REFERENCE PAPERS

WARTIME INFORMATION BOARD, OTTAWA

No. 10 July 20, 1943.

Synthetic Rubber in Canada

Singapore and the Nation's Rubber

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Solving the Problem

In co-operation with the United States, which found itself in a like position to that of Canada after the loss of its major world sources of crude rubber supplies, steps were taken to provide a usable and effective substitute for natural rubber. Stocks of rubber, as well as information within the two countries, were pooled and a decision was reached through joint consultation between the best technical experts of both countries that the only satisfactory substitute for natural rubber under existing conditions was a type known as Buna-S synthetic rubber.

The name "Buna-S" derives from the first syllable of butadiene, "Bu," and the first syllable of natrium, the classical name for sodium, "Na," sodium being originally used as a catalyst in the polymerization of butadiene. The letter "S" stands for styrene. Butadiene is a gas at normal temperature, that is, above 23 degrees Fahrenheit. It may be vulcanized with sulphur and rubber accelerators and cured to hard rubber. Its resistance to atmospheric deterioration is slightly higher than that of natural rubber. Tests made to date indicate that a combination of Buna-S rubber with nylon or rayon fabrics will make a tire

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Co-operation with the United States

At the time the decision was taken to embark on the production of Buna-S, most of the United States program was predicated on the use of petroleum as a base stock in the production of butadiene, which, compounded with styrene in a polymerizing process, becomes artificial rubber. In order to place the project on a working basis with a minimum of delay, and to assist with the obtaining of necessary priority ratings in the United States for equipment and materials not procurable from Canadian sources, it was considered advisable to use existing plans, designs, drawings and specifications prepared and developed by the Rubber Reserve Company in the United States. In addition, patents for the process of polymerization were pooled and made free to both governments for the duration of war and for a certain period thereafter, and the results obtained after extensive development work in the production of butadiene from a petroleum base were made available to Canada on the same basis as similar projects in the United States.

Canada was given full benefit of the patent pooling agreements which had been made by the Rubber Reserve Company with the companies and industries in the United States whom it was felt were best qualified to help the government overcome the intricate problems arising out of the manufacture of synthetic rubber on the large scale required for war. Processes included in valuable patents owned by the Standard Oil Development Company covering the manufacture of Buna-S and Butyl rubber, and butadiene, became royalty free for the period of the emergency. About one-quarter of the materials and equipment required was not obtainable from Canadian sources, and through the correlation of the programs of the two countries Canada was able to obtain considerable

quantities of specially designed equipment be merely duplicating orders with the fabricators.

Petroleum as the Base

The main decision made in Canada was to erect a plant capable of producing 34,000 long tons of Buna-S synthetic rubber a year and the two basic materials required for its manufacture, butadiene and styrene. A survey showed that petroleum, as a base for butadiene, would be the cheapest and most satisfactory process. It was found that the total facilities for the production of alcohol in Canada would produce something less than one-third of the alcohol required to provide the butadiene equivalent of the rubber required for the Canadian war program. It was also determined that the combined cost of building additional facilities for the production of alcohol, and the cost of building plants for the manufacture of butadiene from alcohol, were greater than the costs of building a plant capable of producing a similar quantity of butadiene from petroleum. Technicians also found that in the cracking processes involved in recovering butadiene from petroleum certain valuable materials could be recovered, including ethylene, the basic material required in the manufacture of styrene, and isobutylene, the very cheap basic material used in the manufacture of butyl rubber.

Subsequent tests revealed that amounts of butadiene, ethylene and isobutylene sufficient for the production of 34,000 long tons of Buna-S rubber and 7,000 long tons of Butyl rubber could be procured without materially detracting from normal gasoline and oil supplies in Canada. In the petroleum processes for the production of Buna-S synthetic rubber, that part of the oil that is used consists of the lighter fractions that are taken off in cracking, and after the requirements of rubber have been obtained the fuel oil left is not materially lessened in value. The only difference that may be noted in the oil, after the light fractions have been taken out, is that it may not be quite as active in starting a car.

An additional factor in determining petroleum as the base was the nearby presence of an oil refinery fed by pipe line, which would enable

the centralization of the operations at one point with the assurance of continuous production, whereas production of butadiene and styrene from an alcohol base would be contingent on a ready supply of tankers and tank cars.

By extending the cracking facilities of one of Canada's largest refineries, it was found possible to obtain the desired quantities of three gases for which a limited use had previously been found, namely, ethylene, isobutylene and butylene, on a relatively low cost basis. These gases are then transferred by pipeline to nearby styrene, Butyl and Buna-S copolymer plants, without costs, complications, difficulties and dangers which might be involved in their transportation by tank cars. The main raw material in the production of Butyl rubber is isobutylene, a basic gaseous hydrocarbon collected directly from the refinery-gas stream and polymerized directly into synthetic rubber. At the present time, Butyl rubber is not suitable for the outer casings of tires, since it does not withstand abrasion, but it is more suitable than Buna for certain other commercial uses. Practical applications of Butyl rubber have been comparatively few since there had never been a pound of Butyl made in Canada outside of laboratories and pilot plants before the fall of Singapore.

Rubber and Wheat

In the production of synthetic rubber from wheat the method most widely discussed was to produce alcohol and then to make butadiene from the alcohol. It has been estimated that the cost of production of industrial alcohol from grain at 80 cents a bushel would be from 50 cents to 60 cents a gallon, with the cost of conversion alone estimated as approximately 15 cents to 17 cents a gallon. When other costs are taken into account it would require that, as a practical proposition, grain be purchased at a price from 25 cents to 30 cents a bushel. The production of butadiene from a petroleum base does not, however, preclude the possibility of using an alcohol base at some future date should it be found economical and advisable to do so. It is estimated that a gallon of alcohol yields approximately 2.75 pounds of butadiene, and that the theoretical yields of butadiene from alcohol

and butane respectively are 59% and 93% by weight, and that the cost of producing butane from industrial alcohol is about three times the cost of production from butane.

If all feasible Canadian rubber requirements were made from a wheat base it would probably utilize no more than 20,000,000 bushels at most: Canadian wheat in storage as of March 31, 1943, the last estimate, was 798,000,000 bushels. The estimated Canadian production of alcohol in 1943 is 14,000,000 gallons, which would require about 7,000,000 bushels if the total were made from wheat. It is doubtful whether chemurgic developments will ever take up more than a fraction of the Canadian wheat crop.

Scientific Development

Scientists of the applied biology branch of the National Research Council, working in conjunction with their colleagues in the United States, have pioneered the way in the production of butylene glycol from wheat which can be converted to butadiene more efficiently than alcohol. Two processes have been developed by which glycol may be produced from wheat. In the first, the starch in the wheat is changed into sugar, either by malting or by treating with acid, known as acid hydrolysis. The sugar is then fermented with "Aerobacter", a bacteria obtained from the soil, producing meso-glycol, a liquid with a freezing temperature of about 60 degrees Fahrenheit.

The second method involves cooking the wheat and fermenting it by another type of soil organism known as "Aerobacillus", which works directly on the starch in the wheat and produces a product known as laevo-glycol. While both types of glycol have the same structure and are equally suitable for conversion to butadiene, the latter can be utilized as an antifreeze, which in proper mixtures with water has a freezing point of about 40 degrees below zero, Fahrenheit. The first method, however, produces greater quantities of glycol and contains less alcohol than the second. When glycol has been attained butadiene may easily be made, and through the addition of styrene in the polymerization process, compounded into Buna-S rubber.

Polymer

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Polymer

Production of synthetic rubber in Canada has been centralized at Sarnia, Ontario, an area served by water, rail and highway transportation, and at a relatively short distance from the plants engaged in the production of tires, which will consume about 85% of the synthetic rubber to be produced. The plant, operated by Polymer Corporation Limited, a Canadian Crown company, is expected to be completed and in full production by November 1, 1943. The plant investment, operation, products and by-products are owned and controlled by the Canadian government. The project has been designed to meet the full war needs of Canada, and though it will not meet the peacetime needs in addition, it is expected that it will wholly meet post-war needs, with some allowance for industrial expansion. The government's investment in the corporation is between $40,000,000 and $45,000,000, representing an average plant investment of approximately $1,000 a ton of annual capacity.

Present indications are that the construction of the styrene plant will be far enough advanced to commence with the manufacture of ethylene from alcohol in the near future and of styrene at the rate of 6,000 tons per year within a short time thereafter. On the other hand, the copolymer plant can operate only if supplies of butadiene can be procured from the United States, since the butadiene plant at Sarnia will be the last to be completed and brought into production. The construction of the two butadiene units has been delayed because of difficulties in obtaining certain equipment, but it is expected that the first unit will be completed some time in September, 1943, and the second unit about a month later, each unit with a rated capacity of 15,000 tons a year. If supplies of butadiene can be obtained from the United States the plant should be operating at about 25% of capacity and manufacuring Buna-S rubber by August 31, 1943. Imports of rubber substitutes of the Buna-S and Butyl type are exempt from customs duties and war exchange tax, and the same treatment has recently been extended to imports of butadiene.

Rubber - Synthetic and Natural

In the making of synthetic rubber, it has been found advisable on occasion to add a certain amount of natural rubber in order to

obtain a product of the highest standard suitable for military use under combat conditions. To obtain this natural rubber in Canada a co-operative enterprise involving the science service of the federal Department of Agriculture, which is responsible for the production phases of the program, the applied biology division of the National Research Council, which is engaged in perfecting methods for the extraction of rubber from these plants, and the chemistry division of the National Research Council, which is engaged in processing it, is being carried out. The department of botany of the University of Toronto is also working on fundamental problems of selection, breeding and analysis in connection with the program.

Research in this field was undertaken in June, 1942. Of the numerous plants tested, it was found that milkweed had the most potentially adaptable qualities. In January, 1943, a method for the mechanical extraction of rubber gum from this plant was evolved. Preliminary investigations indicate that this gum will blend well with the Buna-S synthetic product to be produced in Canada, decreasing the heat embrittlement properties, increasing tear resistance and improving tack and processability.

It is estimated that an acre of milkweed will yield from one to two tons of air-dry leaves, which in turn, will yield from 150 to 300 pounds of gum. The leaves must be gathered, dried, cooked in an alkaline solution, washed, and the resulting compound crushed and ground in a pebble mill. An experimental processing mill in Ottawa is expected to produce about five tons of milkweed gum during 1943. This is to be obtained from wild stands harvested by school children and farmers under the general direction of the federal Department of Agriculture.

Other experiments have been conducted in Canada with other plants, including goldenrod, dogbane, and kok-saghz or "Russian dandelion". Although the rubber produced from the latter plant compares favorably with Malayan rubber, production costs at present in

Canada are largely prohibitive. It has been found that the growing of kok-saghz involves considerable labor and mechanical difficulties. The rubber in the plant is in the roots, which sometimes extend 15 to 20 inches into the soil. Some sort of modified potato digger would have to be perfected to harvest this plant. Gathering of the seeds presents another problem, since the seeds do not all ripen at the same time, and a constant vigil would have to be kept over the fields during the period of flowering, which usually continues for about six weeks.

On the other hand, the rubber of the milkweed is found in the leaves, and the seeds are in pods. Some sort of combine should be suitable for the harvesting of this plant. In addition, the seeds might be used in the production of oil, and the stalks produce a fibrous material which can be used for cordage or made to take the place of woodpulp for various uses. The "fluff" of the pods has also been found to make an excellent substitute for kapok, a vital war material which, like natural rubber, is now almost entirely in the hands of the enemy or cut off by hazardous shipping conditions.