RUBBER LATEX*

PRODUCTION OF RAW AND CRUDE RUBBER FROM LATEX

IN the Amazon valley crude rubber is prepared by dipping a paddle into latex and rotating it in the smoke of burning urikuri nuts. The hot, astringent smoke coagulates and dries the rubber; part of the serum trickles away, the rest is dried with the rubber. Many dippings are required to build up a large ball or "biscuit" in which form Para rubber comes to the market.

On plantations latex is almost invariably coagulated by the addition of a small amount of acetic acid. The coagulum may be sheeted between corrugated rolls and dried in smoke houses to produce *ribbed smoked sheet* or it may be passed between rolls running at different speeds in a spray of water to produce *pale crepe.* The light colour of the latter is preserved by the addition of sodium bisulphite to the latex prior to coagulation. In case of both of these important commercial grades of rubber, and particularly the latter, the serum constituents are rather completely removed from the rubber. This is not wholly an advantage since some constituents which improve the ageing characteristics of rubber are removed.

With a view to remedying this shortcoming, various processes have been devised for making whole-latex rubber. One of the best known of these is the Hopkinson process whereby latex is evaporated in a spray drier. The latex-sprayed rubber thus obtained has superior ageing properties and is uniform and tough, but has the disadvantage of including a large proportion of non-rubber constituents than standard plantation rubber.

Preservation, Concentration, and Shipping of Latex.—Latex normally begins to coagulate within a few hours after tapping on account of the formation of acid by bacterial action. Coagulation may be prevented by the addition of an alkali to neutralize the acid, or of an antiseptic to prevent the growth of micro-organisms. The alkalies commonly used are ammonia and sodium hydroxide. The former has the advantage that it is volatile and consequently may be readily removed from rubber products made with latex. The ordinary latex available in the United States at the present time is preserved with about 3 per cent by weight of concentrated aqueous ammonia solution, specific gravity, 0·882. The preservation of latex with alkalies has the disadvantage that the protein layer on the latex particle is slowly hydrolyzed by the alkali with the resultant change in properties of the latex.

Formaldehyde has been used as a preservative of latex in the proportion of 2 to 3 per cent of ordinary 40 per cent formaldehyde solution. Although it has greater anti-coagulating power and is a better antiseptic than ammonia, it is not held in favour because the rubber produced from latex preserved with it has low tensile strength, decreased rate of vulcanization and other unsatisfactory properties.

Various means are employed for shipping latex. One of these is in five-gallon oil or gasoline tins which are packed in wooden boxes. Such

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tins are available second-hand in the tropics, and are convenient for handling latex in small quantities. Shipments of latex from plantations to regular customers are sometimes made in light metal containers so designed that they can be returned to the plantation packed in small space. Large shipments of latex are made in tank steamers and tank cars. In some cases oil tank steamers are used, but vessels have been built exclusively for the transportation of latex.

Since natural latex contains only about one-third its weight of rubber, shipment involves the transportation of two-thirds its weight of useless water. For this reason many means have been devised for concentrating latex prior to shipment. These include creaming, centrifuging, filtration, and evaporation. Creaming may be effected by adding an alkali such as sodium hydroxide to the latex and allowing it to stand for a few hours at 60° or 65°C. This causes the separation of the latex into two layers, the upper of which is thick and rich in rubber. Creaming may also be brought about by means of colloidal substances, such as Irish moss, gelatine ammonium alginate, and the like. The products thus obtained may contain as much as 75 per cent of rubber, but are reasonably stable and may be redispersed when water is added to them.

The concentration of latex by filtration involves difficulties of large scale operation, and the same appears to be true of the use of the centrifuge.

The concentration of latex by evaporation is the basis of the "Revertex" process, which is operated on a commercial basis at the present time. The latex is treated, on collection, with a non-volatile alkaline preservative to keep it unchanged until it is subjected to the evaporation process. The evaporation is effected by means of a rotary dryer of special design. An alkaline protective colloid such as sodium oleate is added to the latex before evaporation and permits the concentration to be carried to a thick paste without destroying the capacity of the latex of redisperse of the addition of water.

VULCANISATION OF LATEX

The individual rubber particles in latex may be vulcanized without coagulating the latex and without altering many of its properties and characteristics. Vulcanization may be effected by as simple a procedure as stirring powdered sulphur into the latex and heating it in an autoclave for two or three hours at about 140°C. Vulcanization is quicker and more effective if the sulphur is used in the form of a dispersion which does not settle readily, or an alkaline polysulphide, which remains in solution. Accelerators which are employed to speed up the vulcanization of ordinary rubber compounds have relatively less effect on the vulcanization of latex than on the vulcanization of rubber.

When vulcanized latex, is evaporated, a film of vulcanized rubber is obtained which is fully as strong as the product obtained by the vulcanization of crude rubber. Vulcanized latex may be coagulated or electrodeposited in the same way as ordinary latex, the only essential difference being that vulcanized rubber is obtained.

Vulcanized latex has the obvious advantage for many manufacturing processes that no treatment beyond drying is required to produce strong, durable rubber. Vulcanized latex is particularly suitable for use in the production of rubber-textile combinations where the heat or the materials employed for vulcanizing rubber would affect the colour or injure the fabric.

MANUFACTURE OF RUBBER PRODUCTS DIRECTLY FROM LATEX

Rubber latex has been suggested for direct use in the manufacture of practically all types and kinds of rubber articles but the applications which have been most successful, thus far, have been those in which the rubber is formed in thin layers as in dipped goods, rubberized fabrics, and rubber coatings on metal.

The importance of latex in manufacture is indicated by the fact that in 1930 the United States imports were equivalent to almost ten million pounds of dry rubber, or approximately one per cent of the total rubber imports. International Trade in Rubber Latex is the subject of Special Circular No. 3147 issued by the Rubber Division of the Bureau of Foreign and Domestic Commerce, November 30, 1931.

Latex may be used in manufacture in either the natural or the vulcanized state. Where vulcanized latex is employed it is only necessary to deposit rubber in the desired form and dry it in order to secure a finished rubber article. Products made from natural latex are ordinarily vulcanized after they have been formed. This may be done simply and quickly by treatment with a dilute solution of sulphur chloride in carbon bisulphite or carbon tetrachloride, but stronger and more durable rubber may be obtained by hot vulcanization with sulphur. This requires that the sulphur and accelerator of vulcanization shall have been incorporated in the latex before the rubber product was formed from it. Methods have been developed whereby not only sulphur and accelerators but also fillers, pigments, softeners, and the like may be dispersed in the latex so as to be co-deposited with it in a uniform and intimate mixture.

The processes in which latex is used for the production of rubber goods include spreading, dipping, electrodeposition, chemical deposition, and froth or foam formation. Fabrics may be coated with rubber by simply spreading latex on them and allowing it to dry. While this process is very simple in principle, careful attention to the composition and the consistency of the latex is required in order to obtain a product of good spreading quality. The impregnation of fabrics, ropes, and cords with latex may be accomplished by passing them through a bath of latex and subsequently drying them on heated rolls or by other means.

Thin rubber articles may be produced by dipping a form or mould into latex and allowing it to dry. This process is less expedient than the common dipping process employing cements made from rubber and benzene or gasoline, because the low viscosity of the latex necessitates a number of dippings in order to build up a layer of useful thickness.

This difficulty may be obviated by employing a porous form so that the serum of the latex is absorbed in the pores by capillary action, while the rubber particles are deposited in the coherent layer on the surface.

Another means of depositing a layer of rubber on a form is electrodeposition. This method is finding extensive commercial application not only in the manufacture of rubber articles, such as gloves, toy balloons, tobacco pouches, bathing caps and rubber tubing, but also in the application of rubber coatings to metal surfaces, including plates, rods, gauze, pipe, pipe-fittings, insulated wire, and the like. Rubber may be deposited with either a small or a large proportion of sulphur so as to produce on vulcanization either soft rubber or ebonite.

The basis for electrodepositing rubber from latex is the negative charge which resides on the latex particle. When electrodes are immersed in latex and a potential is applied, the rubber particles, by reason of this charge, move to the anode where they are discharged and coagulate to form a coherent layer. It might be expected that a very thin deposit of rubber would insulate the anode, but such is not the case for sufficient water is held in the deposit to permit the penetration of ions and layers of rubber as much as one-quarter-of-an-inch in thickness may be formed without difficulty.

The potential used for electrodepositing rubber is of the order of 100 volts, and the current density, from 3 to 5 amperes per square decimeter. The ratio of mass to charge in the latex particle is very high. The amount of deposit obtained per unit of current consumption is relatively much greater than in case of the electrodeposition of metals.

Various metals may be employed as the anode on which rubber is to be deposited, but zinc is most commonly used and gives the most satisfactory results. A porous cup or semi-permeable membrane may be used around the anode and the deposit formed on this rather than directly on the metal.

Sulphur and many accelerators, pigments, and fillers may be dispersed in latex and co-deposited with the rubber. Consequently rubber compounds may be produced employing the same ingredients, in general, as are used in mill-mixed rubber. The hydrogen ion concentration in a latex bath must be carefully controlled in order to obtain a satisfactory deposit. If the attempt is made to electrodeposit rubber from commercial ammonia-preserved latex, the product obtained will be spongy and porous on account of the evolution of oxygen gas by the electrolysis of the alkaline solution. If the solution be dialyzed, however, until most of the ammonia is removed, the deposit will be uniform and free from inclusions of gas.

The "throwing power" of a latex bath is poor and the deposit in recessed portions of an irregular anode is apt to be thin. A uniform deposit may be obtained on irregular forms by the chemical deposition process in which the form is first dipped into a solution of a coagulant and then into the latex bath. The coagulant causes a layer of rubber to be deposited, the thickness of which depends on the time of immersion in latex and on the nature and concentration of the coagulant. The deposit obtained by this means is similar in character to that obtained by electrodeposition. Coagulants which have been suggested for use in this process include acetic acid, alum, formic acid, and various other acids and salts.

Making use of this same principle, rubber thread may be produced by squirting latex into a coagulating bath in a fine stream, in a manner similar to that employed in making rayon and other synthetic fibres.

Rubber that has been freshly deposited from latex by coagulation or by electrodeposition, is soft and contains both water and some enclosed serum. The serum constituents which are soluble may be partially removed by careful washing. The drying of the rubber is best effected in an atmosphere of controlled humidity so as to avoid the early formation of a surface layer of dry rubber which would be difficultly permeable to moisture from the layers beneath.

Ordinarily when the rubber deposit from latex is dried the globules of latex shrink together as the water is removed and coalesce so as to form a product that is substantially without voids or porosity. A process has recently been developed, however, whereby it is possible to convert latex into a gel containing considerable proportions of water, and then to remove the water without destroying the structure of the gel. The product thus obtained is known as microporous rubber. The gel may be vulcanized to any desired stage before the abstraction of the water, so it is possible to produce either a microporous soft rubber, or a microporous hard rubber.

Quite different from microporous rubber is rubber sponge which may be produced from latex by whipping it into a froth or otherwise incorporating gas into it so as to produce a microscopically porous structure, and coagulating and vulcanizing the rubber in this state.

PROPERTIES OF RUBBER PRODUCED DIRECTLY FROM LATEX

Rubber made directly from latex is generally characterized by greater strength and resistance to tear, and better ageing properties than rubber made by processes involving the milling of crude rubber. The tensile strength of latex rubber made without fillers is usually 4,000 to 6,000 pounds per square inch, though strengths as high as 7,000 pounds per square inch have been reported.

The better ageing of rubber made from latex in comparison with that made from crude rubber may be attributed both to the lack of mechanical mastication, and to the inclusion of a relatively larger proportion of natural antioxidants. The natural antioxidants are present in the serum of latex and are to a large extent lost in the usual preparation of plantation rubber.

A rubber compound made directly from latex has a lower resistance to some types of abrasive wear than a similar compound made from milled rubber. This may be observed, for example, by scraping a latex glove with the finger nail or with a knife blade. It is relatively easy to roughen and "pick up" the surface of the rubber or, even to remove small particles of rubber. It is much more difficult to produce this effect with milled rubber, though the latter may have a decidedly lower tensile strength. A critical study of the resistance of latex rubber to abrasion does not seem to have been made. This is not, however, a matter of particular practical consequence since the majority of the products made from latex are not of types that are likely to be subjected to severe mechanical wear.

NON-HEVEA LATICES

Many plants in addition to the tropical rubber tree, *Hevea brasiliensis*, produce latex. In some cases such as *Castilloa elastica* and *Funtumia elastica*, the latex may contain rubber equal in quality to that of the *Hevea*. *Ficus elastica*, a tropical tree closely related to the household rubber plant, and other plants yield latices that contain a considerable proportion of resins along with the rubber. Still other latices contain not rubber, but related gums such as gutta-percha, balata, and chicle.

The various latices differ markedly in behaviour as well as in composition. Some of them are readily coagulable by acids, just as the *Hevea* latex, while others are relatively stable towards acids. Formaldehyde, which is sometimes used to preserve *Hevea* latex, may actually coagulate the latex of other plants. Microscopic examination of latices indicates that the particles differ in size, and that in some instances the particles are globular, and in other instances, rod-shaped.

No latex, other than *Hevea* is commercially available, chiefly for the reason that the trees, vines, or shrubs producing the other latices are wild, and adequate facilities do not exist for collecting, preserving, transporting, and marketing them. It is true that gutta-percha is now cultivated on an experimental plantation, but the gum is obtained by collecting the leaves rather than by tapping the trees, since the latex does not flow freely.