



Helsinki 10.10.2023

REVIEW

by the undersigned foreign supervisor, Professor Heikki Tenhu, of the dissertation of **Mr. Nurbatyr Mukhametgazy** "Synthesis and characterization of acrylamide-based polyampholytes for EOR, drilling of wells, and tracer applications" for the requirements of the degree of Doctor of Philosophy (Ph.D.) in the specialty 6D073900 - "Petrochemistry"

The dissertation of **Mr. Nurbatyr M.** is devoted to the development of novel acrylamide-based polyampholytes, which were synthesized, characterized, and tested as additives for oil recovery, drilling fluid and tracer fluid agents in the oil industry.

In addition, the high salinity of reservoir water in oil fields of Kazakhstan, coupled with the highly viscous oils, constitutes a significant obstacle to increasing oil productivity. Therefore, research aimed at developing new types of temperature-resistant polymer agents capable of withstanding such high salinity is important and has led to both theoretically and practically valuable findings.

As a result of the research, the following cases study were identified:

1. Synthesis, characterization, and confirmation of the optimal monomer composition of high molecular weight water-soluble ternary polyampholytes capable of achieving high viscosity in high salinity (200-300 g.L⁻¹) brine.

2. Study of the rheological characteristics of the chosen ternary polyampholyte (AAm-co-AMPS-co-APTAC= 80:10:10 mol %) in high salinity brine at 25°C and 60°C respectively.

3. To determine the potential use of polymer flooding technology in enhanced oil recovery, laboratory tests were conducted to displace oil by injecting new ternary polyampholyte solutions through the sand pack and core samples.



4. Oil displacement experiments were conducted comparing a high-molecular weight ternary polyampholyte with HPAM. The latter one is a commonly used polymer-flooding agent to enhance oil recovery in Kazakhstan.

5. Study of the application of ternary polyampholytes as rheological enhancers and polymeric fluid loss reducers in salt-tolerant water-based drilling fluids

6. Synthesis and characterization of a novel fluorescently labeled ternary polyampholyte (AMPS-co-APTAC-co-ANB=50:49:1 mol%) containing a fluorescent dye Nile blue acrylamide (ANB) and its testing as a tracer agent in core flooding experiments.

Mr. Nurbatyr Mukhametgazy was unable to come to the University of Helsinki (Helsinki, Finland) for a research internship under the state educational grant 6D073900 - "Petrochemistry" due to the COVID-19 pandemic in the years 2020-2021. Instead, his scientific trip took place by invitation of Associate Professor Nurxat Nuraje in the Department of Chemical & Materials Engineering at the School of Engineering & Digital Science at Nazarbayev University (Astana) between April 15 and August 14, 2021. During the visit, he conducted the characterization of physico-chemical properties using a series of methods, including ^1H and ^{13}C -NMR, SEM, TEM, and (C.N.S.H) elemental analysis, on samples of polyampholyte terpolymer AAm-co-AMPS-co-APTAC (80:10:10 mol %) synthesized by free radical copolymerization in an aqueous solution.

By continuously engaging in research collaboration with us, the analysis and determination of research results in the current year have been incorporated under the title "Synthesis and Characterization of Salt-Tolerant Ternary Polyampholyte as a Rheology Enhancer and Fluid Loss Additive for Water-Based Drilling Fluids" in the Scopus database journal Engineered Science (ES). The article has been accepted for publication in the journal and is classified as Q1 (IF=15.9, percentile-95 %).

Mr. Nurbatyr Mukhametgazy has developed a close partnership with me during the PhD dissertation work. He is theoretically well prepared in the field of research, capable of self-education and development, possesses practical professional qualifications, and has



proven himself as a hardworking, disciplined, and knowledgeable specialist. He is a humble and positive person and gets well along with his colleagues.

Mr. Nurbatyr Mukhametgazy has become a specialist in his field of research, and his qualifications can be highly valuable for advancing new directions in the field of science in Kazakhstan. I am very pleased with his work and truly recommend him to defend his Ph.D. thesis in the specialty 6D073900-"Petrochemistry".

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Scientific Supervisor
Department of Chemistry
University of Helsinki

Professor, Heikki Tenhu