

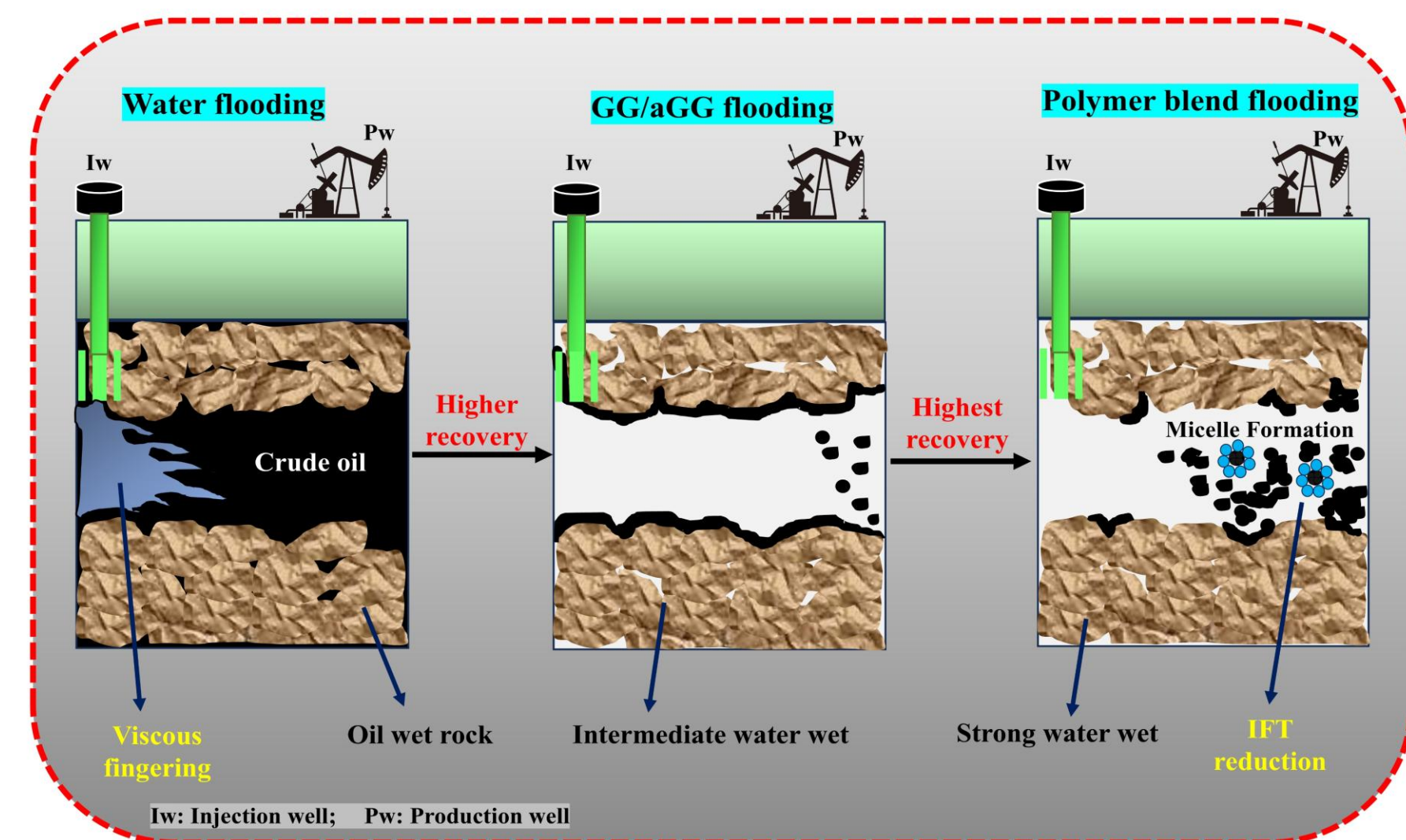
Development and Functional Assessment of Modified Polymers for Enhanced Oil Recovery in Non-Producing Reservoirs

Abhishek Tyagi¹, Akhil Agrawal^{1*}

¹Energy & Environment Research Laboratory, Central University of Rajasthan, India

INTRODUCTION & AIM

- The Problem: Conventional oil recovery methods leave 50-70% of oil trapped in reservoirs due to high oil viscosity and unfavourable rock wettability.
- Current EOR Limitations: Existing synthetic polymers (e.g., HPAM) are prone to degradation in harsh reservoir environments (high temperature/salinity) and are not eco-friendly.
- The Solution: Propose a novel, eco-friendly biopolymer blend (PB) composed of Guar Gum (GG) and Acetylated Guar Gum (aGG) to overcome these issues.



Graphical Abstract. Engineered biopolymer (GG/aGG) and blend flooding enhance mobility control, suppress viscous fingering, induce water-wet conditions, and reduce interfacial tension via micellization, maximizing sweep efficiency and oil recovery beyond water flooding.

METHOD

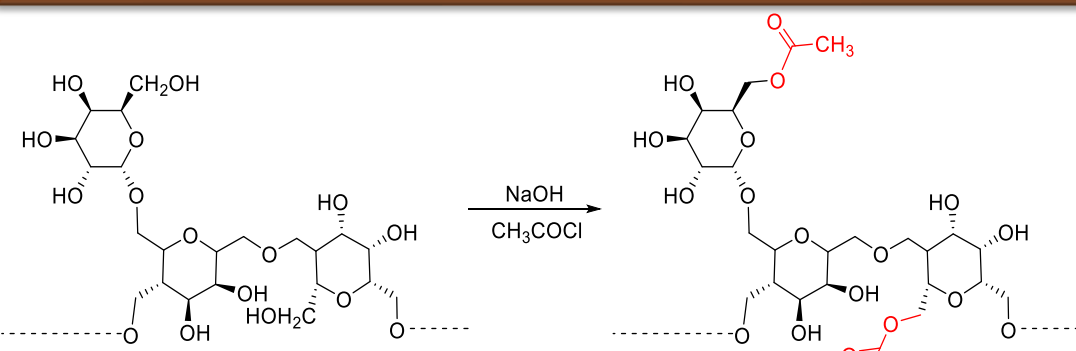


Fig. 1. Schematic of guar gum acetylation under reflux (50 °C, 4 h, N₂), where hydroxyl groups are substituted by acetyl groups to form acetylated guar gum (aGG).

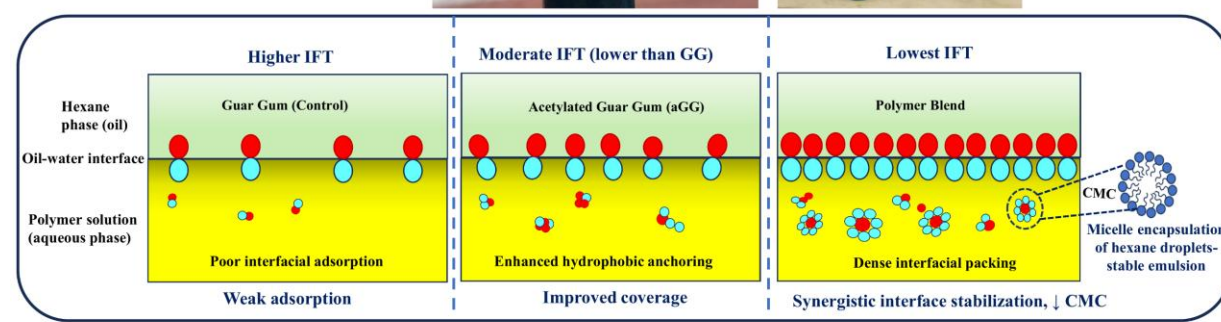
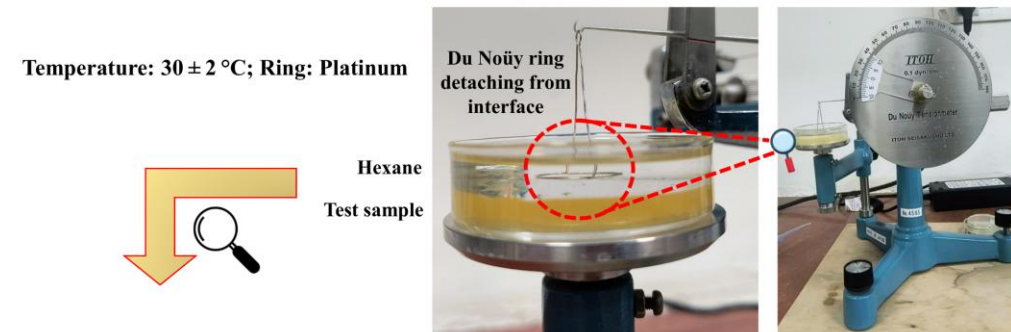


Fig. 3. IFT measurement using a Du Noüy ring tensiometer to evaluate interfacial performance of GG, aGG, and PB (1000-3500 ppm) under EOR conditions

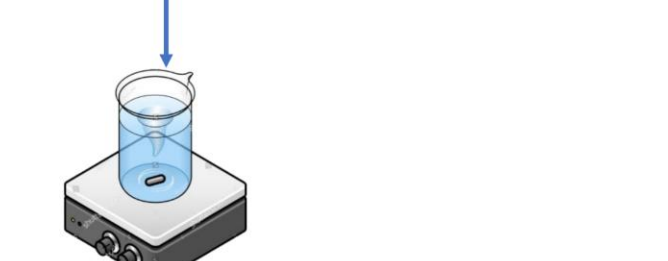
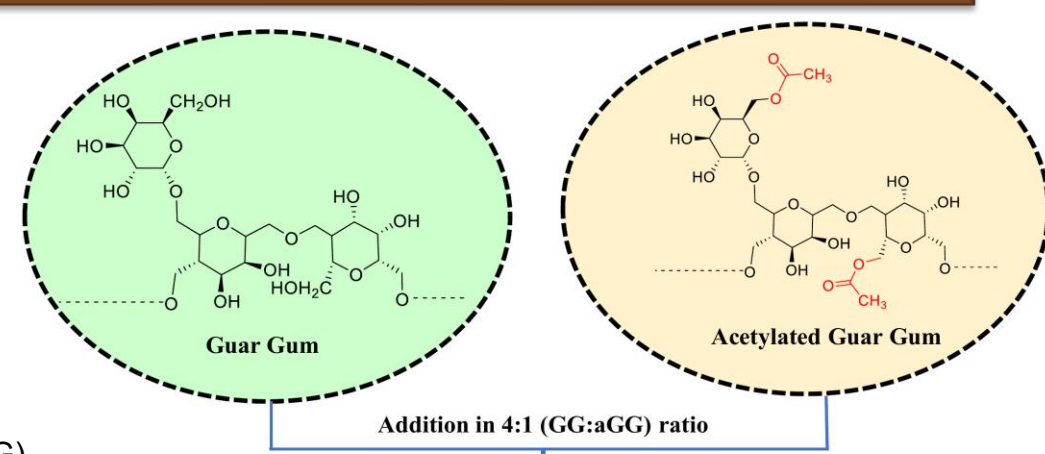


Fig. 2. Synthesis of the GG-aGG (4:1) blend under mechanical stirring to obtain a homogeneous, air-free polymer solution for EOR.

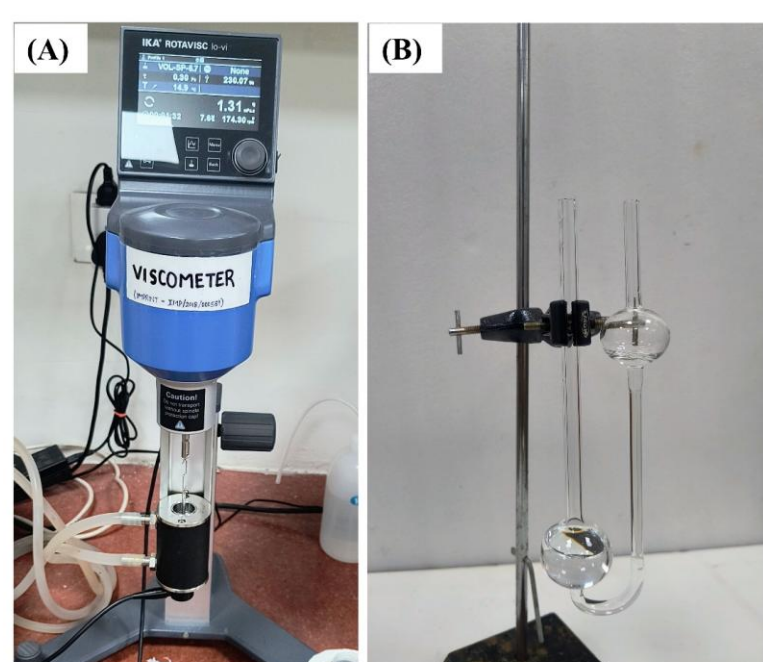


Fig. 4. Dynamic viscosity measured using an IKA viscometer and kinematic viscosity using an Ostwald viscometer.

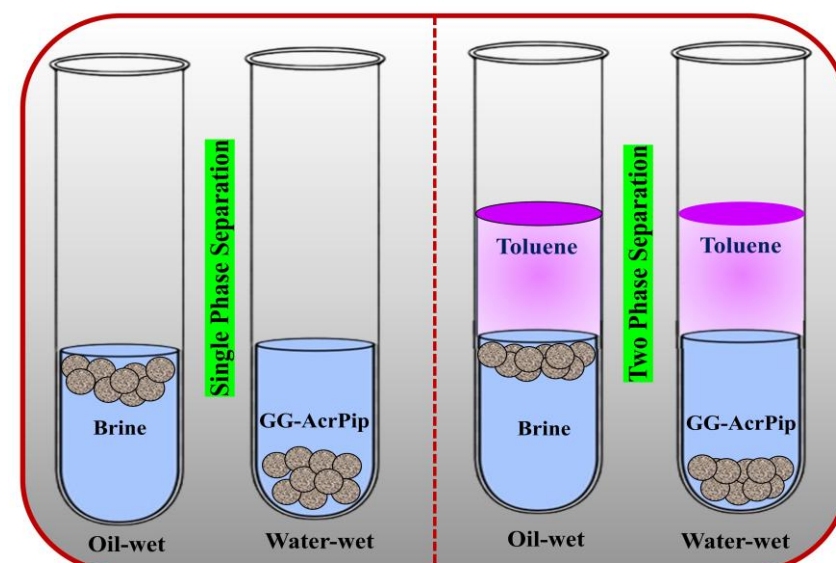


Fig. 6. Flotation test to assess wettability alteration, where polymer-treated oil-aged carbonate particles either float (oil-wet) or sink (water-wet) in a toluene-brine system.

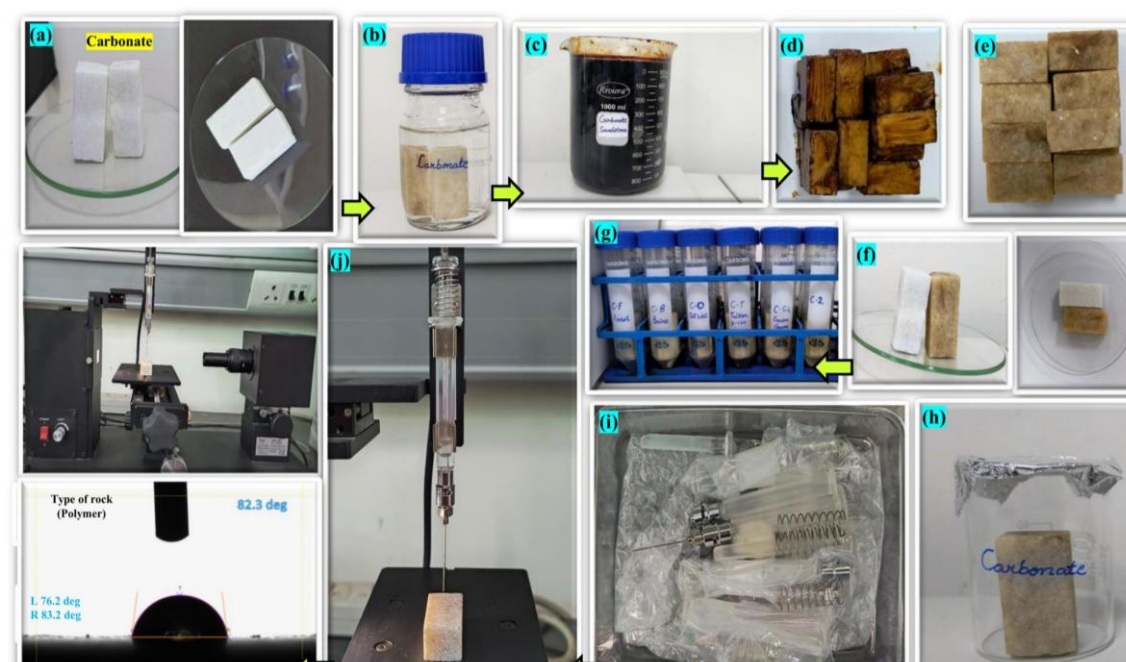


Fig. 5. Workflow for wettability alteration studies using a goniometer.

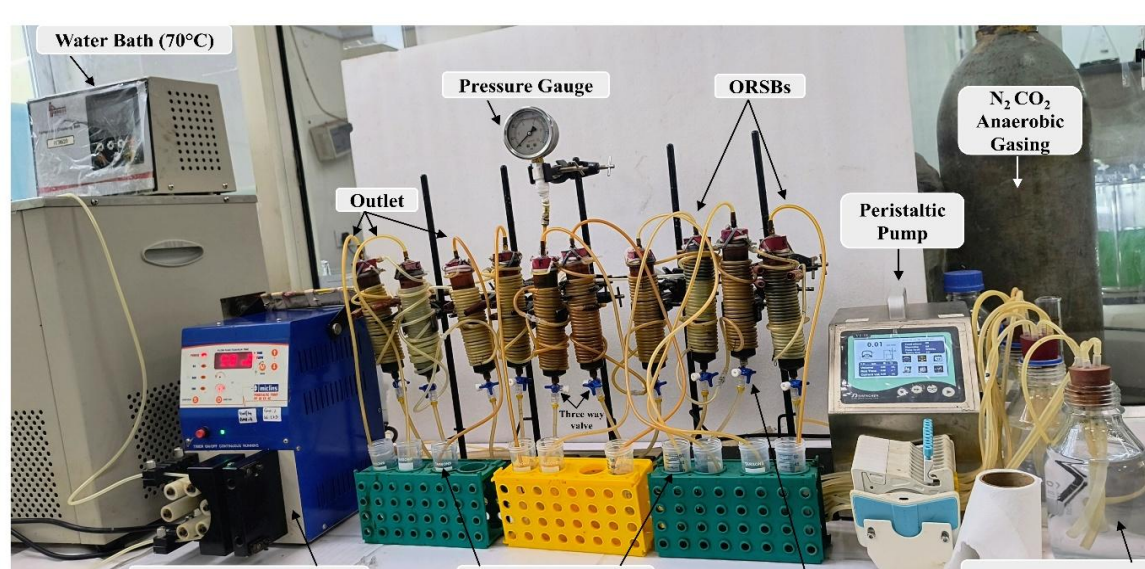


Fig. 7. Oil Reservoir Simulating Bioreactor (ORSB) setup used to evaluate the EOR performance of GG, aGG, and PB under controlled temperature, flow, and pressure conditions.

RESULTS & DISCUSSION

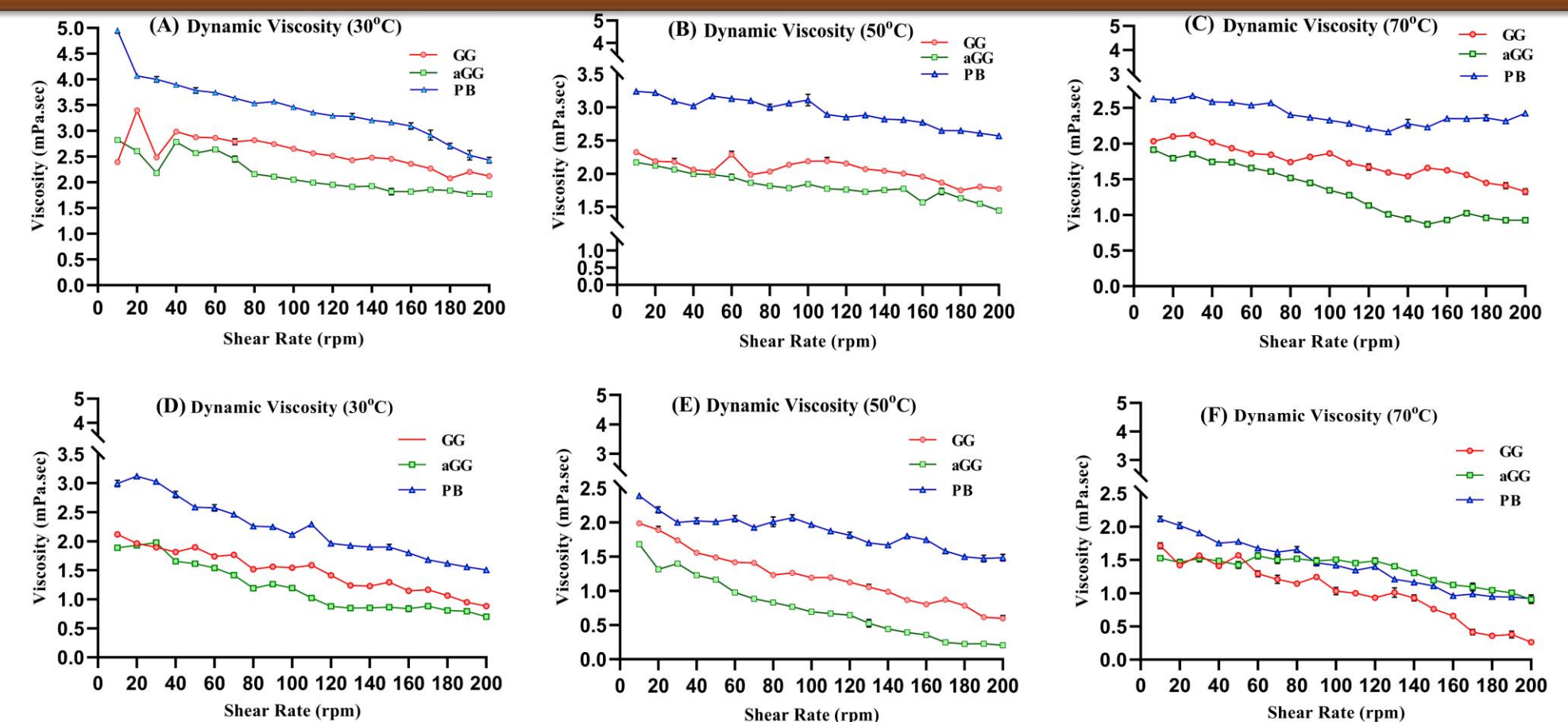


Fig. 10 Dynamic viscosity of GG, aGG, and PB as a function of shear rate in CSBK medium at 5000 ppm (A-C) and 10000 ppm (D-F) salinity, measured at 30, 50, and 70 °C.

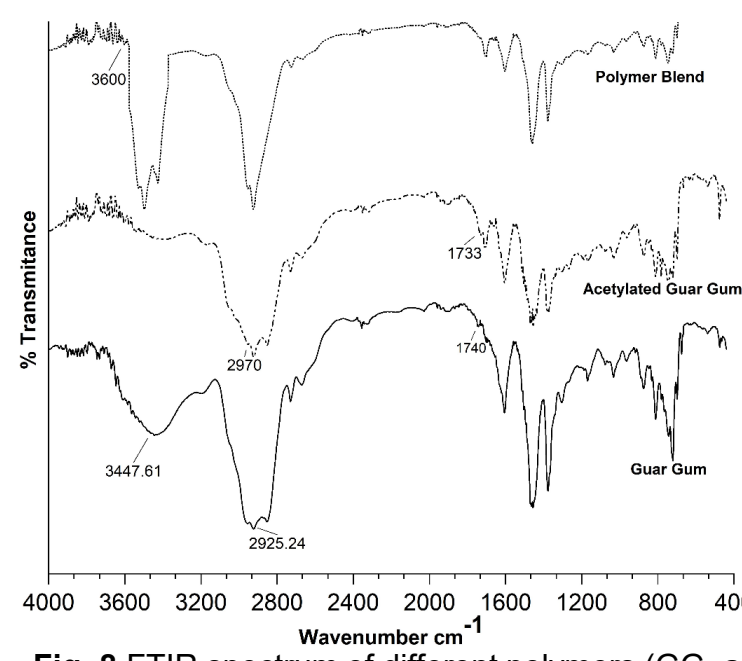


Fig. 8 FTIR spectrum of different polymers (GG, aGG and PB)

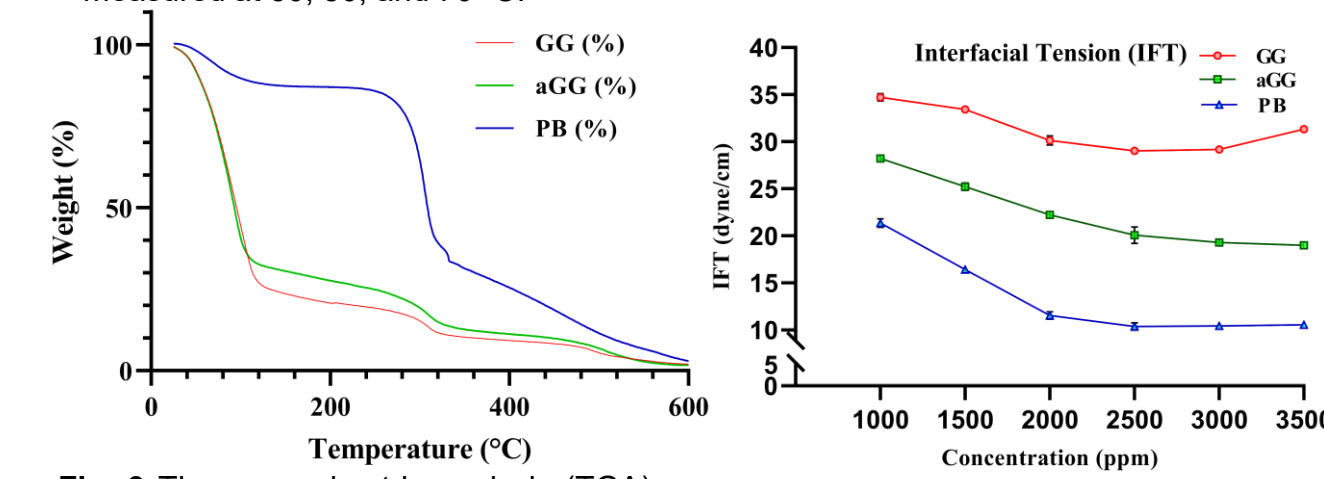


Fig. 9 Thermogravimetric analysis (TGA) curves of PB, GG, and aGG recorded under N₂ atm., plotted as wt remaining (%) vs temp (°C).

Fig. 11 Variation of IFT with different concentration of GG, aGG and PB

Fig. 8 FTIR spectrum of different polymers (GG, aGG and PB)

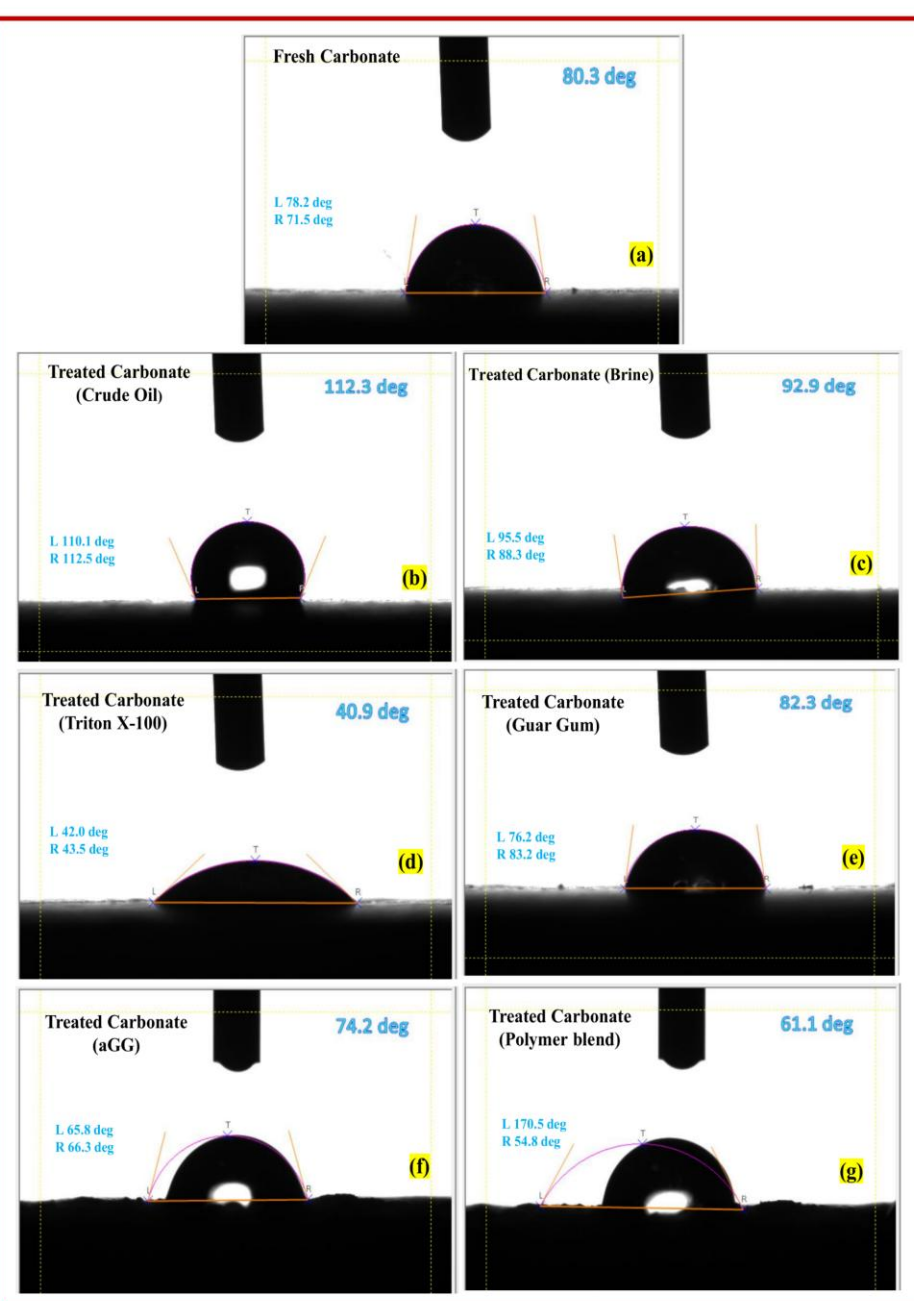


Fig. 12. Contact angle results showing enhanced wettability alteration.

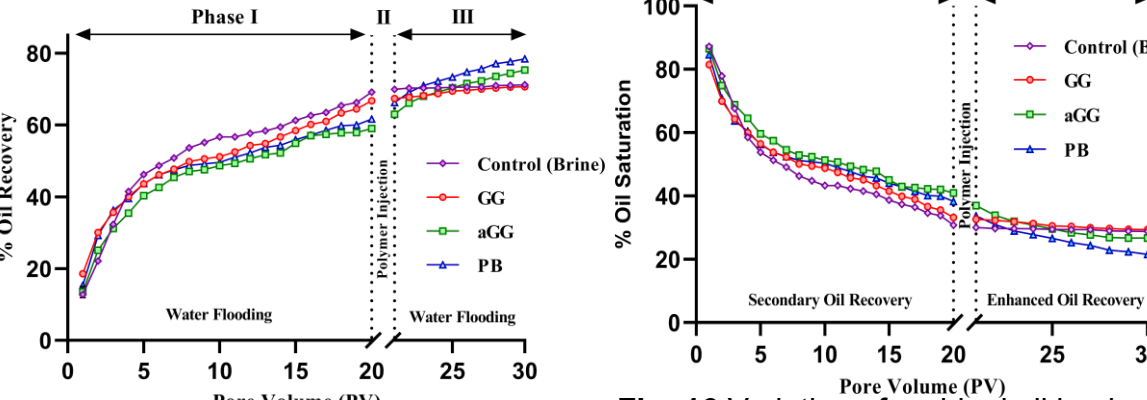


Fig. 15 Additional oil recovery obtained using different ORSB systems

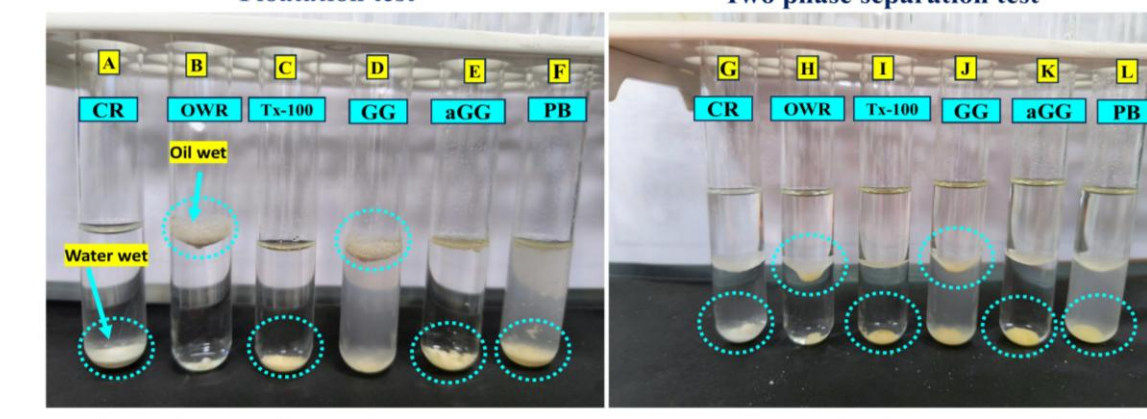


Fig. 16 Variation of residual oil in place (%ROIP) with injected pore volume (PV) for brine and polymer flooding systems

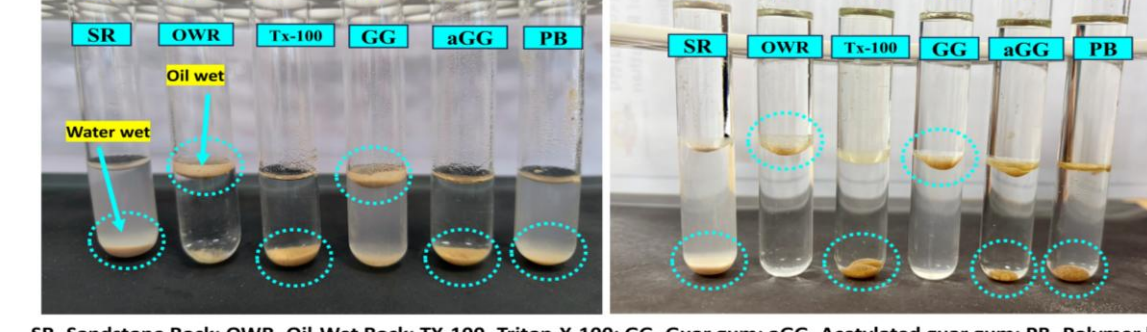


Fig. 13 Qualitative wettability tests with two-phase separation and flotation techniques in carbonate and sandstone rocks

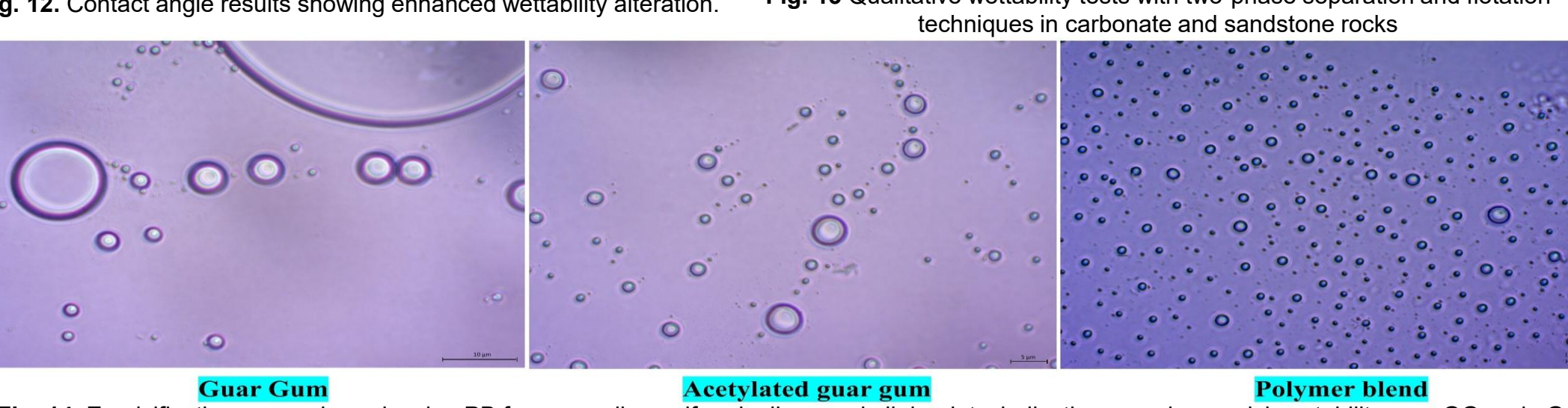


Fig. 14. Emulsification comparison showing PB forms smaller, uniformly dispersed oil droplets, indicating superior emulsion stability over GG and aGG.

CONCLUSION

- ✓ **Superior Performance:** HPMP achieved 16.78% incremental oil recovery
- ✓ **Wettability Conversion:** PB alter the carbonate rock from oil-wet (112.3°) to water-wet (61.1°).
- ✓ **Rheological Advantage:** Exhibits pseudoplastic flow, improving injectivity and reservoir sweep.
- ✓ **Translational Impact:** Cost-effective alternative to synthetic polymers; resists degradation in harsh reservoirs. Eco-friendly biopolymer from renewable sources promotes sustainable energy recovery.

FUTURE WORK / REFERENCES

- ✓ **Pilot Field Trials:** Conduct high-pressure, high-temperature (HPHT) field trials to validate HPMP performance in a live reservoir environment.
- ✓ **Commercial Viability:** Perform detailed techno-economic (cost-benefit) and Life Cycle Analysis (LCA) for industrial deployment.