antioxidant and anti-inflammatory activities.
10.	The quality of writing and design	Academic writing quality: 1) **high;** 2) average; 3) below average; 4) low.	The quality of academic writing is high. The text is structured, the presentation is logical, scientific terminology is used. The design complies with the requirements and includes tables, figures, the necessary list of sources of literature.
11.	Notes on a thesis	1. On page 38, formula (3) may contain an error: the factor of 100 is likely a typographical error/mistake. 2. In the dissertation, Figure 29 presents 'the effect of temperature on the swelling kinetics of bentonite clay with THU-10'. Judging from the graph, these are the results of studying the swelling kinetics. Nevertheless, it remains unclear whether separate studies were conducted on the effect of temperature directly on both swelling kinetics and drug release, and if so, at what temperatures. 3. If such separate studies were conducted, what were their main results? The lack of detailed information in the description of Figure 29 makes it difficult to fully understand this part of the work. 4. The dissertation details the release of THH-10 extract from the hydrogel, but the method of extract immobilization within the hydrogel is not described. What method was used to immobilize the extract into the hydrogel?	

		5. If the extract was incorporated during synthesis, were the extract's properties assessed after exposure to the 80°C synthesis temperature?
12.	Scientific level of the doctoral student's articles on the topic of research (in case of defense of the dissertation in the form of a series of articles, the official reviewers comment on the scientific level of each article of the doctoral student on the topic of research)	The candidate's research has been published in high-impact journals, including a Q1-ranked *Molecules* article (SJR: 0.865, percentile: 80) titled "Hydrogel Delivery Systems for Biologically Active Substances: Properties and the Role of HPMC as a Carrier" (Molecules 2025, 30(6), 1354), and an article in *Chemistry of Plant Raw Materials* ("Ultrasonic extraction of biologically active substances from Tamarix hispida Willd", 2021). A utility model patent was also granted (2022). These publications and a the patent, along with presentations at international conferences, evidence the candidate's scientific competence and the dissertation's relevance.
13.	Decision of the official reviewer (pursuant to paragraph 28 of the present Model Regulations)	Amanzholkyzy Arailym's dissertation, prepared on the topic "Hydrogel forms of hydroxypropylmethyl cellulose and bentonite clay based on *Tamarix Hispida* plant extract," is submitted for the degree of Doctor of Philosophy (PhD) in the specialty "8D05301-Chemistry." In terms of relevance, scientific novelty, significance for theory and practice, and the scope of experimental research, the dissertation fully meets the requirements for dissertations for the degree of Doctor of Philosophy (PhD) in the specialty 8D05301 – "Chemistry." The official decision of the reviewer is that Amanzholkyzy Arailym deserves to be awarded the degree of Doctor of Philosophy (PhD) in the educational program 8D05301 - "Chemistry."

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