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# History of Natural Rubber

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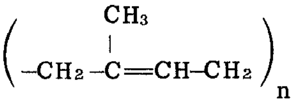
## ABSTRACT

Natural rubber derived from latex of the Hevea brasiliensis tree constitutes over 30% of the world's rubber hydrocarbon consumption. Though known to Indians of South America centuries before Columbus, Europeans could not make practical use of "cahutchu" for some 300 years. Goodyear's discovery of vulcanization in 1839 sparked an industry that was to grow dramatically at the turn of the 20th century with the advent of the bicycle and automobile industries. The transfer of Hevea by Wickham from South America to the Orient and the development of superior tapping methods by Ridley contributed greatly to the domestication and output of the natural rubber (NR) industry. Plantation rubber from Southeast Asia thus provided abundant quantities until World War II. Competition from the synthetic rubber industry, owing to cheap oil (until 1973) and the fast-growing world market in the last 40 years, eroded NR's technoeconomic share of the market. Dynamic production and agronomic programs by the NR industry, especially in Malaysia, are spearheading efforts to meet projected demands for NR in the future, while NR presented in Technically Specified presentation forms now constitutes over 50% of world consumption. The contribution to increased world NR supplies is manifest in the growing smallholder output and constitutes an important socioeconomic element in developing countries. An International Rubber Agreement, completed in 1979, will ensure more equitable returns for the producing industry and more stable prices for the consuming industry. All elements exist for a prosperous future

for the NR industry as it enters its second century. For the foreseeable future it will remain a cheap source of rubber elasticity in this age of depleting nonrenewable resources and social awareness of environmental pollution.

Natural rubber is produced commercially from the latex of the Hevea brasiliensis. The plant is indigenous to South America, especially the Amazon Valley. Due to its susceptability to South American Leaf Blight, commercial production in South America is limited. More than six million hectares are now cultivated in the tropical regions, especially in Southeast Asia, where the annual rainfall is not less than 200 cm and evenly distributed, and where the temperatures generally range from 25-35° C. Hevea grows best below about 300 m altitude and is reasonably tolerant to most types of soil and to moderately hilly terrain. The rubber produced from latex contains, beside the hydrocarbon, small quantities of protein, carbohydrates, resin-like substances, mineral salts, and fatty acids. These other constituents act in part as natural accelerators and antioxidants. Chemically, natural rubber is cis-1,4-polyisoprene with the empirical formula $(C_5H_8)_n$ and the structural formula



$$\left( -CH_2-\overset{\overset{CH_3}{|}}{C}=CH-CH_2 \right)_n$$

## PAST TO PRESENT

Of all the wonderful tales reported by Christopher Columbus after his second voyage to the New World in 1496, none was stranger than the story of the natives in Haiti who played with a ball made from the gum of a tree—a ball which bounced.

Before 1500. Rubber was first found and used by Indian tribes in the New World to waterproof articles of clothing and footwear with the gum dried over smoked fires. In fact, games played with such a rubber ball are known as far back as the 11th century, throwing light on the advanced Mayan civilization.

1500. Columbus is said to have brought some of the bouncing rubber play balls back from Hispaniola (Haiti) to Queen Isabella. (Recorded in 1615 by the court historian to Philip II.)

After 1500. While native rubber articles (play balls, bowls, bottles, hats, capes, shoes) were brought to Spain and Portugal from various parts of Central and Northern South America, no commercial use was made of rubber for nearly 300 years after Columbus.

1745. Frenchman Charles Marie de al Condamine made a report on rubber to the Paris Academy of Sciences, the first scientific or commercial interest shown in the substance. He had been sent to Ecuador in 1735 by the Academy to survey a parallel of latitude at the equator to see if the earth was a sphere or elongated at the poles. He crossed the continent from Quito to Para, over the Andes, and down the Amazon River in $3\frac{1}{2}$ months, coming out on the coast at Cayenne in French Guiana. He brought back a few oval hunks of what he said the natives called "cahutchu" or "weeping wood." (The French word for rubber is now "caoutchouc.") He told how natives made shoes and raincoats by dipping molds or fabrics into the juice of the Hevea tree and curing thin layers over smoky fires. But his samples wouldn't melt and no solvent was available.

1763. French chemist, Macquer, and physician, Herissant, reported turpentine as a rubber solvent. But they found rubber products sticky in warm weather and brittle and hard in cold.

1768. Macquer made a pair of riding boots for Frederick the Great by coating a wax cylinder with rubber dissolved in ether. The ether evaporated and the wax melted in hot water. This was, however, too costly a method to be practical.

1770. The English chemist, Priestly, gave the name "rubber" to the raw material when he found it would "rub off" pencil marks. Ironically, in so doing he may have unawaredly become the first one to add carbon black to rubber.

1791. The first rubber patent was issued to Samuel Peal in England. It called for preparing waterproof fabrics by means of a solution of rubber in turpentine.

1811. The first rubber factory was probably established in Vienna by Johann Nepomuk Reithofer.

1813. First United States rubber patent to Jacob F. Hummel of Philadelphia for a rubber varnish to waterproof shoes.

1823. A patent was issued to Charles Macintosh in Glasgow covering a waterproof fabric of two pieces of woolen cloth held together with a naphtha-rubber dope. But "Macintosh clothing" was stiff in cold weather and had a "gas-house" odor in warm weather. Also the rubber deteriorated and the cloth peeled apart.

Thomas Hancock, a London coachmaker, became interested in Macintosh waterproofs for carriage tops and curtains. He experimented to break the naphtha patents and patented an idea of cutting rubber into long strips—elastic bands—for glove wrists, pocket edges, shoe tops, etc. He was so successful that he gave up his coach business and became the first English rubber manufacturer.

1830. English developments, plus imports of uncured rubber shoes from Brazil (from about 1825), sent many Americans into the rubber business. Much money was lost because turpentine solvent increased stickiness and deteriorated the rubber.

1839. Goodyear made his discovery of vulcanization in 1839 which introduced the great era of rubber manufacturing. He was testing the effects of heat on a rubber-sulfur compound smeared on cloth and carelessly left the sample overnight in contact with a hot stove. It charred like leather. Goodyear recognized the importance of his discovery but couldn't find a backer. He kept it a secret for 5 years.

1844. The patent on vulcanization of rubber was issued to Goodyear. But the delay was costly to him because Hancock had secured the English patent rights in the meantime to sulfur-heat treatment. Goodyear put on rubber shows in London (1851) and Paris (1855), and spent much money defending patents. He patented over 200 applications of rubber—but not tires. He died in 1860, heavily in debt.

1846. Thomas Hancock made solid rubber tires for the carriage of Queen Victoria, perhaps thereby launching our present vast tire industry.

Before 1860. The demand for natural rubber was small and most of it was collected by the Indians of the lower Amazon region. They would go into the jungle, tap the trees, collect the latex, then mold it into bottles, shoes, and "biscuits" over open smoky fires. The Indians would carry the rubber in canoes to trading towns on the Amazon, barter it for trinkets to Portuguese traders who took the rubber to Para where it was sorted, packed, and shipped. Tonnage exported from Para exceeded 1000 tons by 1850.

1860 to 1865. Increased demand for rubber and Civil War inflation of United States currency sent the price up over a dollar a pound in 1865. This stimulated trade in the Amazon and also in Colombia and Ecuador.

1866. Don Pedro II of Brazil opened the Amazon River to ocean steamers and some went as far as 1500 miles upstream to load rubber. As demand grew and the price increased, natives were exploited, became debt-slaves, and organized into gangs on territories staked out by traders to tap, collect, and cure rubber. Many thousands of trees were killed by improper tapping.

1870. The idea of planting and cultivating the Hevea rubber tree had been suggested by both Goodyear (1853) and Hancock (1857) in their autobiographies. Interest in the idea of developing rubber plantations in the Far East grew in the early 1870s following the success of the Dutch in transplanting the quinine tree from Peru to Java and the introduction of tea into Ceylon.

1873. Dr. James Collins, curator of Physic Gardens of London Apothecaries Company, went to Brazil to obtain Hevea seeds. His first lot was shipwrecked. He eventually got out 200 seeds but only a dozen germinated in England. He sent six plants to Calcutta but all died.

1876. Collins wrote Henry Wickham, a young English coffee planter who lived in Brazil above the junction of the Tapajos and Amazon Rivers, and asked him to collect and ship several thousand Hevea seeds. Wickham got natives to collect the seeds, and packed them in wicker baskets between layers of banana leaves, hanging them up in the hold of the ship to allow air to circulate and prevent the seeds from turning rancid. On June 14 the ship docked at Liverpool and the seeds were put on a special train for Kew. Seventy thousand seeds were planted in all available nursery beds, of which 2800 germinated and 1919 young rubber plants were sent to Ceylon the following year. Of these, 90% survived the trip and were planted in botanical gardens of Paradenya and Heneratgodo where some are still alive and yielding rubber today. A few were sent to the British Resident at Perak, Malaya, Sir Hugh Low, who grew seven in gardens at Kuala Kangsar and, in 1882, reported sending seeds and plants to Singapore, India, and Java.

1880. Between 1880 and 1900 there was a period of experimentation with plantation rubber. Actual production was small. It took 7 years from seed to tapping and required large capital investment. Different climates, locations, and methods of cultivation were tried. By 1888, about 1000 trees were scattered throughout the Malay Peninsula. At this point a most significant step in the rubber growing industry took place. Henry Ridley took over the Singapore Gardens. Ridley demonstrated to planters that rubber trees could be grown in cleared areas in regular order, tapped frequently and economically, and the liquid latex converted to dry, clean, raw rubber ready for use. In so doing, Ridley discovered the phenomenon of "wound response" wherein latex flowed more freely after the initial tapping, that the tree could be tapped in intervals of a few days, and that the excised bark would renew itself after a few years for subsequent tapping, thereby permitting trees to yield latex economically and efficiently for at least 30 years. In 1889, only about half a ton of plantation rubber was produced in all the Far East.

1888. The first useful pneumatic tire was made by John Dunlop in England, making possible a new era of movement by bicycle and ushering in the new eras of motor cars.

1899. Year of first official record–4 tons of plantation rubber were produced from 4000 acres under cultivation. In 1905, 145 tons of plantation rubber were produced from a total of 127,000 planted acres. By 1910, production had increased to 8200 tons from 1,125,000 planted acres.

1912. Plantation rubber from Southeast Asia exceeded the output of Brazil for the first time, and 2 years later produced twice as much rubber.

1922. Southeast Asia plantations produced 93% of the world supply of rubber. By 1932 this had increased to 98%.

1920-1940. Wide fluctuations in the supply and demand for natural rubber caused great fluctuations in prices. An attempt to stabilize prices and production in the 1920s failed. Another attempt in the late 1930s was more successful but was discontinued when World War II began.

1940. The United States began stockpiling natural rubber as a strategic material as war clouds gathered. Imports into the United States in 1941 were over a million tons, about double normal prewar consumption.

1942. Japanese occupation of Southeast Asia shut off nearly 90% of the world's normal source of natural rubber. Development of synthetic rubber and the building of synthetic plants in the United States with about a million tons' capacity during World War II was one of the great examples of American engineering and production genius.

1945. Recovery of the rubber-producing areas from the Japanese found the rubber trees intact but the machinery destroyed, the plantations grown up with jungle, and the Chinese and Indian workers dispersed. Rehabilitating these plantations and getting them back into production to meet the postwar demand for natural rubber was a major achievement by the rubber growers. It was accomplished without government subsidy, aid, or control, and with natural rubber selling on a free market at prewar price levels.

1950. The post-World War II petrochemical and polymer developments were massive, and aggressive technoeconomic competition with natural rubber (NR) was the order of the day in the 1950s.

1964. Competition from synthetic rubber (SR) forced the NR industry to adopt a more outgoing and enterprising posture. Deficiencies in NR centered around presentation standards and the traditional system of visual grading. The elimination of both these drawbacks were priority objectives of the Standard Malaysian Rubber Scheme, introduced in Malaysia and later adopted by all other producing countries. Technically specified rubbers now constitute more than half of all NR produced in the world.

1970. The Association of Natural Rubber Producing Countries (ANRPC) was established comprising Malaysia, Indonesia, Singapore, Thailand, Sri Lanka, and Vietnam. This Association provided, among other things, a forum for consideration of a producer approach to bring about a stable price structure.

1973. The petroleum situation of the 1970s, the emerging strong lobbying against environmental pollution, and the growing concern of depleting nonrenewable resources introduced entirely new equations in the NR-SR interactions. While natural rubber obviously could not be thought of in terms of taking back all of the market lost to synthetics, the possibility of a move from 30% of world rubber hydrocarbon consumption to something approaching 40% presented the industry with an exciting challenge—assuming, of course, relative price stability and supply.

1979. Major producing and consuming countries reached an agreement in Geneva to stabilize world market prices and supplies of natural rubber. The arrangement, agreed to under the auspices of UNCTAD, provides for floor and ceiling prices on natural rubber and a buffer stock to be set up of 550,000 tons.

## PRESENT TO FUTURE

Competition with synthetic rubber over the past four decades has had both positive and negative effects on NR. It should be clearly understood that the statistical superiority of SR (70%) owes much more to the availability of cheap oil (until 1973), which was superimposed on a fast-growing world market for rubber, than to any intrinsic technical superiority over natural rubber. No general purpose synthetic rubber has yet emerged—or is likely to—which can claim overall technoeconomic supremacy. Had such a material been developed, natural rubber would have disappeared by now in the same way that indigo was totally obliterated in the 19th century by synthetic dyestuffs.

What should be borne in mind at this point in time and for the future is that the NR industry is a prime user of free energy—sunlight—for its bulk requirements. The direct energy inputs from alternate sources are considerably lower than those required in the production of SRs. It has recently been shown that while it takes 0.5 ton of crude oil to produce 1 ton of NR, it takes 3.5 tons of crude oil to produce 1 ton of SBR and 5.5 tons of crude oil to produce 1 ton of IR [1].

Lately, there has been much talk of a coming shortage of natural rubber. All available evidence indicates this will not happen. Certainly not in 1980 and probably not for at least 2 to 3 years because of the sluggish growth in world economy. It will subsequently become increasingly difficult for natural rubber to meet demand after 1985—unless NR production increases very much faster than at present.

The World Bank has projected total world elastomer consumption to grow to over 5% up to 1990. Natural rubber production, however, will show only a 4% growth after 1980. On the basis of these projections, this gives a 1990 output of 6.1 million tons of natural rubber feeding a total rubber market of 23 million tons. On the basis of these projections, the market share of natural rubber will fall to 30% in 1980, 28% in 1985, and 26% in 1990 [2].

To prevent further eroision of the market share for NR, the maintenance of an NR supply growth in line with the growth of world demand for isoprenic type rubber is clearly of fundamental importance to NR producers. Time is clearly of the essence since NR is a perennial crop with a relatively long gestation life.

What was and is needed is progressive and total replanting of all inefficient rubber trees with the high-yielding varieties developed since the 1920s plus the widespread use of up-to-date agronomic practices. Only one country, Malaysia, has done this on any serious scale and it is only in that country that productivity, as measured in output per acre, is anywhere near the optimum.

The rubber tree, Hevea brasiliensis, is the primary production unit of the NR industry. Changes in production and productivity can be brought about through a multitude of factors including genetic, physiological, agronomic, horticultural, and other types of manipulation of the plant. More than 50 years of organized applied research in these areas has evolved a spectrum of innovations which are at different levels of implementation.

Through conventional breeding techniques, the yield of Hevea has been enhanced from the original level of 500 kg/ha to the experimentally proven yields of over 3000 to 4000 kg/ha, enabling the present commercial levels of 2000 to 2500 kg/ha to be achieved. Theoretical considerations indicate that the yield barrier to upgrading may be as high as 9000 kg/ha. Newer possibilities of greater thrust in this area using ortet selection and tissue culture are indicated for the future. Breeding has also resulted in materials with greater vigor of growth, enhanced resistance to diseases, and more desirable architecture to resist wind.

The gestation period (immaturity) of 6 to 7 years for Hevea prior to the commencement of tapping has been a serious drawback. The length of this period is influenced by factors such as vigor of growth, nursery techniques, branching habits, and magnitude of transplanting shoots. A new combination of techniques now developed enable Hevea clones to be brought to maturity within $3\frac{1}{2}$ to 4 years. Physiological manipulation of roots, trunks, and crowns originating from separate source material is also enabling the industry to utilize newer genetic material at an earlier phase.

The economic life span of Hevea and the comparatively long gestation period determine the rate of utilization of newer high-yielding clones through the replanting process. At any given time there is, therefore, a "yield gap" between the yield potential of commercially available proven clones and the average yield of the industry. This gap is now being reduced through the application of novel stimulants to enhance flow. For example, the use of ethylene gas through the tissues of Hevea bark enables the trees to express their full genetic yield potential by reducing or removing the physical barriers to flow. The amount of yield increase achieved in this manner can range from 60 to 100%. On stimulation, unselected seedlings yielding 500 kg/ha have yielded more than 800 kg/ha, while very high yielding clones at 2500 kg/ha level have yielded more than 5000 kg/ha. To date no detrimental effects of stimulation have become evident. Two other developments of significance are upward tapping with stimulation to achieve yield increases of as high of 150% in many instances, and needle or puncture tapping with stimulants obtaining yield levels comparable to conventional tapping methods. The latter technique has opened the door to semiautomation in the extraction process.

To an outsider, the natural rubber industry must appear to be a blend of agriculture, science, technology, and politics. If so, it's well to remember the industry has to look in two directions at the same time. Not only does it supply a key industrial raw material to consumers around the world, but it constitutes a major element in the socioeconomic fabric of several developing countries.

A look at NR's future would not be complete without considering the socioeconomic implications. The NR industry has slowly evolved through the years to become principally an industry of the small man—the small holder. Statistics available indicate that small farm participation in the NR industry now ranges from 67% in Malaysia to over 95% in Thailand. In spite of the severe competitive and consequent price pressures of the last 30 years, the small farmer has contributed significantly to the increase in NR supply. This small holder enthusiasm must be sustained to insure future supplies. This will require an assurance of more stable returns, and hence the validity of the International Rubber Agreement.

There is a long history of attempts to control and stabilize the price of natural rubber, and it is no easy matter to devise a scheme which satisfies the requirements both of producers and consumers. At Geneva in 1979, there were international movements under the auspices of the U. N. to develop a workable scheme. Despite what has been said by some, the NR producers are not undertaking–and indeed, unlike the oil exporters cannot undertake–some form of massive price increase. Their hands are tied by the existence of synthetic rubber and especially by the ever-present threat of the expansion of production of synthetic isoprene.

The need for increasing the supplies of NR has been accepted by the NR industry. Available technologies can effectively enhance the technoeconomic strength of NR, and it is further possible to consider NR as a possible new source for industrial polymers through chemical modifications. Evidently, all the elements exist for a prosperous future for the NR industry.

Although it is just over one hundred years since the birth of the natural rubber producing industry, it is well placed to meet and overcome the challenges which face it at the beginning of its second century. Many years' application of science and tehcnology, overlaid with full understanding of economic, social, and political implications, provide the industry with what it needs: the ability to be resilient, to produce, to process, and to export efficiently. The market is there, despite the existence of synthetic rubbers. It is and will remain for the foreseeable future the cheapest source of rubber elasticity, and in this age of energy conservation and crisis and of increasing social awareness of the hazards of environmental pollution, the fact that it is based on a nonpolluting renewable resource lends credence to the use of the expression–Nature is on its side! It is quite certain that by the turn of the century one will see an industry that would have been incomprehensible to the early planters at the turn of this century, and very much different from what we know today.

## REFERENCES

[1] Economist Intelligence Unit, Rubber Trends, No. 70, London, June, 1976.

[2] World Bank Report, No. 814/78, June 1978.