

# Extended Abstract

(For Ph.D. Open Seminar)

## Study of Polymer Viscoelasticity and Quantification of Its Contribution to Enhanced Microscopic Oil Displacement

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Global energy demand continues to rise due to economic growth and population expansion, making crude oil a crucial component of global energy security despite the growth of renewable energy sources. Since large new oil discoveries are limited, recovering oil from existing and depleted reservoirs has become increasingly important. Primary and secondary recovery methods leave a significant amount of movable oil trapped in reservoirs, encouraging the development of enhanced oil recovery (EOR) techniques. EOR methods, including thermal, miscible gas, and chemical flooding, improve oil production through mechanisms such as viscosity reduction, pressure maintenance, interfacial tension reduction, and mobility control.

Among chemical EOR methods, polymer flooding has gained considerable attention because of its ability to improve sweep efficiency and reduce viscous fingering by increasing the viscosity of the displacing fluid. Compared to conventional water flooding, polymer flooding can recover additional oil due to the viscous and elastic behavior of polymer solutions. The viscoelasticity of polymers, influenced mainly by molecular weight and concentration, enables polymer chains to stretch and recoil within porous media, helping mobilize trapped residual oil through pulling and stripping mechanisms.

Recent laboratory and field studies have demonstrated the positive impact of polymer viscoelasticity on oil recovery, reporting additional recovery from both core flooding experiments and field-scale applications. Polymer flooding is a well-established enhanced oil recovery (EOR) method, where the reported mechanisms of oil recovery mainly focus on the viscosity effect of polymers, which improves macroscopic sweep efficiency. However, microscopic oil displacement during polymer flooding is not solely associated with viscosity; the viscoelastic behavior of polymers also plays a significant role in mobilizing trapped oil. Previous studies have not clearly established the separate contributions of viscosity and viscoelasticity, making it difficult to quantify the specific effect of polymer viscoelasticity on enhanced oil recovery during polymer flooding.

**Thesis organization** comprises the following chapters which systematically discuss the identification of research gaps and the approaches adopted to address them.

In **Chapter 1**, an introduction to the research topic is presented, along with the motivation for emphasizing the study of polymer viscoelasticity and its effect on enhanced oil recovery

during polymer flooding. The chapter also briefly discusses research problem identification, proposed solutions, and the objectives of the research work.

In **Chapter 2**, a comprehensive review of polymer flooding as a chemical enhanced oil recovery method is discussed, with particular emphasis on the role of polymer viscoelastic behavior in improving oil recovery. It explains the mechanisms of polymer flooding, including mobility control, sweep efficiency improvement, and microscopic displacement of trapped oil due to viscoelastic effects. Based on the literature survey, the existing research gaps are identified, thereby justifying the need and scope of the present thesis work.

In **Chapter 3**, it describes the methodologies adopted and the materials utilized throughout the research work. The chapter provides detailed information on the selection and characterization of polymers, preparation of experimental fluids, and the experimental setup used for polymer flooding investigations.

In **Chapter 4**, the significance of polymer viscoelastic behavior in enhancing oil recovery during polymer flooding processes is discussed. The experimental procedures for evaluating the viscoelastic behavior of polymers through rheological characterization are presented. Furthermore, the influence of polymer viscoelasticity on oil recovery performance and the viscoelastic properties contribution to the microscopic displacement efficiency by mobilizing trapped residual oil within porous media is also discussed.

In **Chapter 5**, the effect of polymer viscoelastic behavior on enhanced oil recovery and development of a relationship between polymer viscoelasticity is discussed. The chapter also focusses on the quantification of polymer viscoelastic behavior and its contribution toward microscopic oil displacement. Furthermore, a viscoelastic factor is introduced to emphasize the reduction in mobility control caused by the viscoelastic effect of polymers, which assists in improving microscopic oil recovery mechanisms.

In **Chapter 6**, the process of validation of the numerical simulation model for viscoelastic polymer flooding using the CMG-STARs simulator is discussed. This chapter includes history matching and validation process carried out using experimental polymer flooding results to ensure the reliability and accuracy of the simulation model. Furthermore, simulation

studies are performed to predict enhanced oil recovery performance for various viscoelastic polymer floodings.

In **Chapter 7**, it presents the overall conclusions of the thesis work and summarizes the major findings related to the effect of polymer viscoelastic behavior on enhanced oil recovery during polymer flooding. The chapter also discusses the significance of polymer viscoelasticity in improving microscopic oil displacement and provides future recommendations for research and field-scale applications.

**Published Research Articles/Prepared Manuscript/Conferences:**

- Experimental Investigation of the effect of viscoelasticity on enhanced oil recovery during polymer flooding. (<https://doi.org/10.1021/acsomega.4c11099>; Journal: ACS Omega; Impact Factor: 4.3)
- Beyond Mobility Control: Quantifying the Contribution of Polymer Viscoelasticity to Enhanced Oil Recovery. (<https://doi.org/10.1016/j.cherd.2026.05.008>; Journal: ChERD; Impact Factor: 3.9)
- Validation of numerical simulation model for viscoelastic polymer flooding and prediction of EOR by different viscoelastic polymers using CMG-STARs. (Manuscript Prepared)
- **Poster Paper Presentation** on “Establishment of the relationship between polymer viscoelasticity and enhanced oil recovery by experimental investigation”. (International Conference: IOGCA-2025, Delhi)
- **Oral Presentation** on “Investigation of the effect of viscoelasticity for likely viscous polymers in enhanced oil recovery”. (International Conference: ICPHD-2024, IIT (ISM) Dhanbad)