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Research Article

ROLE OF MICROBIOLOGY IN PETROLEUM REFINING AND MANUFACTURING OF PETROLEUM PRODUCTS

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ABSTRACT

Petroleum microbiology is an interdisciplinary area involving microbiologists, biochemists, chemists, chemical engineers, physicists and geologists. A wide range of studies have dealt with processes like biotransformation, biodegradation and bioremediation of petroleum hydrocarbons. Petroleum is a complex mixture of hydrocarbons and other organic compounds, including some organo metallo constituents, most notably complexing vanadium and nickel. Petroleum recovered from different reservoirs varies widely in compositional and physical properties. Long recognized as substrates supporting microbial growth, these hydrocarbons are both a target and a product of microbial metabolism.

Practically all geologists agree that petroleum has an organic marine sedimentary origin, but the mode of its formation is not known. Bacterial activity has undoubtedly been involved in petroleum genesis, but the extent to which bacteria have contributed to the formation of petroleum is debatable. Attempts to demonstrate hydrocarbon formation by bacteria under highly artificial conditions have yielded only small amounts of paraffinic hydrocarbons other than methane and practically none of the other myriad compounds present in petroleum. The conservative viewpoint is that bacterial action is limited to producing reduced organic matter more closely resembling petroleum than the original material and that the final stages of petroleum genesis are physicochemical.

INTRODUCTION

Deterioration of Petroleum Products

The literature on the decomposition of hydrocarbons and petroleum products has been comprehensively reviewed by ZoBell (*Zobell, C. E. 1946*). It is clear that virtually all petroleum products, when stored in the presence of water, may undergo some deterioration as a result of the activities of hydrocarbon oxidizing microorganisms. Thaysen (*Thayer, L. A. 1931*) described an interesting case of spontaneous ignition in a tank of purified kerosene stored over river water. An organism was isolated which fermented kerosene and gave methane, acetaldehyde, lactic acid, and acetic acid as products. Nitrate was an essential hydrogen acceptor. The spontaneous ignition was believed to have been caused by the ignition of methane liberated in the fermentation. Steel tanks were also shown to support the growth of sulfate reducing bacteria which contaminated the stored petroleum products with hydrogen sulfide. Allen (*Allen, F. H. 1944*) showed that bacterial action at the interface between gasoline and water in storage tanks may produce peroxides and gums and precipitate lead tetraethyl, leading to deterioration of the gasoline.

Cutting oil emulsions, used in machine shops, support growth of many types of bacteria, including sulfate reducers, which cause deterioration of the oil, and objectionable odors. Some authorities believe that these bacteria may cause dermatitis in workmen handling such oils.

Bacterial, Desulfuriation and Denitrogenization of Crude Oil and Petroleum Products

Maliyantz (*Maliyantz, A. A. 1935*) observed that certain sulfate reducing bacteria attacked Run n crude oil, and removed part of the sulfur in the process. Our own results (*Updegraff, D. M. 1954*) with Mid-Continent American crude oils were different in that no change in the sulfur content of the crude oil was brought about when the crude oil was treated with sulfate reducing bacteria in various media, both with and without the presence of sulfur compounds other than those in the crude oil.

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Strawinski (*Strawinski, R. J. 1950*) observed a decrease of 12.5 per cent in the sulfur content of an Arabian crude oil when the oil was mixed with a sulfur-free medium containing mineral salts and glucose, and incubated for four days with a culture of Peudomonas sp. which had been selected for its ability to utilize sulfur compounds present in the oil. In a later patent, Strawinski (*Strawinski, R. J. 1951*) disclosed an improved two-step process whereby the oil was first treated with a culture of an aerobic bacterium in a sulfur-free medium, thus converting part of the sulfur to sulfates, and then with a culture of sulfate reducing bacteria, which converted the sulfates to hydrogen sulfide. This method was claimed to result in more complete removal of sulfur from the crude oil. ZoBeil (*Zobell, C. E. 1953*) described a general method of desulfurizing petroleum products by means of hydrogenase producing bacteria acting on the oil under anaerobic conditions in the presence of hydrogen.

Bacteriological methods of desulfurizing crude oil are not in general use in the petroleum industry. The sulfur compounds in crude oil are mostly of high molecular weight, and our own experience shows them to be attacked by microorganisms with great difficulty. Microbiologic.al desulfurization of crude oil is not likely to compete with chemical methods unless more economical and effective methods are developed.

A similar problem is the microbial denitrogenization of petroleum. Nitrogen compounds are also troublesome in the refining of certain oils, and might be removed microbiologically in ways similar to those used for sulfur. However, the literature does not reveal any developments toward this goal.

Petroleum as a Substrate for the Industrial Manufacture of Chemicals

Another promising line of research which appears to have been generally neglected is the use of petroleum as a substrate for the industrial manufacture of chemicals. Crude oil and natural gas, pound for pound, are far cheaper than other available organic substrates. Taggart (*Taggart, M. S., Jr. 1946*) obtained a patent on a method of producing fatty acids, esters, and low-boiling alcohols by the action of BaciUus paraffinicus on natural gas under aerobic conditions. With natural gas priced at 0.2 to 0.4 cents per pound of organic matter, it does not seem out of the question to consider the possibility of the manufacture of foodstuffs by microbial action on this substrate since microorganisms are known which convert gaseous hydrocarbons to protoplasm with a high degree of efficiency.

CONCLUSION

Petroleum Microbiology, At least one university laboratory is engaged in such studies under a grant from a petroleum company, and it is hoped that other academic microbiologists will be attracted to this field in the future. An opportunity is here for fruitful fundamental research, which could provide a basis for applications in the refining and manufacturing of petroleum products. Although the petroleum companies do a certain amount of fundamental research, this is the type of information which must, at present, come principally from the academic laboratories, while in the petroleum industry microbiologists pursue information of a more applied nature. As time pass, more microbiologists should swell the thin ranks of those employed in the petroleum industry, and thus permit more fundamental work to be done, with results of mutual benefit to science and the petroleum industry.

Because of developments of possible competitive advantage in this little-known field, individual petroleum companies have restricted the publication of their research findings until they can be adequately protected by patents. Since patents require from two to five years to issue, many developments in petroleum microbiology are undoubtedly being retained in the confidential files of oil companies. The eventual publication of this material should immediately make certain aspects of this review obsolete.

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