SYNTHETIC MOTOR FUELS*

BY

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THE technique of warfare has been revolutionised in the last decade. Machines decide the fate of battles more than anything else. And they are mostly fitted with internal combustion engines which use petrol in large quantities. A fighter plane of the Hindustan Aircraft Co., develops 1000 H.P. in ten cylinders and consumes more than 200 gallons per hour. Ample supply of petrol is therefore an integral part of a defence programme. In Germany, which has no natural resources in mineral oil, synthesis of petrol has received very considerable attention; and in 1937, she produced 1·4 million tons of motor fuel from her factories as against her consumption of 2·5 million tons. This synthetic fuel was constituted as follows:—Coal tar benzene 300,000 tons, power alcohol 150,000 tons; Fischer-Tropsch oil 150,000 tons and Bergius oil 800,000 tons. Coal tar benzene and power alcohol which are bye-products of other industries cannot obviously be depended upon to yield all the motor fuel requirements of a progressive country. In India, a beginning has been made in the production of benzene from coal tar and of power alcohol from waste molasses; and vast developments in these fields should be possible.

The Bergius process consists in the conversion of coal, tar and creosote into oil by hydrogenation under pressures of 200–700 atm. and temperature of 400–500° C. Use of catalysts like oxides of molybdenum and tin has recently helped to make the operating conditions less severe. The Fischer process, on the other hand, has the merit that the operating conditions are very simple; a mixture of carbon monoxide and hydrogen, in the ratio of 1: 2 is passed over a catalyst at temperatures not exceeding 220° and pressures not exceeding 15 atm. More often a pressure of 1 atm. and a temperature of 185° are employed. In view of this simplicity of operation, the Fischer process is making rapid strides and bids fair to cast into shade the older Bergius process.

The complete Fischer process consists of three parts:—(1) Preparation of synthesis gas ($CO : H_2$ as 1 : 2), (2) Conversion of synthesis gas into higher hydrocarbons and (3) Processing of these hydrocarbons into motor fuel.

Synthesis gas is now prepared by enriching water-gas ($CO : H_2$ as 1 : 1) with hydrogen. Considerable economy has been effected in recent years in Germany in the manufacture of water-gas and hydrogen. For example, instead of transporting coke from a coke-oven plant to a water-gas plant where it is converted into water-gas by the action of steam at 1000° C., the German technicians have developed the practice of making water-gas *in situ* by the action of superheated steam on the coke as it is discharged from the coke-oven furnace operating at a temperature of 1200°. Since the ultimate object is to completely gasify the coke into water-gas the very much cheaper brown coal is now used in Germany which yields from the coke-ovens a porous solid fuel capable of much quicker gasification. Hydrogen is manufactured now in a continuous process with the aid of oxygen obtained as a bye-product from the synthetic ammonia industry according to the following simultaneous reactions:—

$$C + O_2 = CO_2 = 98,000 \text{ Cal.};$$
$$C + 2H_2O = CO_2 + 2H_2 - 19,000 \text{ Cal.}$$

If, as in the Lurgi process, the reactions are carried out at a pressure of 10 atm. the carbon dioxide is removed when blowing off the condensed steam, and hydrogen is obtained ready for the enrichment of water-gas. It is claimed that synthesis gas is now produced in Germany at 0·6 Pfg. per m^3.

The catalysts used in the Fischer process consist generally of suitable mixtures of two or more of the carbonates of the following metals:—Cobalt, Copper, Nickel, Iron, Manganese, Thorium. It is expected of the catalyst to selectively disrupt the bond between C and O in carbon monoxide, favour the reaction between this O atom and H_2 to form water, and the reaction between the Carbon with H_2 to form the radical CH_2, which in its turn yields $(CH_2)n$ or $C_n\ H_2n + 2$. The preparation of such a catalyst is even now more of an art than a science; and Fischer's frank statement will be appreciated by all workers in this line:—"After Dr. Tropsch had left me in 1928 in order to found the *Czechoslovakian Institute of Fuel Research* at Prague, it took another six years before Koch, Meyer and I could again produce catalysts of high activity."

The catalysts are kept in vertical cylindrical convertors with arrangements for water cooling, and synthesis gas gives an end product which has the following composition:—

Yield in Grams per m^3 of Synthesis Gas

Paraffin Wax	Oil above 200°	Gasoline Fraction below 200°	Gaseous hydrocarbons more than 50% C_3 and C_4
15	43	73	50

The processing of these Fischer end products to produce gasoline follows the same lines as those developed by petroleum technologists in America. It is the peculiar merit of the Fischer

* A synopsis of a lecture delivered in the Chemistry Colloquium of the Indian Institute of Science on -11-1941.

process that C_3 and C_4 hydrocarbons preponderate in the gaseous products. Their conversion into polymer gasoline by the Ipatief method is quite simple and almost quantitative. These gasolines have very high octane numbers and are prized as aviation petrol. The oil boiling above 200° is processed for Diesel oil, and the residue is subjected to catalytic cracking to yield hydrocarbons which are again converted into polymer gasoline.

Fischer plants in Germany were responsible for production of 150,000 tons of oil in 1937, 600,000 tons in 1938 and 1,000,000 tons in 1939. It is not known what progress has been made during the war. Japan placed orders for 3 Fischer plants from Koppers Co. of Essen in 1938, and their erection was completed in 1939. The question of the cost of production of light motor spirit by the Fischer process was gone into carefully by the Imperial Defence Committee of Great Britain. The estimate came up to 11*d.* per gallon which is not much different from the cost of production of the I.G. Farben-industrie—about 10*d.* per gallon. Before the War of 1914, Germany imported all her requirements of nitre from South America. In 1934, she was producing 1·2 million tons of fixed nitrogen, much of which she was selling abroad at Rs. 350 per ton of fixed nitrogen. It is probable that this war may do for the synthetic motor fuel industry what the last War did for the synthetic nitrogen industry.

The mineral oil resources of India are meagre—small deposits are being worked in Attock and Assam. Following the example of some enlightened European countries, she should insist that mineral oil should be imported in the crude state and refined within her borders. Such refineries in addition to providing employment for skilled labour, will be producing as bye-products, fine chemicals and solvents which are essential for her industrial development. A fuel research organisation with very well-equipped laboratories and financed on a generous scale is one of the crying needs of the hour. We understand that such a project is receiving the attention of the *Board of Scientific and Industrial Research* and we hope that early steps will be taken to bring it into being.

CENTENARIES

Kuhn, Adam (1741-1817)

ADAM KUHN, an American botanist and physician, was born at Germantown, Pa, November 17, 1741. Having studied medicine under his father, he went to Sweden in 1761 to study medicine at the University of Upsala.

There he became a student of Linnaeus. He carried to his professor a new plant of North America in a living state. It belonged to the family compositæ. The professor named it after his pupil and thus Kuhn was immortalised in botanical nomenclature.

From Upsala, Kuhn went to London in 1764 and thence to Edinburgh where he became M.D. in 1767. There his botanical interests were strengthened by his association with John Ellis. Kuhn returned home in 1768 and became professor of botany and materia medica in the College of Philadelphia. He was one of the founders of the College of Physicians of Philadelphia. He was also the first professor of botany in America.

Kuhn died at Philadelphia July 5, 1817.

Foster, Frank Pierce (1841-1911)

FRANK PIERCE FOSTER, an American dermatologist, was born in Concord, November 26, 1841. At the age of 15 he underwent an operation on his right arm and this made him choose his profession. He took the M.D. degree in 1857 from the College of Physicians and Surgeons of New York. He spent a year as a ship's surgeon on a Pacific mail steamer. During his voyages he used his leisure hours in studying German. This scholarship was so kept up by him that he was selected in 1900 to re-edit Adler's *German-English dictionary* (1902).

Having served a while in the army, he settled in New York in 1865. At first he practised general medicine but later specialised in gynæcology. An ingenious method of extracting the fœtus after transverse presentation bears his name.

Still later he specialised in dermatology. Having witnessed the abuses of the then universal practice of arm-to-arm vaccination, he became an earnest propagandist for the use of animal lymph and introduced the manufacture of animal vaccine into America in 1871. He established a vaccine farm which brought him much money. In 1872 he won a prize for his thesis on animal vaccine and in the next year, the British Medical Association invited him to deliver an address on the same subject.

In the seventies he was librarian of the New York Hospital. In 1880, he became editor of the *New York medical journal.* His *Illustrated encyclopædic medical dictionary* (1888–94), 4V., which was translated into four languages engaged him for twelve years. He was also the editor of the *Reference handbook of practical therapeutics* (1896–97), 2 V. As chairman of the Commission appointed by the American Medical Association to revise the medical nomenclature, he wrote the reports published in 1909, 1910 and 1911.

Foster died of cancer of the throat at Chadwick, August 13, 1911.

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University Library,
Madras.