The Uses of Rubber

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THE rubber industry of to-day is concerned almost exclusively with the exudation which results from wounding certain of the tissues of *Hevea brasiliensis*, a large tree 80–100 ft. tall which is indigenous to the Amazon basin. The tree will grow almost anywhere in the belt 10° north and south of the equator, though it does not compete economically at elevations above 2,000 ft. Its translation from the Amazonian forests to plantations in the tropical Middle East is a romantic story associated with the names of Markham and Wickham.

The development of these plantations has been very rapid, the area having increased by fifteen times in the past twenty years, until to-day the production side of the industry is concerned with 7–8 million acres of plantations, chiefly in British Malaya, Netherlands Indies, Ceylon and French Indo-China, capable of producing more than a million tons of the product annually. This enormous aggregate area carries the progenies of the seeds collected by Wickham (1876) from the Amazon basin.

The exudation referred to above is known as hevea-latex, since *Hevea brasiliensis* is only one of some four hundred plant species which elaborate juices containing rubber or rubber-like substances. It is generally ivory white in colour, and tends towards the consistency of cream. It has practically the same density as water, and an average sample contains 35 per cent of rubber as a colloidal suspension of tiny globules which are negatively charged. Rubber itself is an unsaturated hydrocarbon with an empirical formula $(C_5H_8)_n$, where n possibly approximates to 1000. The suspension is very unstable, and if left to itself it develops acidity, when its globules coalesce to produce a coherent junket-like coagulum. Once the latex is coagulated it is not possible to reverse the process and recreate the suspension. The coagulation can be speeded up and be made complete by, for example, the addition of dilute acetic acid. It can also be prevented by the addition of ammonia, whereby the latex is kept 'sweet' and stable. In such condition it can be concentrated by creaming or centrifuging; further, with the addition of protective colloids, for example, soaps, glue, casein, etc., it can be concentrated by evaporation.

Very little is known of the biochemical processes which lead to the formation of latex in the tree, or of the rôle it plays in its life-processes. It occurs, and is probably elaborated, in a definite system of branching tubes, associated with the vascular tissue of the tree, which finds its highest development and greatest density in the inner bark of the base of the trunk, whence it is procured by 'tapping'. Speaking generally, the raw rubber of commerce is merely the dried coagulum of hevea-latex, and except for the preparation of preserved latex, an operation confined as yet to a few estates, the producing side of the industry finishes with the shipment of the dried product. This product is of limited utility. Among other things it becomes tacky with heat, stiffens with cold, and perishes with age. Early attempts to use it entailed its reconversion to liquid form by the use of solvents (Peal 1791 and Mackintosh 1819).

The rubber manufacturing industry of to-day was made possible by two empirical discoveries. Hancock (1820), seeking to shred the material on spiked rollers, discovered that the operation produced a plastic mass which could be moulded to shape. This process of mastication remains to-day as the preliminary in practically all manufacturing operations. We now know that oxidation and the generation of heat are the factors responsible. When, however, Goodyear (1839) and Hancock (1842) discovered independently that raw rubber subjected to heat in the presence of sulphur produced a much toughened product, relatively insensitive to temperature changes, and possessing a large number of other desirable properties, the foundations of the industry were laid. The reaction is known as vulcanisation. The chemistry and physics involved in it are obscure. These two discoveries made possible the transformation of raw rubber into a plastic mass, the incorporation of softeners to ease manipulation, of reinforcing ingredients, of anti-oxidants which preserve its properties, of inert materials which cheapen its products, and of accelerators which speed up the vulcanising process.

The science and art of the technologist enable us to-day to produce materials presenting wide ranges of colour, density, elasticity and resilience, specific electrical resistance and resistance to abrasion; products can be made which are impermeable to liquids and gases and resistant to corrosive chemicals. There are endless combinations of desirable qualities which can be brought together to serve specific purposes. In a survey of the latter, however, it is necessary to distinguish between the following: latex, rubber solutions, soft vulcanised products and hard vulcanised products; all these represent different physico-chemical forms of rubber.

Latex is comparatively new in industrial applications, and one of the most important discoveries in connexion with it is that the rubber can be vulcanised in its natural 'aqueous' form. It is rapidly replacing solutions of raw rubber in coal-tar naphthas, in the treatment of tyre fabrics, in spread- and dipped-goods. It is of special value in the manufacture of sponge rubbers and electrically deposited rubbers, and—looking to the future—its use as a binder, either as a main or auxiliary material, bids fair to penetrate far and wide in industry.

The common solvent for raw rubber is coal-tar naphtha. Solubility is increased by previous mastication of the rubber, though this treatment decreases subsequent adhesive properties. Uses here lie chiefly in the field of adhesives and fabric proofing.

If the process of vulcanisation is carried out in the presence of excess sulphur, vulcanite or ebonite (hard vulcanised rubber) is produced. The two main fields of application are electrical insulation and corrosive resistant goods, such as linings for conveyors, storage tanks and pipes.

There remain the soft-vulcanised products, and it is in this category that rubber displays its amazing versatility. Its applications are literally too numerous to mention.

A rough index of proportionate industrial absorption of rubber based on American data is approximately: automobile industry 80 per cent, footwear industry 9 per cent, electrical industry 1 per cent, fabrics 1 per cent, surgical goods 0·5 per cent and the balance in toys and novelties, floorings, etc.

Of the fundamental problems concerned with the constitution of the rubber hydrocarbon molecule, the process of vulcanisation, now almost a century old, the action of accelerators and the colloidal system presented by rubber-latex, relatively little is known, and it is surprising that the technologist has been able to advance so far without more aid from fundamental research. That his advance has been substantial is a matter of universal experience, but he who would make his experience more intimate and widen his knowledge of a young industry with great potentialities, will find profit in a visit to the Rubber Exhibition at the Science Museum, South Kensington.

This exhibition is a very comprehensive one, and its sponsors have met with a full measure of success in their efforts to make it educative. A wide field is covered from the planting of the *Hevea* seed. The exploitation of the bark, the processing of latex to produce plantation grades of raw rubber, the milling and compounding of the latter to produce articles of everyday use, are shown. It is not possible to deal more than briefly with the general sections of the exhibits.

The plantation section shows the lay-out of an estate and the work involved in good husbandry, the prevention of soil erosion, measures of prophylaxis against disease, the economic tapping systems and the operations involved in re-stocking, by the propagation of pedigree buddings. An exhibit of particular interest to the layman is the display of latex, since, while it was recorded as long ago as 1781 that this material could be preserved by the addition of certain alkalis, it was not until 1920, when bulk shipments were sent in the ballast tanks of steamers from Sumatra to America, that it became important industrially. How important it is now will be evident when the visitor sees rubber-thread, sponge rubber and dipped goods made from it.

The manufacturing section, besides showing the latex applications, shows the machinery for milling, compounding and vulcanising in actual operation.

The scientific section is of special merit in demonstrating the varied contributions of science to the development of the industry. Demonstrations are staged showing the Brownian motion of the latex globule and its movements in an electrical field, the technique involved in dissecting the rubber globule, operations of creaming, centrifuging, homogenising and coagulating. The student technologist can revel in plastometers, viscometers, durometers, etc. He will be attracted by an ingenious device demonstrating the relative activity of various accelerators. He will be able to inspect a Wiegand's pendulum and demonstrate to himself the Joule effect. He should take this unique opportunity to inspect a well-arranged, though congested, set of valuable instruments and apparatus.

The section dealing with applications ranges from the service of the product in the automobile industry to almost the complete fitments of a surgical theatre.

The historical section contains the original plaster study of the bust of Sir Henry Wickham, seeds of the original collection made by him in the Amazon basin, and such interesting exhibits as Hancock's experimental machinery.

There is one inconspicuous exhibit of special interest to the research worker. This contains expanded chlorinated rubbers, oxidation products of rubber, and a variety of new products which touch the fringe of what must be a field of great possibility, namely, the use of rubber as a raw commodity for the manufacture of other substances. In this connexion, we have recently learned that rubber is amenable to hydrogenation.

Exhibitions of this nature are very difficult to organise, and the best-organised of them can be prodigal of a visitor's time. To minimise this, the sponsors have made available a carefully indexed guide. This reaches a high standard and the visitor will find it very informative and almost indispensable.