**Physiology**. — "*Fibrin-excretion under the influence of an electric current.*" By E. HEKMA. (Communicated by Prof. H. J. HAMBURGER).

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Blood-clotting is based as we know upon the formation of a fibrin-gel. The gel or clotted substance obtained by adding blood-serum to a transsudate or to fluid blood-plasm free from elements formed, is likewise generally looked upon as fibrin. These fibrin clottings have until lately been considered as irreversible gels. Wrongly so, however, as my experiments showed. The fibrin-gel formed in the above mentioned way is indeed entirely insoluble in pure water, but by means of traces of alkali or acid it may be brought into a sole-state again, under the formation of optically empty fibrin-alkali- and acidhydrosoles. From these soles the fibrin may be excreted again with its properties unmodified. As regards the fibrinalkalihydrosoles it may for instance be done by weak acid (neutralisation), as regards the fibrinacidhydrosoles by weak alkali (neutralisation), while in both soles a number of reagents e.g. bloodserum, saturated neutralsalt solutions etc. effected an excretion of fibrin.

Further I have observed that the electric current also possesses this property. Both in artificial and in natural fibrinalkalihydrosoles (bloodplasm, transsudate) and likewise in fibrinacidhydrosoles an electric current may effect an excretion of fibrin. In the latter case the fibrin is formed at the negative, in the first two cases at the positive electrode.

For the experiments in question the fluid to be investigated was put into a U-shaped tube into the legs of which thin platinum electrodes were inserted (broad $\frac{1}{2}$ c.m.). As a rule the current was supplied by two accumulators.

In an artificial fibrinalkalihydrosole this experiment produces after some time a slight formation at the *positive electrode*, whilst after some hours a considerable clot has been formed round this electrode.

The fluid in the leg of the U-tube with the negative electrode remains clear; the only thing observable in it being the formation of gas beads. If the experiment is made with a weak fibrinalkalihydrosole prepared with a very weak alkali $\left(\text{e.g. } \frac{n}{500} \text{ NaOH}\right)$ a jelly like, filmy substance settles as a rule on the anode, which substance contains a great number of gas-beads and from whence thin fibres

extend into the fluid. A microscopical investigation shows that this is a network of fibrin fibres, so that there is no question about a real jelly.

If, however, the experiment is made with a highly concentrated fibrinalkalihydrosole, the fibrin likewise settles round the anode, often though as a jelly-like mass in which a microscopical investigation can detect no fibres: in this case we have to deal with a real jelly. If the gel is removed by means of a curved spatula from the fluid, it breaks up into small lumps. If these are put into distilled water, they sometimes take the film- and fibre-shape, whilst in other cases they are further broken up.

In a fibrinacidhydrosole of moderate concentration, made for instance with $\frac{n}{50}$ HCl, the other conditions of the experiment being the same, a clot, which likewise encloses gasbeads, settles in the course of a few hours on the *negative* electrode. Mostly this clot can be carefully removed as a whole; in water it presents the appearance of a mass of threads, which on being examined microscopically are found to make up a network of fibrin fibres. In highly concentrated fibrinacidhydrosoles the fibrin secretion may assume the form of a jelly-like mass or of thin films; mostly, however, a connected film is formed also in this case, which, in water, breaks up into a mass of fibres. It should be mentioned that in these experiments the fluid in the leg of the U-tube with the positive electrode remains clear; here too a few gas beads may be observed.

If in the same manner a current is led through blood-plasm which has been kept fluid, the result will be after a few hours a connected jelly-like filmy clot with numerous gas beads, from whence slender fibres extend into the fluid at the *positive electrode*, whilst the fluid has remained clear in the other leg of the U-tube. When removed in water this clot mostly breaks up into thin flakes and fibres. On being examined microscopically the mass at first appears to be a dense amorphous granular mass. After one of the flakes or fibres has been unravelled a network of fibrin fibres is revealed, which had not been observed before on account of the numerous amorphous substances. These amorphous grains are undoubtedly other albumens, which have been precipitated with the fibrin at the anode.

As regards these experiments made with artificial fibrinalkali- and acidhydrosoles, it is by no means necessary to start from fibrin obtained by adding bloodserum to bloodplasm kept fluid or to a transsudate. The same results are arrived at with fibrin which has

been obtained by adding to the above-mentioned natural coagulation-fluids some suitable reagent. For instance, weak acid (neutralisation) or a saturated neutralsalt solution (especially a saturated NaF solution). If alkali or acid hydrosoles, made from the fibrin gel thus obtained, are exposed to an electric current, they will be found to behave in a manner entirely analogous to that of the soles mentioned before.

How are we to account for the fibrin-secretion or coagulation under the action of an electric current? In my opinion the most obvious supposition is that the electric current renders inactive the alkali or acid of the fibrinalkali- and acidhydrosoles; this may be explained as follows:

If I am not mistaken it is assumed that the molecules of an aqueous alkali-solution e.g. a weak NaOH sol. are split up when acted upon by an electric current, so that the ions of OH are formed at the anode; these are subsequently rendered inactive under the formation of water and oxygen. If this is correct, the alkali in a fibrinalkali-hydrosole, under the influence of which the fibrin is in a sole-state, will be rendered inactive by the anode; it will so to speak disappear from the fluid, at least there. And since the fibrin cannot remain in a sole-state after alkali has been withdrawn, it will be secreted at the anode. It can easily be demonstrated that the part of the fluid which comes into contact with the positive electrode becomes much less alkaline, unlike that part which is in the leg of the U-tube containing the negative electrode. This holds good both for natural and for artificial fibrinalkalihydrosoles.

If on the other hand an electric current is led through a watery weak acid-solution, the acid molecules are, if I have not misinterpreted the current views on the subject, split up into electrically charged atoms (ions), whilst the ions of H with their positive charge become electrically neutral on being brought into contact with the negative electrode or disappear from the fluid there. If we assume this view to be correct, the acid in a fibrinacidhydrosole will suffer an electric dissociation and then become inactive. The consequence will be that the fibrin can no longer remain in a solestate and will be excreted at the cathode. This decreased acidity of the fluid-column which is in contact with the cathode can be easily demonstrated in the experiment. It should be noticed in passing that one gets an impression that the electrolytic dissociation of alkali and acid, or at least the disappearance of alkali and acid from the respective fluids, is restricted to the leg of the U-tube which contains the positive or negative electrode. That is to say if weak currents are applied; if

very strong continuous currents are led through the fibrinalkali- and acidhydrosoles, everything is changed.

The observation that under the influence of the electric current fibrin in natural coagulation-fluids is secreted at the same (positive) electrode as fibrin in artificial fibrinalkalihydrosoles confirms, as it seems to me, the accuracy of a conclusion which I arrived at by another way before, viz. that fibrin in natural coagulation substances, hence also in blood, is present in a preformed state as an alkalihydrosole. That, therefore, the fibrin-secretion in natural coagulation fluids, and consequently the clotting of blood, is in principle based upon a transition from the alkalihydrosole- into the gel-state.

Elsewhere grounds have been adduced for the opinion that fibrin in its optically empty soles is not present in a simply dissolved state, but that the fibrin particles under the influence of electrolytes are expanded by water. That in other words the fibrin-particles in the alkali- and the acidhydrosoles contain so to say a charge of an electrolyte (alkali, acid) *and* water. Such an amicroscopical system: fibrin-substance—electrolyte—water I have denoted by the name of "micell". Taking the word micell in this sense, the optically empty fibrin-soles may be looked upon as micellular solutions. This view also makes it clear why fibrin may be secreted in one case as a real jelly, in another as a system of fibres, which facts we could establish again at the gel-formation under the influence of an electric current. In the first instance we have to deal with an agglutination of the fibrin micells still in a somewhat swollen state (by an imperfect loss of the electrolyte and consequently of the water in them), resulting in a real jelly. The second instance relates to an agglutination of fibrin particles which are no longer swollen; the micells have more completely lost their electrolyte and consequently their water, whilst the unswollen discharged micells (fibrin-particles) owing to a property peculiar to fibrin, agglutinate lengthwise into needles and then into fibres (micellular-crystallization process). From a more general point of view it is a remarkable fact that the fibrin-secretion under the influence of an electric current is entirely analogous to that which is occasioned by weak acid or alkali, by neutral salt solutions, by bloodserum etc. I shall, however, not dwell at present on the further significance of this fact.

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