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Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Ayomikun Bello Sunday

PhD Program: Petroleum Engineering

Title of Thesis: Co-optimization of the methods of oil recovery and CO2 storage using nonionic-based binary surfactant foams

Supervisors: Professor Alexey Cheremisin
Co-supervisor: Dr. Anastasia Ivanova

Name of the Reviewer: Aaditya Khanal

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	**Date: 08-11-2024**

The purpose of this report is to obtain an independent review from the members of PhD defense Jury before the thesis defense. The members of PhD defense Jury are asked to submit signed copy of the report at least 30 days prior the thesis defense. The Reviewers are asked to bring a copy of the completed report to the thesis defense and to discuss the contents of each report with each other before the thesis defense.

If the reviewers have any queries about the thesis which they wish to raise in advance, please contact the Chair of the Jury.

Reviewer's Report

This dissertation addresses the integration of nonionic-based binary surfactant systems for EOR and CO_2 storage within high-salinity carbonate reservoirs. The research adopts a multiscale approach that progresses from molecular-scale analyses of surfactant interactions to laboratory core-scale and reservoir-scale applications, to optimize both oil recovery and CO_2 retention.

The study provides an overarching challenge in CCUS in the petroleum industry, establishing the critical role of sustainable oil production techniques in mitigating CO_2 emissions. A detailed exploration follows in the fluid-fluid and rock-fluid interaction studies, which investigate surfactant efficiency, particularly in reducing critical micelle concentration and adsorption onto reservoir rock. Experimental investigations assess foam stability under high-salinity conditions and interactions with varying oil types, illustrating the potential of these binary surfactants in real-world applications. Core-scale experimental work evaluates the effectiveness of CO_2 foams in trapping CO_2 and increasing oil recovery. At the same time, the reservoir-scale numerical models simulate the impacts of different trapping mechanisms on CO_2 storage efficiency and retention over time. The results show the advantages of binary surfactant systems for improving EOR and CCUS outcomes under varying reservoir conditions. The dissertation concludes with recommendations for further research to optimize surfactant formulations and their application on a field scale, emphasizing the practical and scientific implications of these findings.

The dissertation exhibits several key strengths, beginning with its multiscale approach. By systematically covering molecular, core-scale, and reservoir-scale analyses, the research offers a robust and comprehensive view of binary surfactant applications, making it highly relevant for advancing EOR and CO_2 storage strategies. This multiscale design reflects an extensive depth and scope, allowing the study to assess how surfactant performance scales from laboratory conditions to simulated reservoir scenarios.

Advanced analytical techniques are used in the research that shows the student's proficiency in both experimental and computational aspects of petroleum engineering while providing a strong theoretical basis for interpreting the results. The experimental design is well-structured, with clearly defined procedures in each chapter that address specific research questions. The inclusion of foam stability and adsorption studies, as well as core flooding and reservoir simulations, ensures that the findings are grounded in empirical data. These methods lend credibility to the conclusions drawn on the effectiveness of binary surfactants. The focus on nonionic surfactant systems suited for high-salinity conditions is highly valuable, as it addresses a well-recognized challenge in CO_2 sequestration and EOR applications in carbonate reservoirs. The practical implications of these findings are considerable, offering potential solutions for industry applications where high salinity or mineral content may otherwise limit the use of certain surfactants. The findings in this work provide actionable insights for real-world applications. The outcomes of this research are practical to contribute to more efficient CO_2 storage solutions within the petroleum industry, particularly in complex carbonate reservoirs. The recommendations for future work are thoughtful, outlining a clear path forward for field-scale studies and additional formulation testing that could help drive the adoption of these methods in practice. The quality of the work is also evidenced by the numerous peer-reviewed articles in highly competitive journals and conferences.

While the dissertation is highly commendable, some aspects could be improved to enhance its accessibility and impact. For example, in the introduction, a more explicit statement of the research gap and the unique contributions of this work would provide a stronger context and help readers quickly grasp the novelty and importance of the study. This information is already in sections 1.6 and 1.7, but a separate section would benefit the readers. The individual chapters would also benefit from more explicit links to the primary research question in the introduction. These connections would enhance the coherence of the study, making it easier for readers to see how each experiment or analysis contributes to the overall objectives.

Overall, this dissertation is a substantial contribution to the field of petroleum engineering, offering a rigorous evaluation of binary surfactant systems and their application in high-salinity environments for both enhanced oil recovery and CO_2 storage. The multiscale framework, use of advanced analytical methods, and practical implications make it a valuable piece of research with significant industry relevance.

The summary of issues to be addressed before/during the thesis defense:

None

Sincerely,

Aaditya Khanal, Ph.D.
Assistant Professor
Russell School of Chemical Engineering
McDougall School of Petroleum Engineering
The University of Tulsa, Tulsa, OK, USA

Provisional Recommendation

☒ *I recommend that the candidate should defend the thesis by means of a formal thesis defense*

☐ *I recommend that the candidate should defend the thesis by means of a formal thesis defense only after appropriate changes would be introduced in candidate's thesis according to the recommendations of the present report*

☐ *The thesis is not acceptable and I recommend that the candidate be exempt from the formal thesis defense*