INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: **Indigenous Biosurfactant Producing Strains for Potential Applications in Enhanced Oil Recovery**

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SHORT ABSTRACT

The isolation, screening and identification of potential indigenous biosurfactant-producing and oil-utilizing bacterial strains were carried out from the formation water as well as soil sample of the Assam oil reservoir. Among the isolated strains from the indigenous sources, *Bacillus subtilis* MG495086 and *Bacillus tequilensis* MK 729017 showed better surface-active properties as they lowered the surface tension (ST) to 30 ± 2 mN/m along with a high emulsification index (EI) of 70 ± 2 %. Their growth kinetics and stability studies were also performed. The produced biosurfactants were chemically identified using NMR, FTIR, LC-MS and HPLC and proved to be lipopeptide, Surfactin with very low critical micelle concentration (CMC) value. Response surface methodology based on the central composite design (RSM-CCD) experiments aimed to optimize the suitable carbon source percentage and the environmental parameters to maximize the biosurfactant (Surfactin) production in terms of surface tension (ST) reduction and biosurfactant concentration which was reduced to 29.85 mN/m and the maximum Surfactin concentration was determined to be 7.46 ± 0.39 g/L, respectively. The potential of the biosurfactants in oil degradation was also analyzed with their subsequent biosurfactant production capacity which was found to be very significant. *Bacillus subtilis* MG 495086 and

Bacillus tequilensis MK 729017 were able to degrade the hydrophobic substrate (light paraffin oil and glycerol) almost completely within 96 hours during the course of Surfactin production. Moreover, the isolated *Bacillus* strains were established to be suitable for both *ex-situ* and *in-situ* enhanced oil recovery (EOR) applications.

Surfactants can reduce interfacial tension (IFT) between water and residual oil, which improves the oil recovery factor. But one of the challenges of surfactant flooding is the adsorption phenomenon of surfactant onto the solid surfaces, which decreases its effectiveness in lowering the IFT for EOR application and leaves a negative impact on the process economics. Therefore, the adsorption behavior of Surfactin onto the model sand (silica) sample was discussed. HPLC was used to quantify the amount of surfactant before and after the course of adsorption. The rock mineralogy along with the impact of aqueous media salinity and the experimental temperature was the major variables. EDX, XRD and BET analyses have been carried out to characterize sandstone samples. Both the kinetics and equilibrium adsorption data were obtained from the batch mode studies. Among alternate models, the Freundlich isotherm model, Elovich kinetics and intraparticle diffusion kinetics fit well to represent applied biosurfactant adsorption characteristics. Effect of contact time and temperature on the adsorption process was also analyzed. The thermodynamic feasibility of the adsorption process was studied to verify the spontaneity of the process as well. These findings provided newer insights into real-time biosurfactant adsorption characteristics, which are often ignored in conventional approaches and methodologies.

The suitability of the biosurfactant for core flooding studies and subsequent microbial enhanced oil recovery (MEOR) purpose was evaluated in terms of its oil washing efficiency, stability (thermal and halophilic) studies, interfacial activities and wettability alteration capability. The oil washing efficiency (80 ± 2 %) of the produced Surfactin was quite comparable with the commercial surfactants such as SDS, CTAB and Rhamnolipid. Surfactin improved wetting of hydrophobic rock surface from 90 ± 1 ° to 26 ± 1° and resulted in a lower interfacial tension (IFT) value of 0.32 ± 0.02 mN/m. The stability of the produced biosurfactants was studied over a wide range of temperature, pH, pressure and salinity and they were found to be stable even after their exposure for a longer period. Due to its thermal and colloidal stability, the biosurfactant was further endorsed to be employed for MEOR applications.