INVESTIGATION OF BIOSURFACTANT-PRODUCING MICROORGANISMS AND THEIR POTENTIAL FOR MICROBIAL ENHANCED OIL RECOVERY (MEOR)

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Microbial Enhanced Oil Recovery (MEOR) represents an advanced biotechnological approach for enhancing hydrocarbon recovery from complex and mature reservoirs. This method utilizes the metabolic activity of microorganisms to alter reservoir characteristics, including the reduction of oil viscosity, improvement of permeability, and production of metabolites that facilitate the mobilization of trapped hydrocarbons. The application of MEOR has the potential to substantially increase oil yield and improve the overall efficiency and sustainability of petroleum extraction processes.
The potential of MEOR was investigated using oilfields in Western Kazakhstan that represent the mature phase of reservoir exploitation.Microbiological analysis of formation water revealed a rich and diverse microbial community comprising members of the classes Alphaproteobacteria, Actinobacteria, Clostridia, Gammaproteobacteria, Bacilli, Deltaproteobacteria, Epsilonproteobacteria, and Methanomicrobia. The indigenous microorganisms identified demonstrated adaptation to the extreme conditions of oil reservoirs, confirming their resilience and potential applicability in biotechnological MEOR processes.

A total of 89 indigenous microbial strains were isolated from the studied reservoirs. During the preliminary screening for biosurfactant production, 23 strains exhibited biosurfactant-forming activity. Subsequent secondary screening allowed for the identification of 19 promising biosurfactant-producing isolates, including strains M93-8C, M121-4C, M83-3B, M22-6, M22-7, M142-2, P2, P3, P4, P5, P8, P15, P19, A2, A8, A9, A12, R4, and PW2.

Genetic analysis confirmed the presence of key genes responsible for the synthesis of lipopeptide biosurfactants in the active microbial strains, including srfAA, srfAB, srfAC, srfp, and lchAA. The highest expression levels of these genes were observed in strain A9, reaching a 57,606.7-fold increase.

Infrared (IR) spectroscopic analysis verified the amphiphilic nature of the biosurfactant molecules, consisting of both hydrophilic and hydrophobic components. The observed absorption bands indicate the presence of functional groups characteristic of lipopeptide compounds, confirming their effectiveness in microbial enhanced oil recovery (MEOR) processes.

Optimization of the nutrient medium for model experiments demonstrated that the maximum microbial growth occurred in medium E8 supplemented with 2% molasses, which provided a high level of metabolic activity. This formulation was identified as optimal for biosurfactant synthesis in the selected strains.

Model sand-pack experiments showed that the application of cell suspensions from strains P8 and A9 resulted in an additional oil recovery (AOR) of 30–31%, which is three times higher than control values. Mixed cultures A8:A9 and A9:P15 demonstrated stable increases in oil recovery of 20–24%, confirming the crucial role of biosurfactants in reducing interfacial tension and mobilizing residual oil.