DISPERSOIDOLOGICAL INVESTIGATIONS ON LATEX.(1)

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Received May 29, 1928.   Published July 28, 1928.

In my investigations I used ammonia-preserved latex, *Hevea Brasiliensis*, (about 30% caoutchouc), *revertex*(3) i.e. latex, concentrated to a paste-like condition (about 80% caoutchouc) and vulcanized latex i. e. *vultex*.(4) In the programme of my investigations is also included the study of certain other kinds of latexes.

§1. **On the Structure of Latex.** The ultramicroscopic and microscopic investigations on preserved latex, I carried out by means of three apparatus: an immersion-ultramicroscope, after R. Zsigmondy; a dark-field condenser A (bizentrische Spiegelkondensor) with azimuth-stop; and a large bright-and-dark-field condenser; the two last from the firm of E. Leitz. In the work with these two apparatus was used a special oil-immersion objective 1/12-a (from the firm of E. Leitz; this objective has inside an intermediate fitting with an iris-diaphragm) and periplantic eyepieces × 12 and × 25 (i. e. the magnification was 1140 × and 2375 ×); the investigations were carried out not only at room temperature, but also at elevated temperatures, reaching to about 100°C.

T. Petch and W. Babilioff(5) have stated that some of the particles in a fresh Hevea latex have a pear-like shape; certain particles have "tails"; Babilioff has also observed that latex from young parts of plants consists chiefly of round particles, whilst latex obtained from the trunk and roots contains a prevailing number of pear-like particles.

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(1) In the present paper are summed up briefly the chief conclusions and results of the investigations carried out by me up to this time. The chief results were reported to the Imperial Industrial Research Institute of Osaka, on April 30, 1928. A detailed description with numerous photomicrographs and photo-ultramicrographs of separate latex particles as well as of various structures of latex coagula and jellies will appear in my papers in *Reports of the Imperial Industrial Research Institute of Osaka.*

(2) Translated from Russian by Mrs. P. P. von Weimarn.

(3) I wish to express here to The Dunlop Rubber Co. (Wakinohama, Kobe) my sincere thanks for kindly supplying latex and revertex for my investigations.

(4) The writer expresses his hearty thanks to Mr. W.C. Davey, of The Dunlop Rubber Co., for kindly preparing vultex for the present investigations.

(5) F. W. Hinrichsen und K. Memmler, "Der Kautschuk und seine Prüfung", (1910), Leipzig; B.D.W. Luff, "Die Chemie der Kautschuks", (1925), Berlin; Ernst A. Hauser, *The India Rubber Journal*, 68 (1924), 725; A. van Rossem, ibid., 68 (1924), 1081 & 1123; H. Freundlich und E. A. Hauser, *Ergänzungsband zur Koll. Z.*, 36 (1925), 15; Ernst A. Hauser, "Latex", (1927), Dresden; etc.

On the basis of his detailed investigations, Ernst A. Hauser(1) arrived at the conclusion that particles of sphere-like shape are very rare in Hevea latex, and the great majority of particles have oblong, egg-like, or pear-like shapes; certain of such particles have also "tails".

The investigations of V. Henri, T. Petch, Clayton Beadle and Henry P. Sterens, E. P. Wightman and A. P. H. Trivelli, Ph. Schidrowitz, W. Babilioff, Ernst A. Hauser, H. Freundlich and E. A. Hauser, and others(2) have shown that the particles in ammonia-preserved as well as in fresh Hevea latex vary very greatly in size: in the latex obtained from the trunk of a tree of 10–15 years of age, the diameter of the particles varies between $0.5\,\mu$ and $3\,\mu$; besides such particles this same latex contains a great number of particles discernible only under the ultramicroscope. The dimensions indicated are those of the diameter of the cross-section of the particles, and not those of the length of particles. Their length reaches 4–5μ, and very seldom $6\,\mu$ or more. The greater number of particles of latex from young plants and from green parts of old plants are ultramicroscopical, and the size of particles of the coarse-disperse part of these latexes scarcely ever exceeds 1μ.

The micro- and ultramicroscopical examinations, which I have carried out of ammonia-preserved latex, have shown that among microscopically visible particles are to be found particles of every shape which have been described by the above investigators. The ratio of the number of particles visible in the bright field of view (microscope) to that in the dark field (ultramicroscope) is less than 1, i. e. the number of ultramicroscopical particles is considerably greater than that of microscopical ones. This is most easily demonstrated when examining the latex diluted with water 300 times by means of a bright-and-dark-field condenser; on changing from the bright to the dark field, the increase in the number of visible particles appears striking.

From the *low* layers of a diluted latex (e. g. 1:300) poured into a *tall* cylinder and allowed to stand at room temperature more than 48 hours, it is possible, for investigation in the bright field, to prepare such a preparation in which not *one* single particle is revealed; however, by changing to a dark field, there are immediately observed numerous particles in a lively Brownian movement. A *really colloidal* latex may be obtained from diluted latex by the method of fractionating its particles on standing.

E. Hauser(3) has established that the finest ultramicro-particles of Hevea latex have shapes different from spheres; i. e. one of their dimensions exceeds the others.

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(1) l. c.

(2) l. c.

(3) E. A. Hauser, "Latex," 65.

My examination of latex by means of the immersion-ultramicroscope (the shape of difraction rings) and by the dark field condenser A, from the firm of E. Leitz, with azimuth-stop and oil-immersion objective with aperture-stop, revealed that certain number of particles of ammonia-preserved latex possess the shape of either a sphere, or an elipsoid not far removed from a sphere. Pear-like shapes, and shapes with tails, are not specific shapes for Hevea latex particles, but the same shapes are readily formed in emulsions of oils in water in the presence of emulsifyers, which cover the drops with a film; the consistency of this film must be considered as plastic-solid.(1)

I have observed under the microscope particles of *every* shape appropriate to the particles of Hevea latex, i. e. oblong, pear-like, and with tails, in a preparation which I obtained by mixing one drop of immersion oil with one drop of concentrated aqueous solution of sodium iodide, or lithium iodide;(2) the particles in this preparation are so large that for their investigation a magnification of only 500 fold is quite sufficient.

The investigations of E. Hauser and H. Freundlich(3) of latex by means of the micro-manipulator, after Petérfi, has led them to the conclusion that the particles of latex are drops of a viscous liquid (the degree of viscosity may be compared with that of honey) surrounded with a film almost solid, and elastic. In their opinion, this film in its properties is near to raw caoutchouc.(4) According to these investigators,(5) the film, in its turn, is surrounded with an adsorption layer of proteins and resins. H. Freundlich and E. Hauser hold that latex from Ficus elastica consists of particles *perfectly* liquid and possessing no film of more solid („härtere“) consistency; the adsorption layer consisting probably of resins.

Thus, according to H. Freundlich and E.A. Hauser, a particle of Hevea latex is made up of caoutchouc in two conditions: solid without, and liquid within; the particle of Ficus latex consisting of caoutchouc which is in a liquid condition only. These two investigators advance the following explanation as probable for the two-phase condition of latex: (1) The homogeneous liquid phase of caoutchouc hydrocarbon is surrounded with a solid film of its polymer; (2) The liquid phase is not homogeneous, but represents a colloidal solution of a solid polymer in the liquid caoutchouc-hydrocarbon; the film is the gel of this colloidal solution. Consequently, in the

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(1) Bobert E. Wilson and E.D. Ries, "Colloid Symposium Monograph, I," (1923), 145. In fig. 18, the drop to the left of the picture, possesses one of the forms of the particles of Hevea latex.

(2) The photomicrographs of the drops of these emulsions will appear in one of my papers in *Reports of the Imperial Industrial Research Institute of* Osaka.

(3) E. A. Hauser, "Latex," 66–71.

(4) E. A. Hauser, "Latex," 70.

(5) H. Freundlich and E.A. Hauser, l.c. 24–25.

case of Ficus elastica, either no solid polymer is formed, or no coagulation proceeds on the surfaces of separation of drops of the iso-colloid solution (the term offered by Wo. Ostwald) of caoutchouc and of the dispersion medium (serum).

Formerly⁽¹⁾ I studied the processes of spontaneous disintegration into *gelatinous* spherulites of strongly swollen cellulose fibres, and also the processes of coagulation into gelatinous spherulites, of colloidal solutions of different substances. The *general* consistency of certain of these spherulites must be acknowledged as liquid, though the spherulites e. g. in the case of cellulose, are built up of minute pieces of *solid fibre* and of parts of fibrils, which are soaked with the viscous aqueous salt solution (e. g. of $CaCl_2$).

Under ultramicroscopic examination, the gelatinous cellulose spherulites reveal a structure (though often not quite distinct), because of the considerable difference in the optical properties of the disperse part and those of the dispersion medium in the gelatinous precipitates of cellulose. In those cases when the optical properties of the liquid soaked up by the gelatinous spherulites approach the optical properties of the solid substance of these spherulites, they of course appear optically homogeneous under the ultramicroscope, and no structure whatever can be revealed in these gelatinous spherulites. Such a proximity of optical properties exists in the case of iso-colloidal solutions of caoutchouc.

The comparison of certain photomicrographs taken of Hevea latex by H. Freundlich and E. Hauser⁽²⁾ and especially of the photomicrograph taken by H. Green of the latex from Ficus elastica,⁽³⁾ with the photomicrographs and photo-ultramicrographs which I have taken of the cellulose gelatinous spherulites, has led me to the idea that in the cases of certain latexes of caoutchouc we are dealing with *emulsion-suspensions of gelatinous iso-spherulites.* It is more than probable that these spherulites belong to the forms of the aggregate-fluid-crystalline state.⁽⁴⁾ Especially the picture represented in the photomicrograph taken by H. Green shows a striking resemblance to the pictures of cellulose spherulites in the photomicrographs taken by me.

The temperature must be taken into account as a factor acting upon the consistency of these iso-spherulites. My investigations have shown that *certain* of the latex particles flow together into larger particles; when the

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(1) P. P. von Weimarn, Dispersoidological Investigations XXII, Part II, Chapter II. § 2, Plates X-XI, *Reports of the Imperial Industrial Research Institute of Osaka,* (June, 1928).

(2) H. Freundlich und E. A. Hauser, *Ergänzungsband zur Koll. Z.,* 36 (1925), Tafel II, figs. 10 und 10 a.

(3) E. A. Hauser, "Latex," 130, Fig. 55.

(4) P. P. von Weimarn, *Reports of the Imperial Industrial Research Institute of Osaka,* Vol. VIII, No. 13 pp. 41–66. (November, 1927) ; *Koll. Z.,* **44** (1928), 279.

temperature is raised (to about 100°C.) the instances of such a union of particles become more numerous.

As I have had no micro-manipulator at hand, I have studied the consistency of particles, of their interior as well as of the external skin, by crushing between the cover-and object-glasses the largest particles found in the preparation of latex; the crushing was produced by a more or less strong pressure upon the preparations. In order to deform the particles of latex, I moved in one direction or the other the layer of latex, strongly pressed between the cover- and object-glasses. Under such manipulations, some of the pear-like particles of latex burst, and their liquid contents assumed the forms suggestive of a gelatinous consistency. By deforming the micro-particles of latex, I imparted to them various shapes, even shapes with concave surfaces and sharp angles; these shapes persisted in the particles during all the time of my observations.

By these and similar facts it is unequivocally shown that the film around a particle of latex cannot be likened to the film of raw caoutchouc, which, as is known, possesses considerable elasticity. The consistency of the films around the particles of latex is plastic solid to the same extent as is a film of fibroin-jelly (natural silk), or a film appearing on the surface of separation in the system: immersion oil + aqueous NaI or LiI solution.

I do not admit as sufficient the arguments of H. Freundlich and E. Hauser to the effect that the film by which the "liquid" contents of the particles of Hevea latex is surrounded, is a *pure* gel (or a *pure* polymer) of caoutchouc. In my opinion, the film is of a mixed composition, and is formed of complex particles: of subultramicro-particles of caoutchouc which are intermixed with particles of protein (as also with particles of resins and of other substances from serum).

I shall return to this subject later; now I wish to formulate my chief conclusion on the structure of Hevea latex, arrived at, after the study of the works of earlier investigators, on the ground of my micro- and ultramicroscopical investigations: *Latex is a poly-disperse system of iso-aggregate particles (iso-spherulites), the general consistency of which is fluid-gelatinous. The individual solid particles which compose the iso-aggregate particles of latex are very small, and the greater part of them is invisible under the ultramicroscope; the constituent parts of serum (i. e. the dispersion medium in which the iso-aggregate particles are suspended), viz. proteins, water, resins etc. in various concentrations, are present not only in the surface film, but also inside of the iso-aggregates; these non-caoutchouc components play corresponding rôles in the changes the iso-aggregates undergo in their consistency and structure, during the drying up and during other coagulation processes of latex.*

In accordance with the view previously expressed by me on the caoutchouc-like state of matter, the high elasticity appropriate to this state is due to the presence in the viscous-liquid, or liquid-gelatinous medium, of a definite quantity of solid structure elements,⁽¹⁾ which possess the ability of becoming spirally curled (after the release from tension).

§2. **The Gelatination of Latex and Revertex by Means of Extremely Concentrated Aqueous Solutions of Substances Appearing as Dispergators for Proteins.** As is known, C. O. Weber⁽²⁾ drew a sharp difference between the coagulation of caoutchouc from latex containing proteins, and the coagulation of caoutchouc freed from proteins. The latter case of coagulation C.O. Weber called *coalescence*. The caoutchouc obtained by means of coalescence, Weber considered inferior to that obtained by means of coagulation. Later on, this opinion of Weber has been refuted by other investigators (see W. Esch, l. c.) and Weber himself finally wrote that the caoutchouc obtained by precipitation, by means of an ether solution of hydrochloric and formic acids from the solution in ether of caoutchouc freed from proteins, is of very high quality („einen sehr *hochklassigen* Kautschuk darstellt").

According to my view, the gelatinous iso-spherulites of Hevea latex suspended in the serum, are surrounded by a *plastic-solid* transition layer, or by a film of a mixed composition, chiefly consisting of protein and caoutchouc, and therefore, the decrease in the amount of protein in this layer produces its more gelatinous consistency. Such a consistency of the particles of latex causes their sticking together, which produces a network tissue; under conditions of experimenting rightly selected, this tissue imbibes the whole of the mother solution, i. e. there ensues a *complete gelatination* of latex.

I undertook the study of the precipitation of Hevea latex by extremely concentrated solutions of LiI, LiCNS, $Ca(CNS)_2$, NaI, $Ca(NO_3)_2$, $CaCl_2$ etc., of poly-phenols, e. g. pyrogallol and resorcinol, thiourea and guanidine thiocyanate, because I had formerly proved⁽³⁾ the dispergative action upon proteins (e. g. fibroin-silk) of concentrated aqueous solutions of extremely soluble substances inclined to hydration. The experiments were carried out at room temperatures, and also at elevated temperatures (up to 170°C.).

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(1) P. P. von Weimarn, Dispersoidological Investigations, XXI, *Reports of the Imperial Industrial Research Institute of Osaka*, (November, 1927). I have also studied the micro- and ultramicro-structure of caoutchouc coagula and jellies obtained from latex and revertex; the results of this study will appear in the *Reports of the Imperial Industrial Research Institute of Osaka*, with photomicro- and photo-ultramicrographs appended. Under very different conditions of coagulation of Hevea latex, fibrous coagula are easily obtained; the fibres possess spirally curled fibril structures.

(2) See e.g. W. Esch, *Chemiker-Zeitung*, 29 (1905), 267.

(3) P. P. von Weimarn, Dispersoidological Investigations, XI, *Reports of the Imperial Industrial Research Institute of Osaka* (March, 1926); Dispersoidological Investigations, XVII, ibid., (June, 1927).

I have also carried out experiments on the coagulation of latex by means of extremely concentrated aqueous solutions of acetic acid and potassium hydroxide, because the proteins (e. g. fibroin) become dispergated also by the action of concentrated solutions of acids and alkalies, though in this case, the mechanism of dispergation is different from that in the case of salts, and is accompanied by a more or less deep disintegration of the molecules of proteins.

Besides this, I studied the influence upon Hevea latex of concentrated aqueous solutions of substances, which, with the concentration obtainable under ordinary pressure, prove to be aggregators for proteins (sodium citrate, potassium-sodium tartrate, and potassium sulphate). The following is observed when to a definite volume of latex (or to properly diluted revertex) is added a definite volume (e. g. equal) of a concentrated solution of one of the above-stated substances.

A. The temperatures and the concentrations of the solutions of substances-dispergators for proteins are such that the dispergation of proteins, which are in the latex, cannot proceed at all rapidly. Under these conditions, the latex, at least for several days, does not coagulate, or it yields an incoherent gruel, which is easily shaken down into a system of liquid consistency.

B. The temperatures and the concentrations of the solutions are such as to produce a rather rapid dispergation of proteins. Under these conditions, the formation of *one* piece of a coherent jelly is observed immediately or after the lapse of a short time. This phenomenon is produced by solutions of LiCNS, LiI, $Ca(CNS)_2$, of concentrations attainable at room temperature. LiI and LiCNS are most powerful dispergators for proteins. When, at room temperature, latex is poured into a test-tube containing an equal volume of LiI or LiCNS-solution (approximately saturated at room temperature) and this mixture is shaken several times, there is immediately observed a complete gelatination ; owing to syneresis, subsequent to the gelatination, the rod of elastic jelly can be easily taken out of the test-tube. The process of the complete gelatination of caoutchouc may be demonstrated very successfully as follows: into a test-tube of about 2 cm. diameter, containing 10 c. c. of an aqueous LiI-solution, *saturated* at room temperature, are poured 10 c. c. of ammonia-preserved latex, very carefully, along the walls of the test-tube (in order to prevent mixing). After closing the mouth of the test-tube with the finger, the contents are strongly shaken (only *once* is enough, after some practice) ; the shaking producing immediate gelatination. After the lapse of several minutes, if the finger is slowly withdrawn from the mouth of the test-tube, the whole rod of jelly follows, hanging on the film which has stuck to the finger.

The elastic properties of this rod possess a distinct vectoriality; the stretching force being constant, the rod of jelly may be *elastically* drawn out to a considerably greater extent in the direction of its length (i. e. in the direction in which the shaking has been performed; —here must be kept in mind the "*aggregation by stretching*") than in the direction perpendicular to its length; the breaking strain of the rod is also greater when stretching in the direction of its length. *This vectoriality is in full accord with my view on the caoutchouc-like state of matter* (§ 1).

By such a gelatination may be obtained coherent pieces of caoutchouc of any desired form: it is possible to mould plates, or objects of complicated shape.

By mixing latex or revertex with the solution of a substance-dispergator for proteins, with the concentration suitably selected (the experiments being carried out at a suitable temperature), I prepared a thick uniform liquid or gruel; after pouring it into a mould, I placed the latter into a closet, keeping a suitable temperature; after a certain time, the contents of the mould became one single piece of a coherent jelly; owing to its contraction, (syneresis) the jelly could be easily taken out of the mould for the purposes of washing and further treatment. The objects thus moulded can be subjected to cold vulcanization.

C. The higher the temperature at which proceeds the coagulation of latex by the substances which dispergate protein, the stronger (tensile strength) is the coagulum obtained; the coagula possess high degrees of elasticity. In suitably arranged experiments on coagulation at progressively increasing temperatures, the series of coagula obtained, possess definite mechanical properties, namely, under equal loads, the least elongation is found in the coagulum obtained at the highest temperature.

D. The solutions of substances appearing as substances-aggregators for proteins (e. g. sodium citrate, potassium-sodium tartrate, potassium sulphate) do not cause the coagulation of caoutchouc, for several days at least; or when they cause the coagulation, it proceeds by way of flakes or gruel, easily shaken up into liquid. For instance, after mixing latex with an equal volume of a concentrated aqueous sodium citrate solution (462 gr. of salt in 1 litre of the solution) the resulting system remained mobile (liquid) after the lapse of one month; a thick cream was formed near the surface, which by shaking dispergated into a mobile liquid.

When latex is being poured into *boiling* concentrated solutions of salts-aggregators for proteins (potassium sulphate, sodium citrate, potassium-sodium tartrate), and the boiling is continued for some time, the latex at first coagulates into tiny flakes, but on further boiling these flakes become agglomerated into *one* large, *loose* flake. This flake can be easily torn, it does not possess the great tensile strength of the coherent coagula of caoutchouc obtained by pouring latex into *boiling* concentrated solutions of substances-dispergators for proteins.

It should be pointed out that there is no correspondence between facts and the widely accepted view, that only from latex (or generally from disperse systems of caoutchouc) *freed* from proteins, coagulation produces a coagulum in *one* piece.(1)

Although the solutions of substances-dispergators (but not the *destroyers* of proteins) and also the solutions of substances-aggregators of proteins, do not of course free the latex from the proteins, they produce (the substances-aggregators at a slower rate) at *elevated* temperatures, at the end of the coagulation, *one* single piece of coagulum. At *room* temperatures, only the solutions of substances-dispergators of proteins (see above) effect the gelatination of latex into one coherent, elastic body.

By mixing at room temperature, for instance in a test-tube, Hevea latex with an equal volume of concentrated (96–99%) acetic acid, after shaking there is observed the formation of a rod of jelly which rapidly synerizes; the serum yielded is non-translucent, or only scarcely, when observed through a test-tube of 2 cm. diameter; it is of a greyish colour, and displays under the ultramicroscope a great number of particles in a lively Brownian movement; the aggregates of particles are also present. This turbid serum has not cleared up after the lapse of one month. A slightly turbid, though perfectly translucent, serum is obtained even after the shaking of only several drops of latex with 25 c.c. of 96% acetic acid.

When exactly similar experiments are carried out with extremely concentrated solutions of KOH, the process of the rod formation in the jelly is slow; the process goes only by creaming; on shaking in a test-tube latex with an equal volume of extremely concentrated KOH, there is formed at first a mobile gruel, which gradually becomes thickened, contracted and lifted to the surface (creaming), releasing at the bottom a transparent yellow serum. Already after the lapse of fifteen minutes, nothing flows out on turning the test-tube upside down, because the serum is closed by the thick gruel formed at the top of the test-tube. After the lapse of 24 hours, one third of the system from the bottom represents a transparent yellow serum; the remaining two-thirds being a rod of soft jelly; the jelly can be taken out as a whole by breaking the test-tube. After the washing of such a rod of jelly with water, the latter becomes turbid; if the rod be pressed under the water, the water becomes quite turbid and opaque. This fact shows that the particles of latex have not all as yet solidly grown together.

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(1) Compare the experiments of E. A. Hauser ("Latex", 97) on the coagulation of latex, in which the protein was digested („verdauen") by the addition of trypsin.

Thus, the solutions of those substances, which dispergate protein, at the same time destroying it (extremely concentrated acids and alkalies) cause certain secondary phenomena.

By juxtaposition of the results communicated, the following conclusion is arrived at: *By mixing under suitable conditions latex with the solutions of any substance by which the proteins are dispergated, but the caoutchouc is neither dispergated nor destroyed, a complete gelatination of latex into one coherent, elastic body may be attained.*

It is of interest to dwell a little on the solutions of proteins⁽¹⁾ in the solutions of salts-dispergators for proteins;⁽²⁾ I shall confine myself to only one example: into a boiling (at 170°C.) aqueous solution of a mixture of LiCNS and LiI, was poured Hevea latex, and by means of boiling, the temperature was again raised to 170°C. The caoutchouc deposited in *one* elastic piece, which possessed an extremely high tensile strength; to the naked eye, the piece appeared as of a thread-like structure; it gave the impression of being composed of thin threads tangled and stuck together (they are thin streamlets of the ropy stage in the process of precipitation of caoutchouc).

After taking out the lump of caoutchouc, the remaining hot, transparent solution was diluted with a great amount of alcohol; an opalescence developed at once, then fine flakes appeared in the whole mass of the liquid. After the lapse of 15 minutes, the greater part of these flakes collected into several larger flakes, which gradually deposited on the bottom; the flakes are voluminous and appear yellowish in transmitted light. On diluting the same solutions with great amounts of water, instead of alcohol, a slight turbidity also appears, which gives rise to fine flakes, precipitating with great difficulty; in this case, the number of flakes (the quantity of precipitate) is considerably less than in the case of dilution with alcohol.

§3. **On Complex Coagula of Caoutchouc with Proteins and Polysaccharides.** I have obtained coagula of a mixed composition: Caoutchouc + silk (fibroin); caoutchouc + casein; caoutchouc + cellulose; caoutchouc + chitin and caoutchouc + keratin. These complex coagula are very easily obtained by the coagulation of latex produced by pouring (or pulverizing) into it the solutions of silk, casein, cellulose, chitin and keratin in concentrated aqueous solutions of substances (see above) which are dispergators

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(1) On the protein of caoutchouc, see the interesting works of D. Spence, *The India Rubber Journ*, **34**, 766; **35**, 23. Abstracts: Koll. Z., **3** (1908), 103 etc.

(2) On pouring latex into a boiling, extremely concentrated, aqueous solution of pyrogallol, the coagulation of latex proceeds into one lump, as has been stated above. When this lump is taken out of the fairly translucent mother solution, and the latter is lavishly diluted with water, a milky-white, non translucent disperse system is formed. In this case as well as in certain others, the nature of the disperse phase of this turbid liquid is as yet not ascertained; the investigation is being continued.

for proteins and poly-saccharides. In the case of using fibroin, casein and keratin, the complex coagula obtained must be in addition treated with the solutions of substances which appear as substances-aggregators for proteins (i. e. for fibroin, casein and keratin).

As soon as I have investigated the mechanical properties of these coagula, I shall communicate in detail the results of my experiments in the *Reports of the Imperial Industrial Research Institute of Osaka.*

§4. **On the Gelatination of Vultex.** Since after vulcanization the particles of latex become less plastic and less liable to mutual union than before vulcanization (I refer to the union of the caoutchouc contents of the particles), it may be a priori expected that a wet rod of jelly obtained from *vultex* (by shaking in a test-tube an equal volume of vultex carefully poured into an aqueous solutions e.g. a LiI-solution, saturated at room temperature) will possess tensile strength *considerably* less than does a rod of jelly obtained by the same method from latex.(1) And on the ground of the fact that after vulcanization the particles of latex do not lose their capability to unite under a more or less strong compression, it may be also predicted that the above jelly of vultex, after its compression will acquire elasticity and greater tensile strength. The experiments carried out in this connection have fully confirmed all my above expectations: the wet rod of vultex jelly obtained can be easily torn to pieces and after compression, e. g. even under a cork-press, acquires mechanical properties of a higher order than before.

Good elastic films not only of latex, *but also of vultex,* are obtained by pouring latex and vultex onto large watch glasses and allowing the water to evaporate freely. Without pressure, the caoutchouc contents of the particles of vultex do not rapidly unite and do not form an elastic resistant body; in the case of film formation, the compression is fulfilled by kapillar, surface forces: the adsorption layers of the particles of vultex, consisting of proteins and resins, flow together when the particles come in contact. With progress of the evaporation of water, these non-caoutchouc layers, which have flown together, become contracted and exert considerable pressure upon the caoutchouc contents of the particles, forcing these contents to unite and to form a strong, resistant, elastic body. In no way am I in agreement with the view(2) that *elastic* films of vultex result from the gluing together of the non-caoutchouc layers of vultex particles; I assert that the *elastic* films of vultex are caused by the gluing together (union) of the *caoutchouc contents* of particles.

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(1) On the basis of my micro- and ultramicroscopic investigations, I arrived at the conclusion that in other aspects, i.e. in the form of the particles and in the structures of the coagula, no essential difference exists between latex and vultex.

(2) Ernst A. Hauser "Latex," 130-131.

By the results of my ultramicroscopic investigations of the structure of jellies and films of latex and vultex is established with certainty that their *inner* structure is fibril; the thickness of separate fibrils is less than that of latex or vultex particles, and in no case does their minimum thickness exceed the dimensions of several molecules (because there is *fibril*(1) *cleavage*); they may possess even monomolecular thickness.

In conclusion I have to thank Mr. I. Shoji, D. Eng., President of the Imperial Industrial Research Institude of Osaka, for the opportunity of carrying out these investigations and for the permission to publish the results in this journal.

April-June, 1928.

The Dispersoidological Department of
the Imperial Industrial Research Institute of Osaka.