FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

CATALYTIC HYDROCARBON CONVERSIONS FOR TRANSPORTATION AND DOMESTIC FUELS UPGRADE

By

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Professor of Chemical Engineering

INAUGURAL LECTURE SERIES 53

10TH AUGUST, 2017

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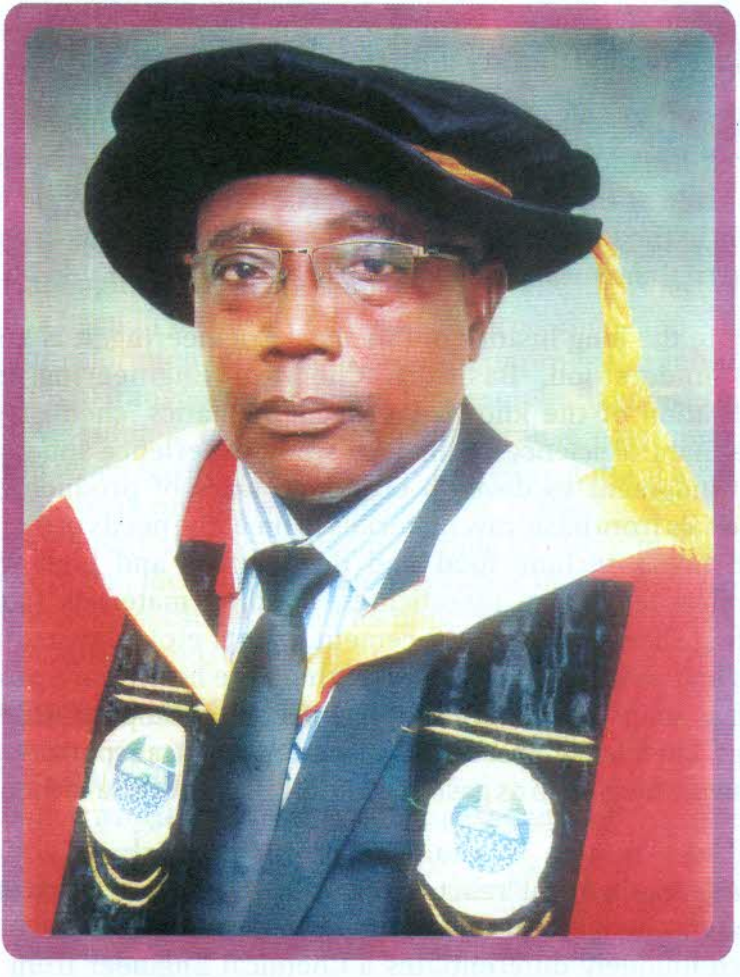

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1.0 INTRODUCTION

It gives me a great privilege and honour to present this inaugural lecture, the third from the Department of Chemical Engineering and the fifty third from the University.

Chemical Engineering as a profession was first established in the United Kingdom when the first Chemical Engineering Course was given at the University of Manchester in 1887 by George E. Lewis in the form of twelve lectures covering various aspects of industrial chemical practice.

Despite the long history of Chemical Engineering, it is still not well understood. Basically, Chemical Engineering is the application of the knowledge of mathematics, chemistry and other natural sciences, gained by study, experience and practice with judgment to develop economic ways of producing bulk materials from basic raw materials to meet the needs of mankind. Such needs include food and drinks, foot and body wears, chemical fertilizers, insecticides, building materials (such as roofing sheets, metal rods, cement, paints etc), plastics, paper; dyes and writing/printing inks. Others are health care products such as soaps and detergents, disinfectants and pharmaceutical drugs, chemically processed insulators and transportation and domestic fuels such as gasoline, diesel and kerosene to mention a few.

Design of chemical reactors for the production of materials through chemical or biological transformation is an activity which uniquely differentiates a Chemical Engineer from other groups of Engineers. Most of the needs of man are met through chemical transformations, hence the importance of Chemical Engineering

An inaugural lecture can take any of the following forms (Ogunye, 1981):

i. Concentrate on the development of the department, if the Lecturer is also the occupant of the Chair to which the leadership is attached,
ii. Focus on the Professor's own work within the general framework of his discipline, and
iii. Be on any general topic where the Professor considers that he has something fresh and stimulating to tell his audience.

For many years, I have been working in various aspects of the Chemical Engineering profession, but a significant aspect of the work has been in the area of catalytic hydrocarbon conversions either for reforming purpose in order to improve the antiknock properties of transportation fuel or for desulphurization in order to remove sulphur from fuel which can cause environmental pollution when burnt in engines. It is therefore natural for me to choose to speak on catalytic hydrocarbon conversions which is an essential part of the petroleum refining industry. In doing so, this lecture will focus on petroleum which is the primary source of hydrocarbons, catalysis and its importance in the petroleum refining industry and our modest contributions.

2.0 BACKGROUND

2.1 Petroleum and its Origin

Petroleum is a mixture of hydrocarbon gases and solids dissolved in liquids. It also contains compounds of oxygen, nitrogen, sulphur and different metals such as cobalt, nickel, potassium, calcium, sodium, silicon, copper, etc.

It is a Greek word coined from petra meaning rock and oleum meaning oil. Accordingly, petroleum means rock oil. It belongs to the family of energy resources called fossil fuel and it is a naturally occurring brown to black flammable liquid. Although exactly how it originated is not established but it is generally agreed that it is obtained from the accumulated debris of dead

plants, animals and living organisms in aquatic or marine environment over long periods of geological times and consequently organic in nature. This accumulated debris gives rise to sedimentary rocks which undergo complicated chemical transformations in the absence of air, in the presence of salt water from the sea and under high pressure. The resulting material becomes richer and richer in carbon and hydrogen, but less and less rich in oxygen and nitrogen. This new product can be liquid (petroleum) or gaseous (methane, ethane, propane, etc). The gases are formed under higher temperature conditions whereas the petroleum is formed under lower temperature conditions.

The formation of petroleum is a very slow process and is influenced by:

i. catalytic effects of clays;
ii. increased temperature (about 250°C);
iii. increased pressure (50-200 atm);
iv. biochemical activity of microorganisms.

The rocks where petroleum and gas were formed are known as the source rock. If these rocks are sealed by a layer of impermeable rock called cap rock, the petroleum accumulating within the pore spaces of the source rock is trapped to form petroleum reservoir. However, if conditions for trapping petroleum do not exist, petroleum and gas migrate under the effects of pressure and gravity, from the source rock until it is trapped in another capped (sealed) rock. The geologic structure in which petroleum reservoir has been trapped and accumulated, whether it is the source rock or the rock to which petroleum has migrated is called petroleum reservoir. Petroleum reservoirs exist in different sizes and shapes of geologic structures (Abdel-Aal et al, 2003). It is from this reservoir that petroleum is produced by drilling well(s) through which it is

pumped or forced by pressure to the surface. Typical reservoirs are shown in Figures 1-5 (Abdel-Aal *et al*, 2003).

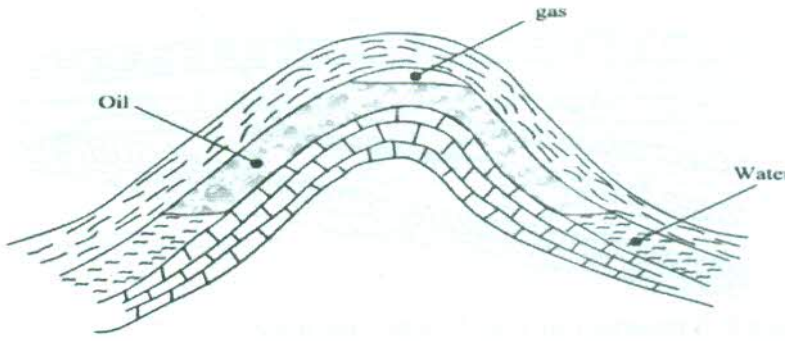

Figure 1: A reservoir formed by folding of rock layers

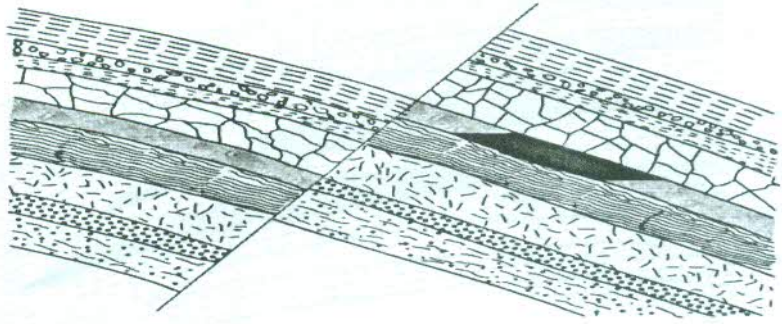

Figure 2: A cross section of a faulted reservoir

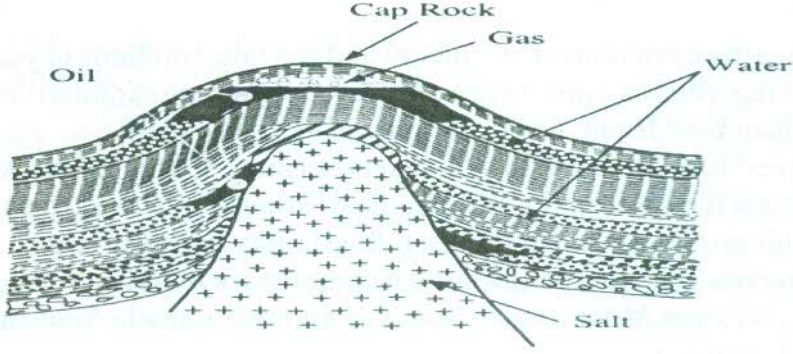

Figure 3: Section in a salt-dome structure

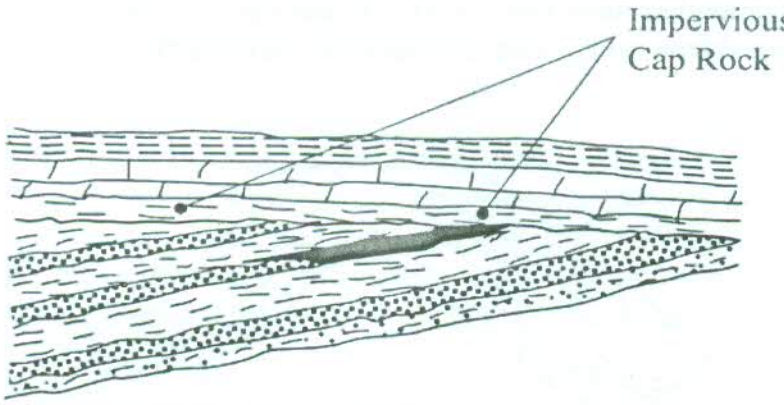

Figure 4: A reservoir formed by unconformity

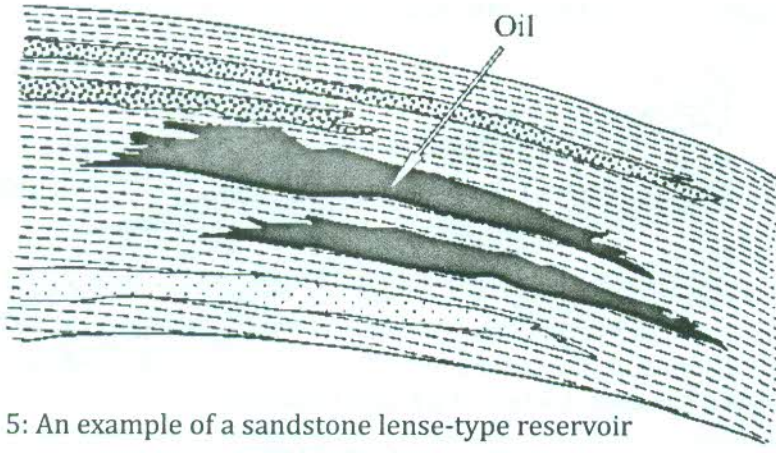

Figure 5: An example of a sandstone lense-type reservoir

Since the formation of petroleum and gas takes millions of years, it is regarded as a non-renewable resource whose exploitation in human time frame will eventually lead to its exhaustion. About three-fifths of the world's oil reserves can be found in Asia with most of it located in the Middle – East. Other Asian countries rich in oil are China and Indonesia. Russia has the next largest oil reserves. The other important oil reserves are found in Northern and Western Africa, United States of America, Canada, Venezuela and Australia.