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Overview of early biosurfactant research

Our interest on biosurfactants started in the 1970's in conjunction with microbial enhanced oil recovery (MEOR). The emphasis and focus of many research projects was to establish the possible role of selected microorganisms in enhanced oil recovery and emulsification/de-emulsification of complex oil-in-water and water-in-oil emulsions that are intrinsically produced during enhanced oil recovery. Using selected microorganisms and/or their inherent surface active properties, a considerable increase of the yield of recovered oil is achievable, as it is generally estimated that, by just applying conventional recovering techniques, for every barrel of oil produced, two were left in the ground. This gave a tremendous boost for new avenues and for development of novel products in industrial biotechnology.

At that time, academic research relating to biosurfactants was limited worldwide, and little information was available in open literature. Industrial research in this field was secretive and protective, and only a handful of patents were accessible. Without much reference backup, our research addressed fundamental questions, such as:

a. What organisms have the potential to be used in MEOR? Under what conditions would these organisms be capable of surviving in the hostile hydrocarbon environment? What are the conditions for biosurfactant production and what are the conditions for their optimal biosynthesis?
b. Selection and categorization of biosurfactants for a specific application, at a specific oil field and environment?
c. In-situ and ex-situ application, and optimization of production of the suitable biosurfactant?
d. Laboratory and pilot-plant in the field studies and applications?

Trying to summarize and answer the above questions, we selected biosurfactants, based on their applicability potential, and performed several field trials. Relevant data and strategies will be presented.

Like always in research, the initial MEOR stimulus created new, exciting problems to be solved. Whether one uses chemically synthesized surfactants or biosurfactants in MEOR, the product one gets, is not a pure oil, but an emulsion of water-in-oil. Such an emulsion cannot go directly to refinery, but must be "cleaned" of water. Our next logical research

focused on de-emulsification of such emulsions, by using purified or raw biosurfactants, produced under specific conditions from selected substrates and industrial wastes.

A follow-up objective, addressed an important environmental problem, particularly related to the tar sands extraction of heavy oil in Alberta, Canada (estimated heavy oil reserves being larger than in the whole Middle East). During this massive process in Fort Mc Murry, enormous quantities of alkaline tailings are produced and directed to ponds. These tailings are actually oil-in-water emulsions, containing also sludge and very valuable recoverable rare earth heavy metals. Biosurfactant-enhanced de-emulsification of these inverse emulsions have been demonstrated and a patent issued on recovery of the heavy rare earth elements from these ponds. In this respect, environmentally friendly biosurfactant enhanced bioremediation of contaminated industrial sludges and water effluents, have been demonstrated.

A large problem in the environment is related to existing soil contaminated with waste hydrocarbons, petroleum or waste recalcitrant organic materials. Such contaminated sites are found everywhere, and particularly, as “war residue”. It was estimated that after the WWII, in Eastern Europe, soil contamination was present, wherever military bases existed. Also, soil is contaminated in vicinity of refineries and at expo sites. Enhanced soil decontamination using selected microorganisms and raw biosurfactants, was another one of our applied research emphasis. In conclusion, many advantages of biosurfactants will be discussed, as compared to chemically synthesized counterparts, such as:

- Biodegradability
- Generally low toxicity, biocompatibility and digestibility - which allow their application in cosmetics, pharmaceuticals and as functional food additives
- Availability of raw materials, as biosurfactants can be produced from cheap raw materials, that are available in large quantities. The carbon source may come from hydrocarbons, carbohydrates and/or lipids, which may be used separately or in combination with each other.
- Acceptable production economics. Depending on the application, biosurfactants can also be produced from industrial wastes and byproducts, and this is of particular interest for bulk production (e.g. for use in petroleum related technologies).
- Use in environmental control. Biosurfactants can be efficiently used in handling industrial emulsions, control of oil spills, biodegradation and detoxification of industrial effluents and in bioremediation of contaminated soil.
- Specificity. Biosurfactants, being complex organic molecules with specific functional groups, are often specific in their action. This would be of particular interest in detoxification of specific pollutants, de emulsification of industrial emulsions, specific cosmetics, pharmaceutical and food applications.

Today, biosurfactants research has skyrocketed as compared to the early stages of our pioneering work. This is particularly reflected in number of patents registered to date worldwide (estimated more than 600 registered patents in the field).