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**ABSTRACT:**

Current Trends in Multi-Solvent Formulations for Sustainable Oil/Bitumen Recovery

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The advancement of solvent-based enhanced oil recovery (EOR) is increasingly validated by field-scale pilots, which bridge theoretical phase behavior with sustainable performance. This review synthesizes current trends through the lens of these demonstrations. Building on foundational multi-solvent concepts established in early patents [1.2], contemporary research focuses on optimizing tailored solvent formulations (e.g., propane-CO<sub>2</sub>, bio-solvent blends) for specific mechanisms. Pilots of solvent-assisted thermal processes have consistently achieved 20-30% reductions in steam-to-oil ratios, proving a major pathway to decarbonize heavy oil production. Concurrently, cyclic solvent injection (CSI) pilots provide critical field data to calibrate models of diffusion and dispersion, the key mass-transfer mechanisms controlling recovery in these processes. In unconventional reservoirs, multi-well huff-n-puff pilots with hydrocarbon gases demonstrate reproducible production uplifts, establishing cyclic gas injection as the leading EOR candidate. The convergence of pilot results, analyzed through the scaling challenges of these mass-transfer mechanisms, defines the current state-of-the-art: sustainability is being achieved through intelligent solvent design and hybridized processes that are precisely tailored to reservoir characteristics. Future innovation hinges on formulating solvents not only for optimal phase behavior but also for deliverability and controlled mixing at the field scale.

[1] Allen, J.C. and Redford, D.A. Method for Recovering Petroleum from Viscous Petroleum Containing Formations Including Tar Sands. U.S. Patent No. 3,927,716. December 23, 1975. (The foundational multi-solvent patent).

[2] Brown, A., Wu, C.H., and Konopnicki, D.T. "Combined Multiple Solvent and Thermal Heavy Oil Recovery", U.S. Patent 4,004,636, Texaco Inc. (1975).