ATMcP:FLD:ED

DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
WASHINGTON

Letter
Circular
LC 321

February 25, 1932

RUBBER LATEX

Abstract

This Letter Circular is intended to give general information on rubber latex and to direct the reader to sources from which special or detailed information may be obtained. Part I is a brief discussion of the production, composition, and properties of latex and its use in manufacture. Part II is a list of recent publications on latex, covering the period 1927-1931.

CONTENTS

(3) Colloidal properties; microscopic examination of latex particles
(4) Physical properties; surface tension, swelling, viscosity

4. Treatment of latex

(1) Straining and filtering
(2) Coagulation

a. Coagulation phenomena
b. Coagulants

(3) Creaming
(4) Drying
(5) Concentration)
(6) Electrodeposition)
(7) Deposition on porous forms)

Most publications dealing with these processes for treating latex also deal with their application in the manufacture of rubber products, hence all references have been included under section 5.

(8) Preservation
(9) Transportation

5. Applications of latex in manufacture

(1) General discussions
(2) Patent reviews
(3) Concentrated latex, its preparation and use

a. General
b. Revertex

(4) Vulcanized latex, its preparation and use
(5) Electrodeposition of rubber from latex
(6) Deposition of rubber from latex on porous forms
(7) Products made with latex

a. Paper
b. Paint
c. Adhesives
d. Footwear
e. Rubber-textile combinations
f. Sponge rubber and microporous rubber
g. Miscellaneous

6. Water dispersions of rubber

INTRODUCTION

This letter circular has been prepared in response to inquiries and requests for information about rubber latex. The aim has been to give a concise description of the production, composition, properties and applications of latex, and to acquaint the reader with publications from which more detailed information may be obtained. The scope and variety of publications on latex that are already available are such that any attempt here to give a comprehensive discussion on the subject would be superfluous.

The present discussion is concerned primarily with commercial latex which is obtained by the tapping of the tropical rubber tree, Hevea brasiliensis, but in the bibliography reference is made to other natural latices, and to artificial dispersions of rubber which closely resemble natural latex in many of their properties and applications.

The references to publications, which comprise the second part of this letter circular, are largely but not exclusively confined to the period 1927 to 1931. Some publications of general interest that appeared prior to 1927 have been included. The reasons for restricting the bibliography to the last five years are two-fold. In the first place, there has been a recent widespread interest in latex and numerous publications have appeared dealing with a variety of theoretical and practical aspects of the subject. It is to this recent literature that the reader seeking general information would naturally turn first. Furthermore, the literature up to 1927 has been exhaustively surveyed in Hauser's monograph on latex which is available in an English translation.

The references have been classified according to topics as indicated in the table of contents. The scheme of classification has been adapted from that of the Information Bureau of the Research Association, British Rubber Manufacturers. Under each topic the references have been arranged by year of publication in the order 1931, 1930, 1929, etc., while under each year an alphabetical arrangement by authors has been followed. The names of journals have been given in full for the convenience of the reader who may have only a limited familiarity with the rubber literature. The place of publication, subscription price, and scope of most periodicals dealing with rubber are given in Letter Circular of the Bureau of Standards No. 305, A Guide to the Literature on Rubber.

The following paragraphs enumerate various governmental and other agencies which have to do with latex and indicate sources from which special information may be obtained.

The Office of Cotton, Rubber, and Other Tropical Plants of the

Bureau of Plant Industry, United States Department of Agriculture, deals with the collection, composition, and properties of latex in connection with studies on the production of rubber. The investigations carried on by this office include many rubber-bearing plants of both temperate and tropical habitat in addition to those which are employed as commercial sources of rubber.

The Rubber Division of the Bureau of Foreign and Domestic Commerce, United States Department of Commerce, collects and publishes statistical information on the production, export and import, and consumption of latex. The world trade in latex up to 1931 is summarized in Special Circular of the Rubber Division, No. 3147, International Trade in Rubber Latex, 4 pp.; November 30, 1931.

Commercial information regarding latex may be obtained from current rubber trade journals, two of which, published in the United States, are:

India Rubber World, published monthly by Federated Business Publications, Inc., 420 Lexington Ave., New York. Annual subscription, $3.00.

Rubber Age, published twice monthly by the Palmerton Publishing Co., 250 W. 57th St., New York. Annual subscription, $2.00.

The price of rubber latex, per gallon, is given in the market quotations which appear in the above journals and also in some daily newspapers. Statistics regarding export, import, and world trade in latex are also given in the rubber journals.

The names and addresses of firms which deal in natural latex, vulcanized latex, concentrated latex, and various latex preparations, may be obtained from the advertising columns of the rubber journals or from the Rubber Manufacturers' Association, 250 West 57th St., New York.

PART I. TECHNOLOGY OF LATEX

Rubber latex is a creamy liquid made up of microscopic rubber globules dispersed in an aqueous serum. Many different trees, shrubs and vines yield latex, but the tropical rubber tree, Hevea brasiliensis, is now almost the exclusive commercial source of supply. A large proportion of the latex produced is converted at once into crude rubber which is used as the raw material for the manufacture of rubber products. Within the last decade, however, developments in the preservation, concentration, and vulcanization of latex have rendered it available for direct use in manufacture, without the intermediate step of the preparation of crude rubber. Latex is

well suited for producing rubber coatings on metal and fabrics, for making thin rubber articles, and for use as an adhesive. Various processes are used in the manufacture of products from latex, one of the most unique being electrodeposition, which is analogous to the electroplating of metals. Rubber products made directly from latex are generally superior in strength, elasticity and durability to those made from crude rubber.

1. Collection of latex

Latex occurs in the leaves, in the inner bark of the branches and trunk, and in the cortex of the roots of the Hevea brasiliensis as well as other rubber-yielding trees. It is contained in microscopic tubes in which it exists under a certain pressure, although there is no evidence that it normally flows or circulates. Latex is wholly separate and distinct from the sap of the tree. The role of latex in plant economy has been the subject of considerable study and speculation, but no theory as to its function seems to have gained general acceptance.

Latex is obtained from the Hevea tree by tapping it near the base. The usual method of tapping consists in making an incision one quarter, one third, or one half way around the trunk and two to four feet above the ground. The bottom of the incision is shaped as a trough to carry latex, which oozes out from the severed latex tubes to a spout from which it drips into a clean glass, porcelain, or aluminum collecting cup.

Successive tappings are performed by paring a thin strip from the bottom of the previous cut by means of a special U or V-shaped tool. Tapping is a delicate operation; the cut must go almost through the bark so as to open the maximum number of latex tubes, but must not penetrate or injure the cambium or thin growing layer between the bark and the wood. The thickness of the paring is such that the cut is lowered at the rate of about one or two inches per month. When the cut reaches the bottom of the tree, a new tapping panel is opened on the opposite side, and the panel which has been tapped is allowed to rest so that the bark may heal.

Originally, rubber trees on estates or plantations were tapped daily, but this proved to be injurious to the trees, and now tapping schedules usually provide for rest on alternate days, weeks, months, or other periods. In some instances trees may be tapped only every third day. With the less frequent tapping, the total yield of rubber may be decreased somewhat, but the yield per tapping operation is greater, so that an economy in labor is effected.

The quantity of latex obtained each time a tree is tapped may range from a fraction of an ounce to several ounces, depending both on the frequency of tapping, weather and seasonal conditions, and

on individual characteristics of the tree. The average yield is of the order of one or two gallons of latex per tree per year, which is equivalent to 3 to 6 lbs. of dry rubber. Trees yielding 10 to 20 lbs. of dry rubber per year are not uncommon, and yields of 50 lbs. have been recorded. Considerable study has been given to the propagation of high-yielding trees, both by seed selection and by bud grafting. The transmission of latex-producing characteristics is by no means simple or direct, but in some cases bud-grafted trees have the yield characteristics of the tree from which the bud was taken. This affords a possibility of greatly increased rubber production. Yields of 1000 or 1250 lbs. of rubber per acre per year are predicted, instead of 300 to 500 lbs. as at present, but such returns have not yet been attained on any considerable area.

The daily routine of tapping trees, collecting and caring for the latex, is described in various books on rubber. A detailed and well illustrated account, which is no longer up to date in all particulars, is given in The Preparation of Plantation Rubber by Sidney Morgan and Henry P. Stevens, Constable & Co., Ltd., London; 1922. Some phases, such as tapping, are discussed in detail in a more recent book, Modern Aspects of Rubber Cultivation, by Charles Herbert Wright; Maclaren & Sons, Ltd., 37-38 Shoe Lane, E.C. 4, London; 1928.

The collection of latex and the production of rubber from wild *Hevea* trees in the Amazon valley is crude and inefficient in comparison to the well-ordered procedure on plantations in the Middle East. A well-illustrated description of South American methods is given in United States Department of Agriculture Bulletin No. 1422, The Hevea Rubber Tree in the Amazon Valley, by Carl D. La Rue; 1926. This publication may be obtained from the Superintendent of Documents Government Printing Office, Washington, D. C., for 15 cents, (stamps not accepted).

The collection of latex on an experimental scale is described in United States Department of Agriculture Technical Bulletin No. 65, Experimental Tapping of *Hevea* Rubber Trees at Bayeux, Haiti, by L.G. Polhamus; April, 1928; price, 5 cents, from the Superintendent of Documents.

2. Composition and properties of latex

When latex is observed under a microscope at a magnification of about 1000 diameters or greater, it is seen to consist of minute globules suspended in an aqueous serum. On account of their small size, the particles are in vigorous Brownian motion. They range in diameter from less than 0.5 micron to about 5 microns, and the particles large enough to be resolved distinctly appear to be pear-shaped and to have tails. The structure of the individual latex particle

has been studied by Hauser by micromanipulation with very fine glass needles. A particle, when punctured by a needle, appears to consist of a tough, elastic sac filled with a viscous fluid. Both the elastic shell and the viscous contents are regarded as different modifications of rubber, while on the exterior of the particle there is a layer of adsorbed protein. Another description and interpretation of the structure of the latex particle has been given by Von Weimarn.

The exterior protein shell plays an important role in the coagulation of latex by acids. As evidence for this, latex from which the protein has been removed by digestion with trypsin or by other means, is practically unaffected by acids in concentrations which would instantly coagulate the original latex. Coagulation phenomena in latex are by no means simple; they have been the subject of detailed study on account of their importance in the preparation of crude rubber.

The rubber content of the fresh latex may vary from 15 to 60 per cent, depending on the age and condition of the tree, the season, the tapping schedule, and the portion of the tree from which the latex was drawn. In most cases, however, the rubber content lies between 20 and 45 per cent by weight, normal or average latex being assumed as containing about one third of its weight of rubber. There is no agreement, however, as to the exact percentage of rubber in normal latex. Various authorities refer to 30, 33, and 35 per cent of rubber, and still others to 3 lbs. or 3 1/2 lbs. of rubber per gallon. The Bureau of Foreign and Domestic Commerce has sought to eliminate the uncertainty in latex import statistics by requesting that the dry rubber content of the latex be declared by weight.

The specific gravity of latex varies with the rubber content since rubber has a specific gravity of 0.914, and the latex serum from which the rubber has been removed, a specific gravity of 1.020. It is common practice on plantations to ascertain the approximate rubber content of latex by specific gravity determinations with a hydrometer graduated in per cent of rubber and known as a "metrolac".

The important co sittuent of latex is the hydrocarbon, rubber. Other constituents are proteins, mineral salts, reducing sugars, quebrachitol or monomethyl-l-inositol, and a variety of substances soluble in acetone which are commonly grouped together and designate as resins. When latex is coagulated some of these minor constituent are included with the rubber hydrocarbon to form crude rubber, while others remain in the serum which is separated from the coagulum. Th composition of latex and of crude rubber is shown in Table 1 which is taken from a review on the Chemistry of Rubber by Fisher.

Table 1

Substances in the latex and in coagulated rubber [1]

	In the latex	In the crude rubber
Crude rubber	30.0	100
Rubber hydrocarbon	28.0	92.0 - 94.0
Total solids	33.0 - 34.0	98.9 - 99.7
Mineral substances (ash)	0.3 - 0.7	0.15 - 0.45
Components containing nitrogen (calculated as proteins; 6 x % N)	1.0 - 2.0	2.5 - 3.5
Components soluble in acetone ("resins")	2.0 (?)	2.5 - 3.2
Quebrachitol	1.0 - 2.0	Trace
Reducing sugars	1.15- 0.35	---

[1]From "The Chemistry of Rubber", by Harry L. Fisher, Chemical Reviews, Vol. VII, p. 57; March, 1930.

3. Production of raw or 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 color 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 aging 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 aging properties and is uniform and tough, but has the disadvantage of including a larger proportion of non-rubber constituents than standard plantation rubber.

4. 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 a 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 favor 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 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 an 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 for 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 to redisperse on the addition of water.

5. Vulcanization 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 pol sulphide, 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 h at or the materials employed for vulcanizing rubbe would affect the color or injure the fabric.

6. 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 10 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, Nov. 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 disulphide 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 mold 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 a 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 com only 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.

7. Properties of rubber produced directly from latex

Rubber made directly from latex is generally characterized by greater strength and resistance to tear, and better aging 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 aging 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 frommilled rubber. This may be observed, for example, by scraping a latex glove with the fingernail 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.

8. 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*. The *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 behavior as well as in composition. Some of them are readily coagulable by acids, just as the *Hevea* latex, while others are relatively stable toward 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.

PART II. SOME RECENT PUBLICATIONS ON LATEX

I. Books

LATEX, ITS OCCURRENCE, COLLECTION, PROPERTIES, AND TECHNICAL APPLICATION. By E.A. Hauser. Translated by W.J. Kelly. Chemical Catalog Co., Inc., New York, 1930. 200 pp. illustrated. Price, about $4.00.

HANDBUCH DER KAUTSCHUK-WISSENSCHAFT. Edited by Karl Memmler. S. Hirzel, Leipzig, 1930. Price about $15.00. Section A, pp. 23 - 183, by A. Zimmermann deals with the botany, production, cultivation, and preparation of rubber and includes chapters on latex, tapping, direct applications of latex, coagulation of latex, and conversion of latex into raw rubber.

THE ELECTROMETRIC DETERMINATION OF THE HYDROGEN ION CONCENTRATION IN THE LATEX OF HEVEA BRASILIENSIS AND ITS APPLICABILITY TO TECHNICAL PROBLEMS. By N.H. Van Harpen. Varekamp & Co., Medan, (Sumatra, Netherlands East Indies) 1930. 460 pp.

LATEX. By H.P. Stevens. Rubber Growers Association, London; 1928. 66 pp. A non-technical treatise on the production, properties, and applications of latex. This pamphlet is designed for the information and guidance of persons wishing to undertake experimental work on latex. A short bibliography is given together with a list of relevant patents with short abstracts. A revised edition was in preparation January 1932.

COLLOID CHEMISTRY OF RUBBER, Paul Stamberger. Oxford University Press, London, 1929.

THE COLLOID CHEMISTRY OF THE RUBBER INDUSTRY, E. A. Hauser. Oxford University Press, London.

Crude Rubber Survey Bulletins

The following Crude Rubber Survey Bulletins of the United States Departments of Commerce and Agriculture contain considerable information on the production and properties of latex. They are available in many public libraries and may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C., for the prices indicated (stamps not accepted).

David M. Figart, The Plantation Rubber Industry in the Middle East, Bureau of Foreign and Domestic Commerce, Trade Promotion Series, No. 2; 317 pages; 1925; price, 50 cents.

William L. Schurz, Rubber Production in the Amazon Valley, Ibid, No. 23, 364 pages; 1925; price, 65 cents.

H. N. Whitford and Alfred Anthony. Rubber Production in Africa, Ibid, No. 34, 136 pages; 1925; 25 cents.

John C. Treadwell and C. Reid Hill, Possibilities of Rubber Production in Northern Tropical America, Ibid, No. 40; 375 pages; 1926; price 65 cents.

Joseph W. Vander Laan, Production of Gutta-Percha, Balata, Chicle, and Allied Gums, Ibid, No. 41; 72 pages; price, 15 cents; 1927.

C.F. Vance, A.H. Huzzall, J.P. Bushnell, and Mark Baldwin, Possibilities for Para Rubber Production in the Philippine Islands, Ibid, No. 17; 101 pages; price, 20 cents; 1925.

Carl D. La Rue. The Hevea Rubber Tree in the Amazon Valley, United States Department of Agriculture Department Bulletin No.1422; 70 pages; price 15 cents; 1926.

2. Source of latex, - plant physiology, yield, tapping, variability.

C. Heusser and H.J.V.S. Holden, Tapping Results with the New Double Cut Tapping System on Hevea Buddings in 1930. Archief voor de Rubbercultuur in Nederlandsch-Indie., Vol. 15, p. 246; 1931.

M. Roeben, Physiology of Latex. Jahrbucher fur wissenschaftliche Botanik (Berlin). Vol. 69, p. 587; Chemical Abstracts Vol.25, p. 3031; 1931.

J. F. Schmole, Relation of the Number of Trees per Tapping Task to the Yield of a Rubber Plantation. Archief voor de Rubbercultuur in Nederlandsch-Indie Vol. 15, p. 219; India Rubber Journal, Vol. 82, p. 124; 1931.

T.A. Tengwall, Results of a Tapping Experiment with Alternative Daily Tap over One-third Circumference versus Tap Every Third Day over One-half Circumference. Archief voor de Rubbercultuur in Nederlandsch-Indie Vol. 15, p. 258; 1931.

D.J.N. van der Hoop, Correlation between Girth and Yield in Seedlings and Buddings, Archief voor de Rubbercultuur in Nederlandsch-Indie, Vol. 15, p. 336; 1931.

J. Schweizer, Hevea Production Factors, India Rubber World, Vol. 81, No. 5, p. 91; Feb. 1931.

H. Ashplant, Latex Tube Bore Theory. Planters Chronicle (Madras) Vol. 25, p. 656; 1930. India Rubber Journal, Vol. 80, p. 904; 1930.

A.Frey-Wyssling, Investigation into the Relation between the Diameter of the Latex Tubes and the Rubber Production of Hevea brasiliensis. Archief voor de Rubbercultuur in Nederlandsch-Indie, Vol. 14, p. 135; 1930.

F.Summers. The Improvement of Yield in Hevea Brasiliensis. Kelly and Walsh, Ltd., Singapore, F.M.S.; 1930 (Price 12 shillings, six pence) India Rubber Journal Vol. 79, p. 447; 1930.

United States Department of Commerce, Yields of Rubber Producing Centers, India Rubber World, Vol. 82, No. 3, p. 92. Average export per acre of mature rubber trees tabulated for 7 rubber producing areas, 1917-1928.

H. Ashplant, Investigations into Hevea Anatomy. Bulletin of the Rubber Growers' Association, Vol. 10, p. 484; 1928.

H. Ashplant, Rubber Planting Matters. Latex Tube Bore. India Rubber Journal, Vol. 76, p. 388; 1928.

H. Ashplant, Latex Tube Bore Theory. Bulletin of The Rubber Growers' Association, Vol. 10, p. 796; 1928.

H. Ashplant, Yield Variability in Hevea Brasiliensis, Nature Vol. 121, p. 1018; 1928.

N. Rae, Seasonal Variations in the Composition of the Latex of Hevea brasiliensis, Society of Public Analysts, Feb. 1, 1928. Nature, Vol. 121, p. 344; 1928. Variations of potash, nitrogen, phosphorus, etc.

Charles Herbert Wright, Modern Aspects of Rubber Cultivation, 132 pp. Illustrated. Maclaren & Sons, Ltd., 37 & 38 Shoe Lane, E.C. London; 1928.

J. van Baalen, Results Obtained with Five Different Tapping Systems, Bergcultures, Vol. 3, p. 351; 1928; India Rubber World, Vol. 79, No. 4, p. 104; 1929.

H. Ashplant, Investigation of Hevea Bark Anatomy, Bulletin of the Rubber Growers' Association, Vol. 9, p. 571; 1927.

E. Aubert, Biological Importance of Latex. Boletin Agricola (Manaos, Brazil) Vol. 1, No. 4, p. 4; No. 5, p. 4.

Anon. Doubling the Yield per Acre on Hevea Rubber Plantations, India Rubber World, Vol. 76, pp. 309-310; Sept., 1927.

Anon. How to Grow High Yielding Rubber Trees, India Rubber World, Vol. 77, pp. 10-12; Oct., 1927.

Anon. Changes in the Character of Latex when New Tapping panels are Opened or after Resting. Planter (Kuala Lumpur, F.M.S.) Vol. 8, p. 127; 1927. Changes in properties and in rubber content.

O. De Vries and W. Spoon, Rubber from Budded Trees. II. Investigations on Latex and Rubber from Some Budded Trees. Archief voor de Rubbercultuur in Nederlandsch-Indie (Buitenzorg, Java) Vol. 11, p. 146; 1927.

C. Heusser, Experimental Tappings on Hevea Buddings, Archief voor de Rubbercultuur in Nederlandsch-Indie, Vol. 11, p. 176; 1927.

G. H. Eady, Yields of Funtumia Rubber on Experimental Stations, 1906-1928. Bulletin of the Imperial Institute (London) Vol. 27, p.130 1929.

B. J. Eaton and R. G. Fullerton, Dry Rubber Content from Deep and Shallow Tapping. Rubber Research Institute of Malaya, Quarterly Journal, Vol. 1, p. 132; 1929. Shallow tapping gives the higher rubber content.

C. Heusser, Experimental Tapping of Hevea Buddings. Archief voor de Rubbercultuur in Nederlandsch-Indie, Vol. 13, p. 488; 1929.

C. Heusser, Tapping Results and Other Observations Concerning Crosses of Hevea Trees in the Experimental Garden of Soengei Pantjoer, Ibid, Vol. 13, p. 531; 1929.

E. G. Holt, Budgrafting in Rubber May Double Acre Yield. Rubber Age (New York) Vol. 25, p. 682; 1929.

L. Lord, Budgrafting of Rubber, India Rubber Journal, Vol. 78, p. 461; 1929.

R. M. Richards, High Yielding Rubber. India Rubber Journal, Vol. 78, p. 641; 1929.

A. R. Sanderson and H. Sutcliffe, Vegetative Characters and Yield of Hevea. Rubber Research Institute of Malaya, Quarterly Journal (Kuala Lumpur, F.M.S.) Vol. 1, p. 151; 1929.

G. W. Templin, Memorandum on A B C Rotational Tapping System, Planter, Vol. 10, p. 127; 1929.

T. A. Tengwall, Tapping Systems in Java and South Sumatra in 1927. Bergcultures (Buitenzorg, Java). Vol. 3, p. 1502; 1929.

T. A. Tengwall, Results of Rubber Statistics for 1927. I. Rubber Production in Relation to the Age of the Plantation. Archief voor de Rubbercultuur in Nederlandsch-Indie, Vol. 13, p. 662; 1929.

Anon. The Fine Art of Rubber Tapping, India Rubber World, Vol. 78, No. 1, pp. 71-72; 1928.

Anon. Latex Tube Bore. India Rubber Journal, Vol. 76, p. 134; 1928. Bulletin of the Rubber Growers' Association, Vol. 10, p. 490; 1928.

W. Spoon, Quality of Latex and Rubber from Hevea Buddings and Their Mother Trees. Bergcultures, Vol. 2, p. 184; 1927.

F. G. Spring, Further Results of Yields of Rubber from Bud-Grafted Trees on Kajang Estate, Sungei Reko Division. Malayan Agricultural Journal (Kuala Lumpur, F.M.S.) Vol. 14, p. 351; 1926.

R. A. Taylor, Inheritance of Rubber Yield, Bulletin No. 77, Dept. of Agriculture, Ceylon. Nature Vol. 119, p. 683; 1927.

A. Zimmermann, Physiological Considerations Relating to the Flow of Latex from Rubber Producing Plants. Kautschuk, Vol. 3, March, p. 95; April p. 118; May p. 147; 1927.

3. Properties of Latex

(1) Bacteriology of latex.

A. S. Corbet, Preliminary Study of Bacteriology of Hevea Latex. Rub. Res. Inst. Malaya Quart. Journ. Vol. 2, p. 139; 1930.

(2) Chemical properties

a. Rubber content; methods of determination

S. D. Gehman and J. S. Ward, Microturbidimeter for determination of Rubber Content of Latex, Industrial and Engineering Chemistry (Analytical Edition) Vol. 3, pp. 300-304; July 15, 1931. Rubber Chemistry and Technology, Vol. 4, p. 601, 1931.

P. Scholz, Specific Gravity and Crepe Content of Hevea Latex, Kautschuk, Vol. 7, pp. 142-145; Aug. 1931.

P. Scholz and R. Klotz, Crepe Content of Latex, Kautschuk, Vol. 7, pp. 66-68; April, 1931. India Rubber World, Vol. 84, No. 3, p. 71; June 1, 1931.

P. Scholz. Two Years in the Rubber Producing Area of British Malaya and Netherlands Indies. Gummi-Zeitung, Vol. 45, p. 1416; 1931. Gives method for determining crepe content of latex.

E. A. Hauser, Metrolac, Kautschuk, Vol. 4, p. 89; April, 1928. Discusses the use of hydrometer for determination of rubber content of fresh latex.

H. H. Krause, Determination of Total Solids of Certain Liquids (Latex), Chemist-Analyst, Vol. 17, No. 4, p. 14; 1928.

W. Spoon and N. Beumee-Nieuwland, Determination of the Rubber Content in Latex Preserved with Trisodium Phosphate and Formalin, Archief voor de Rubbercultuur in Nederlandsch-Indie, Vol. 12, p. 672; 1928.

R. O. Bishop, Rubber Content of Ammoniated Latex, Malayan Agricultural Journal, Vol. 15, p. 1, 1927. Variations in rubber content according to stage of preservation.

b. <u>Non-rubber components; methods of determination</u>

B. J. Eaton, E. Rhodes, and R. O. Bishop, Observations on the Effect on Vulcanization of the Lipin of *Hevea* Latex. Rubber Research Institute of Malaya, Quarterly Journal, Vol. 2, No. 3, pp. 136-138; Nov. 1930. Rubber Chemistry and Technology, Vol. 4, No. 3, pp. 339-344; July, 1931.

E. Rhodes and R. O. Bishop, The Lipin of Hevea Latex. Rubber Research Institute of Malaya, Quarterly Journal, Vol. 2, No. 3, pp. 124-135; Nov. 1930. Rubber Chemistry and Technology, Vol. 4, No. 3, pp. 330-338; July, 1931. Method of preparation, properties, constants, and bibliography of 13 references.

G. H. Levi. Quebrachitol from the Serum of *Hevea* Latex. Gaz. Chim. Ital. Vol. 59, No. 8, pp. 550-552; August, 1929. Rubber Chemistry and Technology, Vol. 3, No. 1, pp. 1-2; January, 1930.

W. Bobilioff, Investigation on the Physiological Significance of Quebrachitol. Archief voor Rubbercultuur in Nederlandsch-Indie, Vol. 13, p. 118; 1929.

L. R. Van Dillen, Determination of Nitrogen in Latex from *Hevea brasiliensis* by the ter Meulen Method. Archief voor Rubbercultuur in Nederlandsch-Indie, Vol. 11, p. 287; 1927.

c. <u>Hydrogen ion concentration in latex.</u>

J. McGavack and J. S. Rumbold, Determination of pH of Ammonia Latex. Industrial and Engineering Chemistry, (Analytical Edition) Vol. 3, p. 94; Jan. 15, 1931. Rubber Chemistry and Technology, Vol. 4, No. 2, pp. 264-272; April, 1931.

<u>Determination of the pH by the glass-electrode method.</u>

N.H. Van Harpen. Hydrogen Ion Concentration of Hevea Latex. Archief voor de Rubbercultuur in Nederlandsch-Indie, Vol. 15, p. 68; 1931. Selected portions of the book cited above.

J. G. Mackay. The Measurement of the pH value of Rubber Latex, India Rubber Journal, Vol. 79, pp. 353, Mar. 10, 1930. Rubber Chemistry and Technology, Vol. 3, pp. 616-617; Oct., 1930.

L. R. Van Dillen, Studies on the Hydrogen Ion Concentration for Coagulating Latex of Hevea brasiliensis. Archief voor de Rubbercultuur in Nederlandsch-Indie, Vol. 13, p. 465; 1929.

E. A. Hauser and P. Scholz, Contribution to the Colloid Chemistry of Rubber Latex. On the Determination of the Actual and Potential Alkalinity of Latex from Hevea brasiliensis. Kautschuk, Vol. 3, p. 304; Oct. 1927.

d. Oxidation of latex

J. G. Fol and W. de Visser, Latex Contaminated with Copper Compounds as a Source of Dangerous Fire. Bulletin of the Rubber Growers' Association (London), Vol. 10, pp. 124-127; 1928. Rubber Chemistry and Technology, Vol. 1, pp. 288-290; 1928.

(3) Colloidal properties; microscopic examination of latex particles.

E. A. Hauser. Study on Technique of Micromanipulation, Revue Generale des Colloides (Paris) Vol. 8, p. 358; 1931.

E. A. Hauser. Micromanipulations of Latex in the Dark Field. Kolloid-Zeitschrift (Dresden) Vol. 53, No. 1, pp. 78-81; Oct.,1930. Rubber Chemistry and Technology, Vol. 4, pp. 219-222; April, 1931.

A. Frey-Wyssling, Microscopic Investigations on the Occurrence of Resins in Hevea Latex. Archief voor de Rubbercultuur in Nederlandsch-Indie, Vol. 13, p. 392; 1929. A complete account of the occurrence of resins in latex.

E. A. Hauser. Importance of Colloid-Chemical and Colloid Physical Research in Future Problems of the Chemical Industry. Industrial and Engineering Chemistry, Vol. 21, p. 102; 1929.

A. Van Rossem, Colloid Chemistry and the Rubber Industry, Kolloid-Zeitschrift, Vol. 48, p. 283; 1929. A review of the literature, 1924-1929 with references to important work.

Anon. Brownian Movement in Latex, India Rubber World, Vol. 79, No. 1, p. 120; October, 1928.

S. E. Sheppard, Charge on Rubber Particles. Journal of the Franklin Institute, Vol. 206, p. 245; 1928.

E. A. Hauser, Contributions to the Colloid Chemistry of Rubber Latex. III. Form of the Latex Particle and Its Inheritability. Kautschuk, Vol. 3, p. 357, Dec., 1927. Correlation of the particles of grafted trees with those of the mother tree.

P. P. von Weimarn and Collaborators, Dispersoidological Investigations. XXIII. Contributions to the Dispersoidology of Rubber. Part I. The Structure of Jellies and Other Coagula of Ammonia-Preserved Hevea Latex and Hevea Vultex. Reports of the Industrial Research Institute, Osaka, Japan. Vol. 9, No. 5, pp. 1-50; August, 1928. Rubber Chemistry and Technology, Vol. 2, pp. 108-137; 1928.

H. Freundlich, Structure and Formation of Colloidal Particles, Transactions of the Faraday Society (London), Vol. 23, p. 614; 1927.

E. P. Wrightman and A. P. H. Trivelli, Rubber Latex Particles, Industrial and Engineering Chemistry, Vol. 17, p. 164; Feb., 1925.

E. A. Hauser. Microscopical Researches on Hevea and Other Latices, India Rubber Journal, Vol. 68, pp. 725-726; Sept. 27, 1924.

E. A. Hauser. Rubber Latex Particles. India Rubber Journal, Vol. 68, pp. 19-22; July 5, 1924.

(4) Physical properties; physico-chemical properties; surface tension, swelling, viscosity.

W. Esch, Behavior of Rubber (Latex) toward Textile Fabrics and Threads. Kautschuk, Vol. 7, p. 155; 1931.

P. Scholz, Studies on Latex Chemistry. I. Surface Tension of Fresh Latex and Its Relation to the Non-Rubber Constituents. II. Determination of Rubber Content. Kautschuk, Vol. 7, pp. 42, 66; 1931.

L. Blaringhem and M. Chopin, Surface Tension of Fresh Latex of Euphorbia lathyris. Nature, Vol. 127, p. 330; 1930.

F. Evers, The swelling of Latex, Kautschuk, Vol. 6, pp. 46-50; March, 1930. Rubber Chemistry and Technology, Vol. 3, pp. 361-369; July, 1930.

The effect of benzene, toluene, etc. on latex.

C. M. Blow, Study of the Viscosity of Rubber Latex, Transactions of the Faraday Society, Vol. 25, p. 458; 1929.

E. A. Hauser and P. Scholz, Contribution to the Colloid Chemistry of Rubber Latex. II. On the Measurement of the Surface Tension of the Latex from Hevea Brasiliensis, Kautschuk, Vol. 3, p. 332; 1927.

4. Treatment of latex

(1) Straining and filtering

C.G.T. Kroemer, Simple Latex Sieve, Bergcultures (Buitenzorg, Java) Vol. 3, p. 777, 1929.

A. W. K. de Jon, Centrifuging Latex. Industrial Mercury, 50th Anniversary Number, p. 34; January, 1928.

O. Zimmermann, Rubber Latex - Latexia Straining Machine, Tropfenplanzer (Berlin) p. 189; May, 1928. Gummi-Zeitung, Vol. 42, p. 2260; 1928.

Anon. Device for Straining Hevea Latex. Tropfenplanzer, Vol. 30, p. 385; 1927.

R. Riebl, Sieves for Latex. Archief voor de Rubbercultuur in Nederlandsch-Indie, Vol. 11, p. 107; 1927.

(2) Coagulation

a. Coagulation phenomena

N. Beumee-Nieuwland (Mrs.) The Coagulation of Hevea Latex. Archief voor Rubbercultuur in Nederlandsch-Indie, Vol. 13, pp.555-565; October, 1929. Rubber Chemistry and Technology, Vol. 3, pp. 353-360; July, 1930.

R. G. Fullerton, Observations on the Coagulation of Hevea Latex, Rubber Research Institute of Malaya, Quarterly Journal, Vol. 2, No. 3, pp. 155-181, Nov., 1930. Rubber Chemistry and Technology, Vol. 4, pp. 310-328; July, 1931.

A. S. Corbet, Natural Coagulation of Hevea Latex, Rubber Research Institute of Malaya, Bulletin No. 1, 17 pp., Sept., 1929; Rubber Chemistry and Technology, Vol. 3, pp. 254-263; April, 1930.

Paul Bary, Coagulation of Latex, Revue Generale du Caoutchouc, Vol. 31, p. 118; February, 1928. Review of recent work with comments.

O. de Vries and N. Beumee-Nieuwland, Coagulation Phenomena in Hevea Latex. V. Alcohol, Alum, and Sodium Chloride, Archief voor Rubbercultuur in Nederlandsch-Indie, Vol. 11, p. 518, 1927. VI. Some Further Observations on B-Mixture, Ibid, Vol. 11, p. 534. (B-mixture is latex diluted with water). VII. Rubber Obtained by Freezing the Latex. Ibid, Vol. 12, p. 683; 1928. VII. Phenomena in Alkaline Latex, Ibid, Vol. 12, p. 465; 1928. VIII. Influence of Some Heavy Metal Salts on Coagulation and Coalescence, Ibid Vol. 13, p. 205; 1929.

P. Scholz, Coagulation of Fresh and Preserved Latex by Electrolytes, Kautschuk, Vol. 4, pp. 5-8, 1928.

R. Audubert and G. Lejeune, Two Coagulations in Latex, Revue Generale des Colloides. Vol. 5, p. 713, 1927.

F. H. de Balsac and Collaborators, Contribution to the study of the Coagulation of Rubber Latices - Industrial Value of the Rubbers Obtained by the Employment of Divers Coagulants. Bulletin de l'agence generale des colonies (Paris). Vol. 20, p. 65; 1927. Bulletin of the Imperial Institute (London) Vol. 25, p. 189; 1927.

F. H. De Balsac and Collaborators, Physico-chemical Studies on Rubber Latices. Relations among the Concentrations of the Latices, that of the Coagulating Agents; the Presence of Proteins and the Mechanism of Coagulation. Bulletin de l'agence generale des colonies (Paris). Vol. 19, p. 1472; 1926. Bulletin de l'agence generale des colonies (Paris). Vol. 19, p. 1472; 1926. Bulletin of the Imperial Institute (London) Vol. 25, p. 189; 1927.

O. de Vries, Coagulation Phenomena in Hevea Latex, Recuil des Travaux Chimiques des Pays-bas, Vol. 42, pp. 701-705; 1923.

b. Coagulants

O. De Vries, Alum as a Coagulant, India Rubber World, Vol. 76, p. 320; 1927.

Anon., Relative Advantages of Acetic Acid, Formic Acid, Sulphuric Acid, and Alum as Coagulants. Planter, Vol. 8, p. 67; 1927.

D. F. Van der Burg, Formic Acid vs. Acetic Acid, Bergcultures, (Buitenzorg, Java), Vol. 2, p. 1010; 1928.

Anon. Formic Acid as a Coagulant. Tropenpflanzer, Vol. 31, p. 118; 1928.

Anon, Formic Acid as a Coagulant, India Rubber Journal, Vol. 75, p. 749; 1928.

T. E. H. O'Brien, Notes on Rubber Manufacture, Tropical Agriculture (Ceylon) Vol. 69, p. 197; 1927. Describes experiments showing the advantages of formic acid coagulation.

N. H. Van Harpen, Sodium Silico-fluoride as a Coagulant of Latex. International Rev. Agr., Mar. 1928. Ind. Chemist, Vol. 4, p. 233; 1928.

T.E.H. O'Brien, Rubber Manufacture, Tropical Agriculture, (Ceylon), Vol. 70, p. 232; 1928. Discusses coagulation of rubber with sodium silico-fluoride and describes properties of rubber coagulated in this manner.

Anon. Sodium Silico-fluoride as a Coagulant for Hevea Latex, Tropenpflanzer, Vol. 31, p. 155; 1928. A summary of several articles on sodium siliocfluoride coagulation.

N. H. Van Harpen, Economy of Sodium Silico-fluoride as a Coagulant II, Archief voor Rubbercultuur in Nederlandsch-Indie, Vol. 11, p. 487; 1927.

(3) Creaming

A. Kopp, Separation (Ecremage) of Hevea Latex, Rev. Bot. Appl. et Agr. Trop. Vol. 9, p. 138; 1929. Bulletin of the Imperial Institute, Vol. 27, p. 255, 1929.

O. De Vries and N. Beumee-Nieuwland. Cream from Latex. Archief voor Rubbercultuur in Nederlandsch-Indie, Vol. 11, p. 390; 1927. A study of creams obtained from ammoniated latex on long standing.

(4) Drying

Anon. Powdered Rubber Latex, India Rubber World, Vol. 77, No. 6 p. 59; March, 1928. A review of efforts to produce reversible dried latex.

A. Jones, Sprayed Rubber - Its Development and Special Characteristics, India Rubber Journal, Vol. 77, p. 754; 1929.

E. Hopkinson, Spray Processes of Preparing Rubber from Latex. Gummi-Zeitung, Vol. 41, p. 1046; 1927.

J. A. Reavell, Recent Development of Spray Drying, Chem. Ind. Vol. 46, pp. 925; 1927.

(5) Concentration)
(6) Electrodeposition) See Section 5.
(7) Deposition on porous molds)
(8) Preservation

Aladin. Latex Preservation and Concentration, Gummi-Zeitung, Vol. 43, pp. 1047, 1105; 1929. A survey of patent literature from 1920 to 1929.

N. Beumee-Nieuwland. Preserving Latex with Borax, Archief voor Rubbercultuur in Nederlandsch-Indie, Vol. 12, p. 453; 1928.

Anon. Use of Paranitrophenol, Planter, Vol. 8, p. 126; 1927.

O. De Vries and N. Beumee-Nieuwland. Investigations on Preserved Latex. VI. Further Data on Rubber from Latex Preserved with Ammonia. Archief voor Rubbercultuur in Nederlandsch-Indie, Vol. 11, p. 343, 1927. V. Some further Data on Preserving Latex with Ammonia, Ibid. Vol. 11, p. 317; 1927.

R. Ditmar, Production of Rubber Articles from Latex Preserved in Different Ways and Prevention of Tackiness. Gummi-Zeitung, Vol. 41, p. 1688; 1927.

J. Duque. Antioxidant for Rubber Latex. Gummi-Zeitung, Vol.42, p. 471; 1927.

(9) Transportation

Anon., Latex Shipping Containers, India Rubber World, Vol. 85, No. 1, p. 79, October, 1931.

Anon., Transportation of Liquid Latex. Rubber Age (New York), Vol. 23, p. 680; 1928. Describes methods employed by the U. S. Rubber Co.

5. Applications of latex in manufacture

(1) General discussions

J. Edwardes, Heveatex Products, India Rubber World, Vol. 85, No. 3, p. 52; December, 1931. Heveatex products are commercial brands of natural and concentrated latex for which uniformity is claimed.

E. A. Hauser, Latex and Crude Rubber, Institution of the Rubber Industry, Transactions, Vol. 7, pp. 298-302; 1931.

Webster Norris, Liquid Rubber Compounding, India Rubber World, Vol. 83, No. 5, p. 53, February, 1931. Describes commercial methods for employing latex and "Revertex", and includes representative formulas.

S. D. Sutton. Is Manufacture Direct from Latex Worth While? India Rubber World, Vol. 85, No. 2, pp. 59, Nov. 1, 1931. Includes consideration of manufacturing costs.

D. F. Twiss, Some Considerations of Latex Processes, Transactions of the Institution of the Rubber Industry, Vol. 6, pp. 419-431; February, 1931.

Anon., Rubber Latex, India Rubber World, Vol. 83, No. 3, pp. 57-58, December, 1930.

W. H. Stevens, Applications and Analysis of Latex, Transactions, Institution of the Rubber Industry, Vol. 5, p. 362; 1930.

E. A. Hauser, Chemistry and Technology of Latex, Kautschuk, Vol. 5, p. 65; 1929. A review of recent progress.

E. Enna, Latex vs. Latex, Gummi-Zeitung, Vol. 42, p. 1930; 1928. Remarks adverse to the direct use of latex.

K. Geissler, Use of Rubber Latex in Industry, Die Umschau, Vol. 32, p. 349; 1928.

P. Schidrowitz, Industrial Applications of Latex, Transactions, Institution of the Rubber Industry, Vol. 3, p. 362; 1928. Includes discussion of costs and of preservation of latex.

Anon., New Local Rubber Industry, Planter, Vol. 8, p. 26; 1927. Description of Selangor works for manufacture of products directly from fresh latex.

H. N. Blommendaal and N. H. Van Harpen. Latex as a Marketable Grade of Rubber. Archief voor Rubbercultuur in Nederlandsch-Indie Vol. 11, p. 547; 1927.

E. A. Hauser, Direct Use of Latex in the Modern Rubber Industry, Revue Generale due Caoutchouc (Paris) Vol. p. 5; February, 1927. A reply to criticism of the direct use of latex.

E. A. Hauser. Advantages and Disadvantages of the Direct Use of Latex, Gummi-Zeitung. Vol. 41, p. 1577; 1927.

P. Schidrowitz, Rubber (Recent Developments), India Rubber Journal, Vol. 73, p. 347; 1927. A review on sprayed latex, concentrated latex, the compounding of latex, and dipping, proofing, and electrodeposition processes.

H. P. Stevens, New Methods and Modifications of Rubber Preparation. India Rubber Journal, Vol. 73, p. 187; 1927. Gummi-Zeitung. Vol. 41, p. 1046; 1927. Rubber Age (London), Vol. 7, p. 501; 1927. Discussion on the direct use of latex.

M.M. Wavelet. Advantages and Disadvantages of Direct Employment of Latex in the Rubber Industry, Gummi-Zeitung, Vol. 41, p. 1046; 1927.

A. Zimmermann, Direct Applications of Latex, Tropenpflanzer, Vol. 30, p. 223; 1927. Bulletin of the Imperial Institute, Vol.25, p. 463; 1928.

A. Van Rossem. Rubber Latex: Its Properties and Development of its Industrial Applications. Journal of the Society of Chemical Industry, Vol. 44, pp. 33-41; Jan. 23, 1925.

<u>Anon</u>., Addition of Compounding Ingredients to Rubber Latex. India Rubber World, Vol. 68, pp. 763-765; Sept., 1923.

(2) <u>Patent Reviews</u>

<u>Anon</u>. Latex Paste Patent, India Rubber World, Vol. 84, No. 5, p. 89; Aug., 1931.

R. Ditmar, Rubberizing Textiles with Latex, Kolloid-Zeitschrift, Vol. 56, pp. 124-125; 1931.

R. Ditmar, Latex Concentration. Kolloid-Zeitschrift, Vol. 55, p. 365-366; 1931.

R. Ditmar. Concentrated Latex. Le Caoutchouc et la Gutta-Percha (Paris), Vol. 28, p. 15607; 1931.

Joseph Rossman, Making Rubber Thread II., India Rubber World, Vol. 85, No. 2, p. 51; Nov. 1, 1931. Includes patents on the making of rubber thread by the extrusion of latex.

Aladin. Technology of Latex, Gummi-Zeitung, Vol. 44, pp. 737, 787, 837, 894, 915, 993; 1930.

Joseph Rossman, Uses of Rubber Latex, India Rubber World, Vol. 81, No. 6, p. 65; Vol. 82, No. 1, p. 69; March and April, 1930, respectively.

Joseph Rossman. Uses of Rubber Latex. India Rubber World, Vol. 81, No. 1, p. 63; No. 2, p. 67; October and November, 1929, respectively.

(3) Concentrated latex, its preparation and use

a. General

J. H. Carrington. The Uses of Concentrated Latex. Transactions of the Institution of the Rubber Industry, Vol. 6, pp. 438-453; February, 1931.

D. F. Twiss. Concentration and Compounding of Latex for Industrial Use. Transactions of the Institution of the Rubber Industry, Vol. 7, pp. 280-289; 1931.

P. P. von Weimarn. The Gelatination of Latex and "Revertex" by Means of Extremely Concentrated Aqueous Solutions of Substances Appearing as Dispergators for Proteins. Proceedings World Engineering Congress, Tokyo, 1929, p. 473; 1931.

F. W. Warren. Concentrated Latex and Its Industrial Uses. Transactions of the Institution of the Rubber Industry, Vol. 6, pp. 431-438; February, 1931.

J. Fisher. Use of Latex Concentrates. Kunststoffe, Vol. 20, p. 1, 1930.

Anon. Use of Concentrated Latex for the Preparation of Friction Compositions for Rubberizing Fabrics, Gummi-Zeitung, Vol. 44, p. 192; 1929.

R. G. Fullerton. Notes on the Concentration of Latex. Rubber Research Institute of Malaya, Quarterly Journal, Vol. 1, p. 115; 1929.

P. Schidrowitz, Vulcanization of Concentrated Latex, Kunststoffe, Vol. 18, p. 41; 1928.

E. A. Hauser and A. Gould, Concentrated Latex vs. Standard Grades. India Rubber Journal, Vol. 74, p. 700; 1927.

E. A. Hauser. Concentrated Latex and Industrial Use. Rubber Age (London) Vol. 7, p. 449; 1927; Gummi-Zeitung, Vol. 41, p. 1046; 1927. Describes the spraying of latex onto heated mandrels to form tubes.

E. A. Hauser. New Processes in Latex and Raw Rubber Domains at the Seventh International Rubber Conference in Paris, Gummi-Zeitung, Vol. 41, p. 1162; 1927. A review of the Emka, Hopkinson, and "Revertex" processes.

P. Schidrowitz, Vulcanization of Concentrated Latex, Kautschuk, Vol. 3, p. 202; June, 1927.

E. A. Hauser. Problem of Rubber Latex Concentration and the Industrial Application of Concentrated Latices. Transactions of the Institution of the Rubber Industry, Vol. 2, p. 226; 1926.

b. "Revertex"

G. Genin, Manufacture of Concentrated Latex by the Revertex Process, Revue Generale des Materieres Plastiques, Vol. 7, p. 329; 1931.

E. A. Hauser. Story of the Revertex Process. Gummi-Zeitung, Vol. 44, p. 1432; 1930.

Anon. Revertex, La Goma (Barcelona), March 1929, p. 10.

R. Ditmar. Why is "Revertex" Inconvenient for the Manufacture of Rubber Articles?" Le Caoutchouc et la Gutta-Percha, Vol. 25, p. 13842; 1928.

E. A. Hauser. Revertex Process, Kautschuk, Vol. 3 p. 2; January, 1927.

Anon. Revertex Process, India Rubber Journal, Vol. 73, p. 595; 1927.

(4) Vulcanized latex, its preparation and use

Anon. Vultex (Vulcanized Latex), India Rubber World, Vol. 84, No. 3, p. 58; June 1, 1931.

S. D. Sutton. The Application of Vulcanized Latex in the Manufacture of Rubber Footwear, India Rubber Journal, Vol. 82, No. 14, p. 436; October 3, 1931.

E. B. Spear, Some Practical Applications of Cured Latex, Rubber Age (New York) Vol. 28, p. 8; October 25, 1930.

Anon. Process for Manufacture of Articles by Immersion in Revultex, La Goma (Barcelona), June, 1929, p. 17.

Anon. Note on the Employment of Vulcanized Latex (Revultex), Gummi-Zeitung, Vol. 43, p. 2325; 1929.

P. P. von Weimarn. Gelatinization of Vultex. Kolloid-Zeitschrift, Vol. 46, p. 223; 1928; India Rubber Journal, Vol. 76, p.875 1928.

P. Schidrowitz. Vulcanized Latex and Its Commercial Applications, Rubber Age, (New York), Vol. 24, p. 203; 1928.

P. Schidrowitz. Direct Use of Rubber Latex, Especially Vulcanized Latex, Industrial and Engineering Chemistry, Vol. 18, pp. 1147-1152; 1926.

P. Schidrowitz. Vulcanized Latex and Its Commercial Application, India Rubber Journal, Vol. 71, p. 13; 1926.

Anon. A Visit to the Vultex Products Works, India Rubber Journal, Vol. 70, pp. 147-148; July 25, 1925.

W. C. Davey, The Vulcanization of Rubber Latex, Journal of the Society of Chemical Industry, Vol. 42, pp. 473-484 T; 1923.

(5) Electrodeposition of rubber from latex

J. G. Mackay. Experiments on the Electrodeposition of Rubber from Latex, India Rubber Journal, Vol. 81, p. 380; 1930; Chemical Age (London) Vol. 24, p. 253; 1931; Transactions of the Institution of the Rubber Industry, Vol. 7, pp. 254-272; 1931.

H. A. Abramson and L. Michaelis. Influence of Size, Shape and Conductivity of Microscopically Visible Particles on Cataphoretic Mobility, J. Gen. Physiol. Vol. 12, p. 587; 1929.

P. Klein. Making Rubber Goods of Latex by Electro-deposition, India Rubber Journal, Vol. 76, pp. 874, 879; 1929; Transactions of the Institution of the Rubber Industry, Vol. 4, pp. 343-351; Dec., 1928; Rubber Chemistry and Technology, Vol. 2, pp. 278-284; April, 1929.

Anon. Anode Process Still in Laboratory Stage, Rubber Age (New York) Vol. 23, p. 387; 1928.

Anon., Electrodeposition of Rubber (on Fabrics), Journal of the Textile Institute (Manchester), Vol. 18, p. A66; 1927.

Anon. Electrodeposition of Rubber, Chemistry and Industry, Vol. 46, p. 47; 1927.

Anon. Rubber Moulded by Electricity, Rubber Age, (London), Vol. 7, p. 451; 1927.

G. M. Couret, Electrodeposition of Cellulose Derivatives and of Rubber, Revue Generale des Materieres Plastiques, Vol. 3, p. 617; 1927.

"M.L.P." Electrophoresis of Rubber, Revue Generale du Caoutchouc, 1927, May-June, p. 15; July, p. 10; August-September, p. 15.

S. E. Sheppard. The Electrical Deposition of Rubber, Transactions of the American Electrochemical Society, Vol. 52, pp. 47-58; 1927.

H. P. Stevens, Electrodeposition of Rubber and the Anode Process, Bulletin of the Rubber Growers Association, Vol. 9, p.514; 1927.

A. Szegvari. Electroplating of Rubber: Colloidal Galvanoplasty. India Rubber Journal, Vol. 73, p. 630; 1927; Rubber Age (New York) Vol. 21, p. 29; 1927.

(6) <u>Deposition of rubber from latex on porous forms</u>

H. W. Greenup, Rate of Deposition of Latex on Porous Moulds. Industrial and Engineering Chemistry, Vol. 23, pp. 688-691; 1931: Rubber Chemistry and Technology, Vol. 4, pp. 437-444; 1931.

(7) <u>Products made with latex</u>

a. <u>Paper</u>

<u>Anon</u>. Rubber in Paper Making India Rubber World, Vol. 85, No. 1, pp. 53-55; October 1, 1931.

Merle B. Shaw and George W. Bicking. Rubber Latex in Paper, Paper Trade Journal, Dec. 28, 1922 (Reprints available from Paper Section, Bureau of Standards.

Merle B. Shaw and F. T. Carson. Aging of Rubber Latex in Paper, India Rubber World, June 1, 1923, pp. 561-562 (Reprints available from Paper Section, Bureau of Standards).

F. Arledter, Sizing of Paper, Revue Generale du Caoutchouc, 1928, March-April, p. 37.

b. <u>Paint</u>

<u>Anon</u>. Rubber Bound Paint, India Rubber World, Vol. 84, No.6, p. 90; Sept., 1931.

R. E. Liesegang. The Colloid Chemistry of Paints, Farben-Zeitung, Vol. 34, p. 2460, 1929.

c. Adhesives

Anon. Latex Adhesives, India Rubber World, Vol. 84, No. 2, p. 57; May, 1931.

d. Footwear

Van der Schuyt, Rubber Sole Crepe, India Rubber World, Vol.83, No. 5, p. 88; February, 1931. Describes a method of preparing sole crepe from latex by spraying.

Anon. Middle Soles for Footwear, India Rubber Journal, Vol. 79, p. 302; 1920.

E. Enna. Use of Latex in the Footwear Industry, Gummi-Zeitung, Vol. 41, p. 2097; 1927. A criticism of Hauser's latex process in the footwear industry.

E. Enna. Cemented Leather Footwear, India Rubber Journal, Vol. 74, p. 726; 1927.

E. A. Hauser. Use of Latex in the Footwear Industry, Gummi-Zeitung, Vol. 41, p. 1750; 1927. Describes the advantages of latex as an adhesive.

e. Rubber-textile combinations

Anon. Latex Treated Carpet, India Rubber World. Vol. 84, No. 2, p. 60; May, 1931. A discussion of latex-backed carpeting, its use and advantages.

Anon. Latex Processed Rope, India Rubber World, Vol. 84, No. 6, p. 67; September, 1931.

Anon. Use of Rubber Yarns in Knitting, India Rubber Journal, Vol. 82, p. 554; October 31, 1931.

Anon. Rubber Backed Rugs, India Rubber World, Vol. 84, No.6, pp. 59-60; Sept., 1931. Description of the manufacture of nap face rugs without weaving.

Anon. Gelatin-Latex Processed Gas Bags on the U.S.S. Akron, Rubber Age, (New York), Vol. 29, No. 9, p. 408; August 10, 1931.

Webster Norris, Liquid Rubber and Carpets, India Rubber World, Vol. 83, No. 6, p. 56; March, 1931.

P. W. Hutchinson. Rubberizing of Fabrics for Belting by Means of Concentrated Latex. Revue Generale du Caoutchouc, Jan. 1930, p. 7.

Webster Norris, Liquid Rubber and Textiles, India Rubber World, Vol. 83, No. 4, p. 53; January, 1931.

Anon. Use of Latex in Rubberizing Asbestos Textiles in Manufacture of Packing, Gummi-Zeitung, Vol. 44, p. 1647; 1930.

Anon., Making Web Cord Tire Fabric, Rubber Age (New York), Vol. 21, p. 553, 1927.

W. De Visser. Prevention with Latex of Slipping of Loose Carpets on Floors, Bergcultures (Buitenzorg, Java), Vol. 2, p. 241; 1927.

f. Sponge rubber and microporous rubber

H. Beckman, Microporous Rubber, Its Preparation, Properties, and Applications, Kautschuk, Vol. 7, pp. 151-155; August, 1931. Summary in India Rubber World, Vol. 84, No. 4, pp. 72-73; July, 1931.

Anon., Latex Sponge Rubber, India Rubber World, Vol. 85, No.1, p. 58; October 1, 1931: No. 3, p. 63; December 1, 1931.

g. Miscellaneous

Anon. Latex Inner Tubes, India Rubber World, Vol. 84, No. 2, p. 64; May, 1931.

Bjorkland, Rubber Roads. India Rubber World, Vol. 84, No.2, p. 90; May, 1931. Description of a process of road construction with the use of latex.

Anon. Latex Gloves Popular, India Rubber World, Vol. 83, No.1 p. 67; October, 1931.

Anon. Latex for Floor Laying. India Rubber Journal, Vol. 79, p. 819; 1930.

Anon. Latex Improves Violin Wood, India Rubber World, Vol. 80, No. 3, p. 62; June, 1929.

W. Spoon. Experiments on Preserving Mangosteens with Latex, Bergcultures, Vol. 3, p. 1215; 1929.

W. Spoon, Preservation of Fresh Fruit with Latex, Gummi-Zeitung, Vol. 41, p. 1047; 1927.

D. R. R. Burt, New Injection Mass - Rubber Latex, Nature, Vol. 121, p. 497; 1928.

Anon. Gold Rubber, India Rubber Journal, Vol. 73, p. 238; 1927. Gummi-Zeitung, Vol. 41, p. 1110; 1927. Latex and aluminum powder produce a gold effect.

R. Ditmar. The Making of Rubber Tubing with the Aid of Latex. Le Caoutchouc et La Gutta-Percha, Vol. 28, p. 15527; 1931.

R. E. Liesegang. Use of Rubber Latex in Photography. Phot. Industrie, Vol. 24, p. 503; 1926. Chimie et Industrie, Vol. 19, p. 100; 1928.

6. Water dispersions of rubber

Wallace H. Carothers, Ira Williams, Arnold M. Collins, and James E. Kirby. Acetylene Polymers and their Derivatives. II. A New Synthetic Rubber: Chloroprene and its Polymers, Journal of the American Chemical Society, Vol. 53, pp. 4203-4225; November, 1931. A description is given of the preparation of a synthetic latex by emulsifying chloroprene in water, on pp. 4221-4224 of this paper.

E. Enna, Dispersions of Raw Rubber in Water. Gummi-Zeitung Vol. 45, pp. 1107; 1454; 1931. Discussion of the Pratt process.

Joseph Rossman, Water Dispersions of Rubber, India Rubber World, Vol. 82, No. 5, pp. 55-58; No. 6, pp. 63-64; August and September, 1930, respectively. Discussion of the Alexander, Plauson, and Pratt processes.

Anon. Dispersed Rubber Middle Soles. Rubber Age (New York), Vol. 24, p. 258; 1928.

Arthur D. Little, Inc., Applications of Water Dispersed Rubber, Rubber Age (New York) Vol. 24, p. 85; 1928. India Rubber Journal, Vol. 76, p. 605; 1928.

P. Schidrowitz. Dispersed Rubber and Latex, India Rubber Journal, Vol. 76, p. 419; 1928. Comments on the relative merits of dispersed rubber and latex.

H. L. Trumbull, Preparation and Properties of Aqueous Rubber Dispersions, Colloid Symposium Monograph, Vol. 6, pp. 215-224; 1928.

H. A. Winkelmann, New Developments with Dispersed Rubber, India Rubber World, Vol. 78, No. 4, pp. 53-55; July, 1928. India Rubber Journal, Vol. 76, p. 53; 1928.

J. Bongrand, Technical Preparation of Water Dispersions of Raw and Vulcanized Rubber, Gummi-Zeitung, Vol. 41, p. 1046; 1927.

J. M. A. Touchon. Improvements in the Preparation of Aqueous Emulsions or Dispersions of Rubber and Analogous Materials, Revue Generale du Caoutchouc, December, 1927, p. 34.