Opponent's Review of the Habilitation Thesis of

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Thesis entitled: **Application of Green Nanocomposites in Enhanced Oil Recovery**
Habilitation field: **Physical chemistry**

The habilitation thesis submitted here is composed of a compilation of 10 published scientific works (5 as a first author), accompanied by a commentary, in accordance with Act No. 111/1998 Coll. on Higher Education and on Amendments and Additions to Other Acts (Act on Higher Education). This compilation presents the results of the scientific research conducted by Dr. Jagar Ali, with a focus on physicochemical materials research in the synthesis and application of nano- and microstructural materials. The emphasis lies particularly in their potential application within the complex mineral oil/rock deposits field.
The introductory Chapter 1 underscores the pressing need to address the challenges posed by the increasing global energy demand, particularly in the context of petroleum production. While acknowledging the advancements in renewable energy, the focus remains on the sustained significance of fossil fuels. The chapter effectively introduces the relevance of nanotechnology in the petroleum sector, emphasizing its potential applications across various facets of oil and gas production.
Chapter 2 provides historical perspective on nanomaterials, establishing a crucial foundation for their subsequent exploration. The classification of nanomaterials based on various parameters is presented with clarity, laying the groundwork for a comprehensive understanding. The chapter delves into the distinctive properties of nanomaterials and elucidates different synthesis methodologies, establishing a fundamental knowledge base for their diverse applications.
The section on Nanocomposites in Chapter 2.1 provides a detailed examination of the synergistic integration of nanoparticle layers, emphasizing their role in enhancing material properties. The classification of nanocomposites and their properties are succinctly outlined, with a focus on polymer matrix nanocomposites and their applications in various industries, including oil recovery. The shift towards green synthesis methods is underscored, aligning with contemporary environmental considerations.
The Characterization section (Chapter 2.2.3.) effectively highlights the crucial role of in-depth analysis in understanding nanomaterials, introducing key analytical techniques used in the project. The emphasis on size, morphology, crystal structure, and composition elucidate the comprehensive approach taken in characterizing nanomaterials.
The exploration of Interfacial Tension Reduction (Chapter 3) in the context of Enhanced Oil Recovery (EOR) (Chapter 5) demonstrates a clear understanding of the role nanomaterials play in improving oil recovery. The incorporation of nanomaterials in nanofluids for wettability

alteration and interfacial tension reduction (Chapter 4) is meticulously explained, highlighting the experimental methodology and key findings. The study's focus on factors such as temperature, pressure, and smart water composition adds depth to the analysis.
The concluding section effectively summarizes the key findings of the study on greenly synthesized nanocomposites in EOR applications. The emphasis on even dispersion, effectiveness in specific water types, and the notable impact on interfacial tension and wettability alteration is clear. The study's recognition of the need for more specific investigations and a focus on eco-friendly practices aligns with contemporary research imperatives.
In conclusion (Chapter 6), the thesis presents a comprehensive exploration of the application of nanotechnology in the petroleum sector, particularly in Enhanced Oil Recovery. The systematic organization of chapters and sections facilitates a clear understanding of the research objectives, methodologies, and key findings. The study effectively bridges the gap between theoretical concepts and practical applications, contributing valuable insights to the field of nanotechnology in oil and gas production.
In the context of the presented scientific works, it is also appropriate to emphasize, from the point of view of the habilitant's professional quality, that out of a total of 45 published scientific works (WoS), he has participated in 9 publications as the first author and in 26 as the corresponding author. Even considering the citation response of these scientific publications (884 citations WoS), it can be concluded that Jagar Ali, Ph.D. meets the professional criteria for a successful habilitation procedure in his scientific field.
The above-mentioned facts prove that Jagar Ali, Ph.D. demonstrates high professional activity at his university workplace, and therefore I recommend that the submitted habilitation thesis be accepted for further discussion before the Scientific Board of the Faculty Science of Palacky University Olomouc in the context of the procedure for awarding the scientific and pedagogical title of Associate Professor in the sense of the currently valid wording of Act No. 111/1998 Coll. on Higher Education.

Question for the discussion on the topic of the habilitation thesis: In two-phase flows within porous media, the occurrence of viscous fingering phenomena is notable. These phenomena contribute to the entrapment of residual oil during secondary oil recovery, consequently diminishing the efficiency of oil extraction. In the classical theory, the onset of instability is controlled by a single parameter, i.e. the viscosity ratio. However, coupling with other physicochemical processes could enhance or suppress viscous fingering. What are your insights on the feasibility of actively controlling (either enhancing or suppressing) the occurrence of viscous fingering instability through the application of external electric fields?

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