

Mohamad Nasir Mohamad Ibrahim
B.Sc.(1994), M.Sc.(1997), Ph.D.(1999)
University of Missouri~Rolla, USA
Professor

E-mail : mnm@usm.my
Telephone: 04-6533554
Facsimile: 04-6574854
H/P: 019-456-7913

November 28, 2025

To Whom It May Concern

It is my pleasure to provide this review letter for the Ph.D. dissertation of Kussainova Gulsara, entitled «New biocidal flocculants based on vinyl monomers for use in oilfield technologies». This dissertation deals with one of the topical issues for many industrial enterprises - obtaining polymeric compounds that can be used as biocidal substances that inhibit the growth of corrosive bacteria (antimicrobiological corrosion) in various industries and as flocculants necessary for cleaning industrial wastewater from highly dispersed particles of harmful mechanical impurities.

Gulsara Kussainova's research is comprehensive and well-structured, aimed at synthesizing copolymers of [3-(methacryloylamino)propyl]trimethylammonium chloride with N,N-dimethylacrylamide (TMAPMACH-DMAA) and [3-(methacryloylamino)propyl]trimethylammonium chloride with itaconic acid (TMAPMACH-IA), which have biocidal and flocculating properties, based on available industrial monomers. The research further studies the physicochemical, biocidal, surface and flocculating properties of the copolymers. The results make a significant contribution to the field of green chemistry, sustainable materials, and thermal insulation technologies.

Key Contributions and Novel Findings

1. Synthesis and Characterization of a new cationic polymeric surfactant

- For the first time, copolymers of [3-(Methacryloylamino)propyl]trimethylammonium chloride and N,N-dimethylacrylamide (TMAPMACH-DMAA) with different molar composition were synthesized by radical copolymerization method in the presence of initiator ((NH₄)₂S₂O₈) at a temperature of 333 K, and the optimal reaction conditions were determined.
- For the first time, the activities of the monomers in the radical copolymerization reaction in a mixture of TMAPMACH and DMAA monomers in the presence of the initiator ((NH₄)₂S₂O₈) at a temperature of 333 K were determined by the Mayo-Lewis ($r_{\text{TMAPMACH}}=1.25\pm 0.02$ and $r_{\text{DMAA}}=2.00\pm 0.02$) and Feynman-ROSS ($r_{\text{TMAPMACH}}=1.16\pm 0.02$ and $r_{\text{DMAA}}=2.25\pm 0.02$) methods. It was then found that the activity of DMAA in the radical copolymerization reaction was greater than that of the TMAPMACH monomer. By studying the effect of monomer and initiator concentrations on the rate of the copolymerization reaction, the kinetic equation of the reaction was obtained for the first time: $R_C = k \times [M]^{2.70} \times [I]^{1.24}$ and the value of the rate constant was calculated: $k = 11.8 \text{ l}^{2.94} \times \text{mol}^{-2.94} \times \text{s}^{-1}$.

2. Synthesis and Characterization of a new ampholytic polymeric surfactant

- For the first time, copolymers of [3-(Methacryloylamino)propyl]trimethylammonium chloride and itaconic acid (TMAPMACH-IA) with different molar composition were synthesized by radical copolymerization method in the presence of initiator ((NH₄)₂S₂O₈) at a temperature of 343 K, and the optimal reaction conditions were determined.

- For the first time, the activities of monomers in the radical copolymerization reaction in a mixture of TMAPMACH and IA monomers in the presence of the initiator $((\text{NH}_4)_2\text{S}_2\text{O}_8)$ at a temperature of 343 K were determined by the Mayo-Lewis ($r_{\text{TMAPMACH}}=0.50\pm 0.02$ and $r_{\text{IA}}=1.50\pm 0.02$) and Feynman-Ross ($r_{\text{TMAPMACH}}=0.44\pm 0.02$ and $r_{\text{IA}}=1.51\pm 0.02$) methods. Then it was found that the activity of IA in the radical copolymerization reaction is more than that of TMAPMACH monomer. By studying the effect of monomer and initiator concentrations on the rate of the copolymerization reaction, the kinetic equation of the reaction was obtained for the first time: $R_C = k \times [\text{M}]^{1.66} \times [\text{I}]^{0.35}$ and the value of the rate constant was calculated: $k = 0.049 \text{ l}^{0.92} \times \text{mol}^{-0.92} \times \text{s}^{-1}$.
3. For the first time, it was investigated biocidal properties of cationic and ampholytic polymeric surfactants:
 - TMAPMACH-DMAA copolymers have a biocidal effect against *Thiobacillus ferrooxidans* (TB) thiocyanate bacteria at a minimum concentration of 1.0 wt. %, that is, they completely inhibit the growth of bacteria. However, it was found that they cannot stop the growth of sulfate-reducing bacteria (SRB), but at a concentration of 0.2÷1.0 wt. % they significantly delay their development.
 - TMAPMACH-IA copolymers were shown to completely (100%) inhibit the growth of *Thiobacillus ferrooxidans* TB bacteria at a concentration of 0.1-1.0%, and at a concentration of 0.5-1.0% wt. %, they were found to have a biocidal effect against SRB bacteria, that is, they completely inhibit the growth of bacteria.
 4. TMAPMACH-DMAA and TMAPMACH-IA copolymers were studied as flocculants for the purification of bentonite clay suspensions in water from dispersed particles.
 - It was proved that the mentioned copolymers are effective flocculants and can be used for the purification of industrial wastewater from highly dispersed impurities. Then, the following optimal conditions should be met for the flocculation of suspension particles: for the TMAPMAX-DMAA copolymer, the molar composition [TMAPMAX]:[DMAA] = 50:50 %, and the concentration should be 2.1 mg SP / g B. And for the TMAPMACH-IA copolymer, the molar composition [TMAPMACH]:[IA] = 50:50, and the concentration should be 2.1 mg SP / g B.

Scientific significance and practical application

The dissertation contributes to both fundamental and applied science by proposing alternative biocidal flocculants for their application:

- as flocculants for the purification and disposal of industrial wastewater and spent drilling mud from fine particles.
- as biocidal compounds that suppress the growth of SRB and TB bacteria, causing microbiological corrosion.

Publications and Research Impact

Gulsara Kussainova's research findings have been presented at international scientific conferences and published in high-impact journals, including:

1 article in the journal "ES Materials and Manufacturing" (Q2, percentile 92%), 1 article in the journal "Engineered Science" (quartile Q1, percentile 96%) included in the Scopus database; 1 articles in the "Chemical Journal of Kazakstan" recommended by the "Committee for Quality Assurance in Science and Higher Education" of the Ministry of Higher Education and Science of the Republic of Kazakhstan; 3 reports and abstracts were published at international and republican scientific conferences. 2 patents of the Republic of Kazakhstan were obtained for the method of synthesizing new polymeric biocidal compounds. This demonstrates the scientific merit and international recognition of his work.

Conclusion

Gulsara Kussainova's dissertation fully meets the high academic standards required for a Ph.D. degree in Petrochemistry. The study presents original scientific contributions with strong experimental validation and clear practical implications. The research findings provide a solid foundation for future advancements in biocidal polymeric flocculants.

I strongly support Gulsara Kussainova's candidacy for the Ph.D. degree and highly evaluate his research as a valuable contribution to modern science and environmental sustainability.

Sincerely yours,



MOHAMAD NASIR BIN MOHAMAD IBRAHIM
Professor Dr.
School of Chemical Sciences
Universiti Sains Malaysia
11800 USM, Penang, Malaysia