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The reserves of petroleum, a major source of hydrocarbons, are dwindling fast. Its increasing price has further lowered the competitiveness of synthetic elastomers produced from petroleum-based feedstocks. A renewable source of petroleum-derived polyisoprene rubber will, therefore, be a preferred source in the future. Moreover, natural rubber is still preferred in applications that demand elasticity, resilience, tackiness and low heat build up and is indispensable for bus, truck and aeroplane tyres.

Only a few among the various species of plants known to contain rubber give substantial yields of it. Two of these, the rubber tree Hevea brasiliensis (H.B. & K.) Muell. Aug. and the guayule shrub (Parthenium argentatum A. Gray) have been a continuing source of commercial rubber. In fact, guayule, an inconspicuous shrub in contrast to the majestic hevea tree, remained a continuous minor source of rubber for almost 40 years since 1910.

In recent years, the demand for natural rubber has increased sharply and is believed to exceed the expected production from hevea plantation in 1980s and 1990s resulting in a world-wide shortage. The shortfall in the production of natural rubber in India during 1985 and 1990 is expected to be to the tune of 64,500 and 76,400 tonnes respectively. Hence, a plant like guayule is particularly worthy of investigation as a renewable source of rubber hydrocarbons.

Guayule holds an advantage over hevea; while the latter can be cultivated only in the tropical zone, guayule could be easily cultivated in arid zones. Hence, with increasing population growth, guayule offers the opportunity for utilizing marginal lands productively and providing jobs and income to desert dwellers. Hevea, on the other hand, requires fertile land and a humid climate, which limits the possibility of expansion of its cultivation owing to the mounting pressure on agricultural land for food production.

There is also now-a-days a strong view that trees which have to be operated like hevea are hopelessly outclassed by small shrub-like plants with respect to yield, quality of rubber and ease of production and their cultivation and treatment can be mechanized more successfully.

As it has been decided to develop guayule as an alternative source for natural rubber in India, it is desirable to review the information already available with respect to the factors controlling its growth and rubber content, methods of determining rubber content and composition.

Botanical Description

Guayule is a member of the family Compositae and belongs to the genus Parthenium. It is named Parthenium argentatum because of a silvery sheen on its grey green leaves. It is a perennial shrub in high, dry weight 6-32 oz, diameter of the trunk at base 7/8-2.1/4 in with very few leaves, narrow and alternate, and a canopy of small flowers borne on an exceptionally long stem. They are covered in a drought protecting white wax. The taproot of the plant sometimes penetrates the soil more than 20 ft supplemented by extensive fibrous roots that spread about 10 ft laterally. This root network allows guayule to absorb moisture from a large volume of desert soil and thus to withstand periodic drought, while during severe and extended droughts the plant survives by becoming dormant and can survive 30-40 years under desert conditions where annual rainfall may be less than 10 in.

In nature, guayule grows in a wide variety of shallow, strong, calcareous and friable soils. It grows best in well-drained soils and cannot tolerate water logging.

Pollination and Germination

Guayule flowers are pollinated by wind and by insects. The tiny seeds are produced at a prolific rate; a plant can yield several thousand flowers after a single rainfall. Vigorously growing plants bloom and set seed continuously throughout summer and fall. If stored carefully, the seeds can remain viable for several decades. Flowers and seeds are produced as early as six months after germination.
Guayule is usually propagated by nursery-grown seedlings, though grafts and cuttings can be successful. Young seed requires a simple treatment to break dormancy.

**Genetics**

Guayule has an inherent genetic variability and is amenable to genetic improvement. Individual plants with chromosome numbers $2n = 36$ are completely sexual and reproduce in the usual way by pollination. Guayule plants of higher chromosome numbers reproduce apomictically without requiring double fertilization, i.e., the embryo of their seeds arises from a non-fertilized nucleus and thus reproduces a plant that is genetically identical to the parent.

With sexual types, the plant breeder can develop hybrids with useful characteristics. The hybrid plants can then be induced into apomictic forms to replicate the characteristics of the hybrid, generation after generation, thus facilitating guayule breeding.

**Factors Affecting Growth of Guayule and Its Rubber Content**

(i) **Light intensity** — Reduction in light intensity by shading lowers the yield of plants grown in fertile soil, while in less fertile soils where the yield is already low, there is no further decrease. Shading favours seed production, while withholding of inorganic nutrients tends to reduce the size of seeds. Under ordinary light, the resin content is not affected by nutrient supply, but is increased under shade. During the germination period of three weeks, dormancy of both embryo and inner seed coat of freshly harvested plants is completely broken by continuous exposure to daylight.

(ii) **Moisture stress** — Moisture is perhaps the most important determinant in guayule growing. Low moisture stress in nursery-grown guayule plants leads to enlargement of the tissues of the plant with corresponding increase in rubber-bearing capacity, loss of capacity to accumulate inulin and retention of the capacity to accumulate relatively lower percentage of total water soluble carbohydrates and levulinates during winter in response to lower temperature. High moisture stress leads to increased deposition of rubber and lignin, enlargement of resin canals and accumulation of products of photosynthesis. The plants retain a significantly higher pentosan content in June due to more rapid growth resumption. A relatively high percentage of water soluble carbohydrates (high moisture stress due to more rapid growth resumption and greater percentage survival) is utilized extensively in October due to early and relatively more vigorous growth.

During periods of high moisture stress, the rate of increase of dry weight of the entire plant is depressed. The percentage of levulinates increases, especially in roots and stems, while that of inulin and pentosan remains constant. Low moisture stress followed by high stress decreases levulinates, suggesting them to be the principal form of reserve. Rubber yield increases more rapidly during high moisture stress than during low stress and its absolute content per plant is further increased after each successive period of high stress above that of plants continuously on low stress. Rubber accumulation can be forced by alternating periods of stress, but the periods of low stress must not be too short and should occur at seasons of the year other than winter.

(iii) **Soil** — Soil differences are dominant factors in influencing the yield of rubber per acre. The highest yields of rubber hydrocarbon are obtained by growing larger shrubs with a lower rubber percentage. In fields, plots of sandy loam soil maintained at high moisture level give plants with highest yield of shrub and rubber per acre, while plots of silty clay loam give highest rubber yield with lowest moisture level. Soil temperature also affects guayule shrubs.

(iv) **Frost injury** — The rubber content of guayule is not affected by frost injury, but a frost of $-7^\circ C$ can injure tender plants.

(v) **Response to fertilizers** — Fertilizers have little or no effect on rubber or shrub yields. While they improve the vegetative growth, they do not necessarily increase the amount of rubber produced.

(vi) **Salt content** — Like some other plants, guayule requires an optimal concentration of boron, but has a wider tolerance range (0.1-2 ppm of boron in nutrient) within which occur the maximum vegetative growth, seed production and rubber concentration. Deficiency of boron leads to decrease in rubber concentration and production of fewer smaller seeds with lower germination rate, while an excess up to 10 ppm is also associated with the lower rubber output.

On the other hand, guayule is not a salt tolerant plant and is very sensitive to magnesium (being killed in the presence of 1 atm osmotic pressure) and sodium salts (more sensitive to $Na_2SO_4$ than to $NaCl$). Guayule production is not feasible in soils containing salts in excess of 0.5% in 5 ft profile, because with increase in salt content, the osmotic pressure increases resulting in increase in the total soil moisture stress and hence increase in rubber percentage, but the shrub size and consequently the yield of rubber decreases.

The diameter of the shoots of guayule shrubs is proportional to their potassium content, while the length of the shoot varies with calcium content. Sodium and phosphorus have a strong positive effect on the rate of growth of seedling with $\pm 25\%$ variation from normal, while potassium has the reverse effect.
The percentage of rubber is not influenced by extremes of 1.4-14.4 meq of N per litre nutrient, but in plants receiving extremely small amounts of Ca and N (1.8 meq per litre) rubber is less than in plants receiving 7.2-21.5 meq per litre. The overall production of rubber per plant parallels closely the extent of vegetative growth. Low quality seeds are produced during warm weather and the highest quality and greatest number of seeds are formed under conditions of large and continuous supply of Ca and N. A relatively slight increase in the thickness of bark of plants under low nutrient supply is not associated with increase in the percentage of rubber.

(iii) *Pests and Their Control* 

Lygus hesperus reduces the weight and viability of guayule seeds by feeding on the embryos. Dusts of S and Ca arsenate, Ca arsenate-S (1:2) mixture and Paris green-S (1:8) mixture reduce lygus population, while those of As and As-S increase the percentage of viable seeds. A 2.5% DDT dust kills most of lygus bugs, but has no effect on nymphs which hatch after dusting. Therefore, a second application about 10 days later is required. DDT emulsions are also useful in controlling red spider and mealy bugs on guayule. Besides Lygus hesperus, DDT is also useful against the western spotted cucumber beetle, the false chinch bug, larvae of the diamond-back moth and turnip, green peach and pea aphids.

Guayule seedlings are affected by pythium and Rhizoctonia. Effective economical killing of weeds, without injury to guayule plants, is obtained with 20% aqueous mixtures of stove oil with casein as a spreader. Spot disease of guayule is caused by Ramularia and is controlled by treating the seeds with a 5% solution of Ca(OCl)₂.

### Chemical Constituents of Guayule

Guayule shrubs contain about 10% water soluble substances (tannins, carbohydrates, N substances, etc.), 10-15% substances soluble in water after hydrolysis (pectins, proteins, etc.) besides cellulose, resins and rubber.

(i) **Carbohydrates** — Fructose comprises about 10% of the reducing sugars in stems and roots of guayule and 25% in inflorescence. The non-fructose portion does not contain appreciable quantities of glucose, mannose or galactose. Inulin, a polysaccharide of fructose, constitutes 0.2-12% of the dry weight of roots and stems, depending upon the conditions under which the plants are grown. Levulins, another class of polysaccharides, have also been reported by Traub and Slattery. On the basis of diffusion coefficients, it has been shown that Pringsheim’s hypothesis for the presence of a homologous series of polymers between inulin and the monosaccharides does not hold for guayule and that apparently difructose anhydrides are not present in guayule plants.

(ii) **Auxins** — 3-Indole acetic acid is the natural auxin of guayule. It is not present in the fresh tissues of the plant, but is found in dry or mature leaves. It has a retarding effect on the growth of the plant. Hence, the presence of mature leaves causes inhibition of bud growth in guayule.

(iii) **Terpenes** — The essential oil contents of guayule plants are: 3-pinene, dipentene, codinene, di-, tri- and higher terpenaceous compounds, elemol-like sesquiterpene alcohol, phallandrol, sesquiterpene alcohol with an azulene nucleus, guajene-like sesquiterpene, terpene ketone and aldehyde, β-pinene, small amounts of easily oxidizable terpene, partheniol and parthenyl cinnamate. These compounds play an important role in the formation of rubber in guayule. Reference is made to the ethereal oil obtained by stem distillation of the wood of *P. argentatum* as a greenish yellow oil with a peculiar odour of pepper. Two new sesquiterpenes, guayulines A and B, and three triterpene argentatins, A, B and C, have also been reported in guayule.

(iv) **Wax** — Wax occurs almost exclusively in the phloem above the crown in the actively growing parts and its content is constant in shrubs of the same age.

(v) **Enzymes** — An enzyme which catalyses the formation of coenzyme A (CoA) from acetate, adenine triphosphate (ATP) and CoA has been reported in guayule.

(vi) **Betaine** was obtained by the extraction of defoliated guayule shrub. Duisberg has described certain alkaloids like β-phenylamine, saponins and mexogenins in the desert plants, including guayule.

Guayule also produces substances which are toxic to growing plants. *Parthenium argentatum* produces acetone soluble resins. These constitute 10-15% of the plant (dry weight) and are present in resin ducts which are found throughout the shrub. Chromatography of resins on alumina column affords three fractions: (i) a yellow fraction of the highest Rf position made up chiefly of parthenyl cinnamates and other esters in...
which linoleic, palmitic, stearic and linolic acids participate, (ii) a colourless fraction containing two diterpenes (ketopartheniols), and (iii) a green fraction with the lowest $R_f$ value made up of unsaponifiable substances of high molecular weight. The resins constitute about 30% of the plant extract and could be industrially utilized as such or for incorporation into guayule rubber.

Partheniol, parthenyl cinnamate and cetopartheniol have been isolated from resins.

(viii) Rubber—Rubber occurs as a colloidal suspension in the parenchyma cells of guayule. Within the cells, the rubber does not exist in the form in which it is recovered. The suspended globules are in rapid brownian movement and their agglomeration and subsequent coagulation by ordinary reagents can be followed microscopically.

The rubber content of the plant varies with the season of the year. A more rapid growth of the plant during summer accompanied by less rapid secretion of rubber suggests the secretion of rubber as a secondary physiological process.

There is considerable variation in the amount of rubber present in different parts of the plant (leaves, stalks, roots, bark, etc); the amount also varies with the time at which extraction is done. A larger proportion of rubber is contained in branches than in root and crown; leaves and flower peduncles contain insignificant amounts of rubber. Generally speaking, the percentage of rubber increases from the cold to the hot season. The average yield of rubber from the whole plant does not exceed 2% for the Russian variety, while the American varieties yield as much as 7-10% rubber showing the predominant part played by climate. A study carried out on six types of guayule for percentage of rubber, tar and water soluble substances separately in bark and wood gave the following results:

<table>
<thead>
<tr>
<th></th>
<th>Bark</th>
<th>Wood</th>
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<tbody>
<tr>
<td>Rubber, %</td>
<td>2.87-9.92</td>
<td>0.05-2.71</td>
</tr>
<tr>
<td>Tar, %</td>
<td>10.74-15.31</td>
<td>3.24-6.52</td>
</tr>
<tr>
<td>Water soluble, %</td>
<td>21.94-27.82</td>
<td>4.17-15.57</td>
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The molecular weight of rubber in the above samples varied from 21,900 to 44,000. The refractive index of benzene solution of rubber decreased with decrease in concentration. The tars had low acid number.

Lloyd has summarized the information available on the origin and occurrence of rubber in the plant tissues of guayule as follows: (i) Rubber appears in the root earlier than in the stem and is first secreted in the primary canal cells. (ii) Accumulation in the root usually takes place in the oldest cells first and is more rapid in parenchyma ray cells than in either the pith or the cortex, except in the hypocotyl. (iii) Accumulation of rubber in the stem takes place earlier in the pith than in the parenchyma rays or cortex, earlier in the rays than in the cortex, and earlier in the secreting cells of resin canals than in the surrounding tissues. (iv) Rubber occurs in the pseudotylose tissues of the resin canals in quantities comparable to those found in adjacent cells. (v) The secretion of rubber occurs from the base towards the top of new shoots and from the pith and cortex towards the cambium in older stem. (vi) The accumulation of rubber is more rapid in desert plants than in irrigated plants. (vii) The rate at which rubber is secreted by irrigated plant is such that at the close of the second season of growth, the amount is sufficient to agglomerate into large masses like those which are typically formed during the mechanical process of extraction of rubber from the wild desert plants. Although the amount of rubber is lower in cultivated than in desert plants, the rate of growth under irrigation is enormously in excess of that under desert conditions. (viii) There appears to be no direct physiological relationship between the secretion of rubber and of resin. (ix) Rubber appears to have no physiological function in the guayule plant.

As the tissues of the bark are the principal site for rubber deposition, the portion of bark in various segments of stem and root is a factor in their resultant rubber content. The rubber content is maximum in the primary root and increases from the root upwards in the progressively younger parts with smaller diameter. There is a noticeable, although relatively slight, gradient of decreasing rubber concentration in the bark from the oldest stem to the youngest, whereas there may be a very slight gradient of increasing rubber concentration from the older stems to the younger ones within the wood of 2 or 3 year old plants. This gradient disappears or may be partially reversed in the older plants.

Analysis of annular parts of the wood cylinder of plants of various ages indicates that cells of the inner xylem and pith continue to accumulate rubber for several years after they are formed. The increase in rubber concentration with age is due to continued accumulation in the old inner tissues rather than to high rubber content in the xylem added in later years. The inner annual rings of the xylem have a much higher rubber concentration than the outer ones and the corresponding annual rings of young plants.

Like concentration, the molecular weight of rubber also varies in different parts of the plant, e.g. the rubber in roots has the highest molecular weight, that in the stems the next highest, followed by that in the branches and then in the tops. But the highest estimate for molecular weight of rubber (210,000) obtained for any fraction of guayule is not as high as that reported for hevea rubber.
Staining of Rubber in Plant Tissues

Staining of rubber is a useful and rapid method in the microscopic examination of rubber in ground guayule tissues. Rubber-containing tissues, after pretreatment with alcoholic KOH and bleaching with NaClO, are stained differentially with Sudan IV and iodine green; while rubber is stained crimson, lignified tissues and cork cells are stained bluish green. In the presence of suberin, the colour of cork cells varies. If the colour is not readily distinguishable from that of rubber, the cork cells may be recognized by their characteristic structure.

Function of Rubber Hydrocarbon in the Plant

The exact function of rubber hydrocarbon in guayule plant is not known, but it has been established that it does not function as a food reserve, e.g. guayule plants when grown under a very low level of carbon assimilation by repeated removal of new top growth almost to zero and utilized a part of the pentosans; they lost no rubber hydrocarbon, but rather showed a significant increase which was associated with a corresponding decrease in the resin fraction. Hence, it was speculated that the resin fraction may contain a rubber precursor; other reserves, such as pectins, might possibly be important food reserves and deserve greater attention.

Another evidence of non-utilization of rubber as a food reserve is that the stems and roots of guayule plants become exhausted of their food reserves, sugars, levulin, inulin and pentosans during the spring of the year as a result of repeated defoliation, but no loss of rubber hydrocarbon occurs.

Mechanism of Rubber Formation in Guayule

Rubber synthesis in guayule is controlled by a rubber precursor formed in the leaves. Acetate is an intermediate in rubber synthesis and may be metabolized to β-methyl-crotonic acid as a further intermediate. There is a far-reaching analogy between fatty acid formation and rubber formation with crotonic acid replacing acetate as the fundamental replacing unit. This theory was the result of studies carried out on plants growing in nutrient solutions and of stem sections grown in agar medium containing mineral salts, sucrose, indole acetic acid, small amounts of vitamins B₁ and B₆ and yeast extract. In the absence of indole acetic acid, little growth occurred. Addition of glycerol acetate, acetooacetate, acetone, β-methyl crotonic acid and acetic acid to the nutrient medium increased rubber formation. The effect of acetate was inhibited by fluoroacetate. A suggested course of rubber formation is:

Glycerol acetate → acetooacetate → acetone → β-methyl crotonic acid → rubber

The addition of leaf extracts to the nutrient solutions increased the rubber content of seedlings of only those plants which were actively engaged in rubber formation; in experiments on plants not engaged in rubber formation, there was no effect.

Taylor et al., from their experiments on reciprocal grafts with guayule and moriola, sunflower and the Jerusalem artichoke, concluded that the leaves of non-rubber producing plants produce the necessary precursor compounds for the formation of rubber in the stem and roots of guayule, while the leaves of guayule plant do not produce the precursor of rubber in non-rubber producing plant stems and roots. Isotopic studies have also been carried out to study the mechanism of rubber formation in guayule.

Methods for the Estimation of Rubber

Among the methods developed for the estimation of rubber in guayule are the semi-microphotometric method, a modified photometric method due to Perry, the Spence and Caldwell extraction method, the Holmes and Robins method, which is a simplified version of the method of Spence and Caldwell and the method of Meeks et al. A method for the analysis of rubber based on spectra of ground guayule shrub has been reported to be accurate when the rubber concentration is in the range 2.5-5.0%. No accurate method is available for the estimation of rubber when the rubber content is high. A rapid analytical method to determine the rubber content in guayule shrub developed by Gutierrez and Ransaw is based on attenuated total reflectance infrared spectroscopy (ATR-IR).

Two new methods have been developed which enable the determination of rubber content in guayule without sacrificing the plant. One method due to Mehta et al. utilizes trichome and leaf morphology as an indicator of high rubber-bearing plants and the other due to Bauer makes use of the anatomy of the plant as indicator of rubber storage; it involves treating and staining microtome stem sections for rubber. Both the methods lack precision and accuracy.

An extraction method developed by Garrot et al. makes use of liquid nitrogen to eliminate the time-consuming steps of drying and conventional extraction.

Another method consists in grinding the plant material to a particular mesh size, pulping it in the presence of alkali and extracting rubber from the pulp with a suitable solvent. The results obtained by this
method agree well with those obtained by the extraction method. Clarke and Benson carried out a critical study of the methods of determining rubber and observed that extraction with benzene gives less accurate results than with acetone; benzene forms a benzogel which goes into solution slowly and diffuses slowly out of densely fibrous material even when finely ground.

Extraction of Rubber

A freshly harvested shrub can be successfully processed for recovering its rubber, without the use of chemical coagulants, the latex being coagulated by parboiling and mechanical treatment. Mill yields of rubber from freshly harvested latex are in general high, but the method of preparation of shrub influences the recovery of rubber hydrocarbons. When the shrub is conditioned and stored under conditions of large scale operation, the yield of hydrocarbon decreases with increase in the period of storage.

The method of extraction consists of the following stages:

(i) Parboiling—The shrubs are dipped in hot water (10 min at 75°C) to coagulate the rubber in the latex cells. This checks the deterioration of rubber during processing and simplifies its separation from vegetable matter. Parboiling removes much of the soil from roots and defoliates the branches, thereby reducing the bulk of material to be handled, increasing mill capacity and improving the final product, because leaves contain copper, manganese and resinous compounds that contaminate rubber and catalyse its degradation.

(ii) Milling—To remove rubber from the cells, the plant tissue is separated and disintegrated in Jordan or Bauer mill. Caustic soda is added during pulping, which helps break open the rubber filled cells and promotes separation of rubber from the vegetable matter. Pulping is done in water which causes rubber and brown pungent matter to agglomerate into a spongy form known as guayule "worms".

Milling is done in an aqueous coagulant medium which may be strong acid with or without small quantities of a trivalent metal salt, such as Al(SO₄)₃ or a weak acid with the said salt. In a large slurry tank, the slurry of pulped shrub separates; the waterlogged bagasse sinks, the worms float and are skimmed from the surface and the residual bagasse is separated. The tacky resinous worms are then rinsed to remove caustic soda. They are difficult to handle and gum together, trapping water, cork and fibre between them. To keep them small, manageable and easy to deresinate, the worms are next warmed in water containing a surfactant (e.g. zinc stearate) which forms a coating on the particles. This coating does not interfere with the deresination or drying of the rubber.

(iv) Deresination—Guayule worms contain 17-25% resins. To remove these, the small highly porous worms in water are extracted with warm acetone. Water aids in keeping the worms in loose aggregate form and does not reduce the effectiveness of deresination. The acetone is then distilled off from the resin-water mixture and is recycled. After steam sparging to remove the residual acetone, the grey white guayule rubber contains about 2% resins as well as cork and debris that failed to sink in the slurry tanks.

Deresination with EtOH-gasoline (3:1) mixture and by open boiling and decantation has also given good results. Temperature has a marked influence on the nearness of completion of deresination and the extent of this influence depends upon the particular solvent used. The uniformly deresinated rubber so obtained can be dried using a screw press followed by a hot air drier.

Drying the crude guayule rubber without an antioxidant present is extremely deleterious both to the original quality and to the aging behaviour. Deresinated rubber is more stable when heated than the resinous product. A relatively large change in inherent viscosity takes place as a result of such treatment, which may be due to the change in shape, structure or solvation of the rubber hydrocarbon molecule independent of change in molecular weight.

(v) Final purification—Unlike hevea rubber, guayule rubber contains little gel and dissolves satisfactorily in hexane and cyclohexane. The solution is filtered to remove residual insoluble cork, fibre and dirt. The filtered solution is homogeneous and the rubber can be bleached, protected with antioxidants or treated with other reagents to give a high quality uniform product.

The solution phase of rubber provides the manufacturers the opportunity to chemically modify the rubber, e.g. in solution the rubber can be altered by polymerization, chlorination, copolymerization with methacrylates and by other reactions that produce rubbers with different properties.

The recovered rubber coagulated from the solution with wet steam is homogeneous and of high quality with exceptionally low amounts of ash, copper and iron. Constant viscosity rubber can be obtained by this method. By adding a surfactant during coagulation, a powdered rubber suited to bulk handling can be obtained.
Treatment of Rubber

Guayule rubber is heated in NaOH(10%) and subsequently with a dispersion or emulsion of water insoluble acid (e.g. palmitic or oleic acid) which forms with the alkali a detergent salt. This rubber after treatment approaches hevea rubber in quality and is far superior to acetone extracted guayule of comparable resin content. The product has improved tear resistance and resilience and when properly compounded or cured gives vulcanizates with improved physical properties and better aging qualities.

Improvement of Quality of Guayule Rubber

The quality of guayule rubber can be improved considerably and with consistent results by retting the shrub before milling. The resinous contaminants of crude rubber are reduced to about 0.5% of their content in unretted guayule rubber; the tensile strength after vulcanization is increased by about 50% and certain other physical properties are improved. The shrub is handled more advantageously and the recovery of rubber is greater. These improvements are the result of the action of micro-organisms; the success of the process, therefore, depends on the establishment of conditions which favour the rapid development of an active microbial flora, including molds, bacteria and actinomycetes. Poor results from retting reported by Spence were attributed to lack of aeration through large masses of shrub. Forced aeration makes it possible to ret the shrub under packing conditions equivalent to a depth of 5.2 ft and improves the quality of the resulting rubber. Not only is the excess of oxygen available to the shrub essential, but the temperature and moisture must also be within suitable ranges, which depend on the degree of mechanical reduction of the shrub and the frequency of mixing, e.g. by retting shrub for 21 days with adequate aeration under 50-70% moisture and a temperature of 40-48°C rubber of better quality is obtained. With shorter periods of retting, rubber of proportionately lower quality is obtained. Experimental evidence indicates that the physical superiority of guayule rubber prepared by retting depends on the selective removal of deleterious resins by micro-organisms.

Summary

World’s supply of natural rubber comes from Hevea brasiliensis, which alone may not be able to cope up with the increasing demand because of shortage of land suitable for extending its cultivation Guayule (Parthenium argentatum) has the potential of overcoming this deficit substantially, as it can grow on marginal arid lands. Factors affecting its growth and chemistry are discussed. Methods for determining its rubber content and extraction of rubber from the plant are described.

References

27. Skeeth B, Phytopathology, 36 (1946) 999.


52 Meeks J W & Banigan T F (Jr), U S Pat, 2,744,125, 1956; Chem Abstr, 50 (1956) 12512b.


59 Lloyd F E, Chem Abstr, 6 (1912) 1235.

60 Curtius O F Jr, Pl Physiol, 22 (1947) 333.


62 Haasis F W, Ind Engng Chem analyt Edn, 16 (1944) 480.


65 Bonner J, J chem Educ, 26 (1949) 628.


75 Shoolery J, NMR applications in laboratory, Varian Instrument Group Palo Alto, California, USA, Unpublished.


82 Jones E P, U S Pat 2,434,412, 1948; Chem Abstr, 42 (1948) 2809c.


86 Williams I, U S Pat 2,390860, 1945; Chem Abstr, 40 (1946) 1344.


93 Gracia A J, U S Pat 2,410,180, 1946; Chem Abstr, 41 (1941) 615e.


96 Spence D, U S Pat 1,918,671, 1933; Chem Abstr, 27 (1933) 4956.


100 Meeks J W & Banigan T F Jr, U S Pat, 2,584,163, 28 Apr 1951; Chem Abstr, 45 (1951) 8034a.