

Title: Microemulsion Formulations for Environmental Remediation: from Laboratory to Field Implementation

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Microemulsion Formulations for Environmental Remediation: from Laboratory to Field Implementation

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Abstract. A Winsor Type III microemulsion is a separate, surfactant-rich phase that forms in equilibrium with excess oil and water. Varying the amount of an added simple electrolyte can induce the formation of a Type III microemulsion from an oil/water/surfactant system. The concentration of sodium chloride at which equal volumes of oil and water partition into the middle phase is called the optimal salinity, which exhibits ultra-low interfacial tension (IFT) with capacity of mobilization of the entrapped contaminants and hydrocarbons in porous media. I will discuss the critical formulation parameters, ranging from surfactant structures, phase behaviors and separations (e.g., adsorption), impacts of oil properties (both light and dense non-aqueous phase liquids), water chemistry and specific ions effects, and additives like co-solvents. The hydrophilic-lipophilic difference (HLD) equation has shown utility in guiding surfactant formulations for Winsor I, II and III microemulsions under various subsurface conditions, ranging from unconsolidated sands to consolidated rock matrix. Injection of the developed surfactant-only formulations (or so called Surfactant Enhanced Aquifer Remediation, SEAR) exhibited superior performances for remediation of source zone contaminations in subsurface in last decade. Examples of successful field-scale tests from single-well pilot to full-scale implementation projects will be described. More recently, we also developed modified surfactant formulation suitable for contaminated sites impacted by dense non-aqueous phase liquids (DNAPLs). Based on the data of numerous field projects and various site contaminants, our current and newly developed surfactant formulations offer significant advantages and differences from other technologies in several aspects to safely address site impacted by toxic chemicals to minimize negative impacts on both humans and the environments.

Keywords: Winsor Type III Microemulsions, Ultra-low Interfacial Tension, SEAR, Surfactant Flushing