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EXPERIMENTS AND OBSERVATIONS

ON

ALBUMINOUS FLUIDS.

BY DR. BABINGTON.

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THE changes which albuminous fluids undergo by a union with the pure alkalies and the neutral salts do not seem to have attracted so much attention as their importance merits. Accident has lately led me to their consideration: and as the facts and inferences at which I arrive appear to possess some interest, I venture to make them the subject of a few remarks.

During an attendance, some months since, on a gentleman who had calculus in the bladder, together with prostatic disease, I had frequent occasion to examine the condition of his urine; which, under the use of acidulated infusion of Buchu, maintained an acid re-action, and was in itself clear and of a natural colour. Towards the end of micturition, however, more especially when first performed in the morning, a cream-coloured opake fluid was voided; which became mixed with the urine, and ultimately settled at the bottom of the vessel in which it was received. This fluid was not ropy; so that, on decantation, it could be made to flow off, drop by drop; and when thus divided, it appeared to consist of minute flocculi. The application of heat caused an immediate flocculent precipitate; and alcohol, acids, and all such agents as precipitate albumen, had the same effect. On the addition of a moderately strong solution of pure potassa, a remarkable change occurred: the thick creamy sediment became transparent; and was converted, on agitation, into a semi-solid mass, so viscid and tenacious, that, in pouring it from one test-tube to another, a continuous string, several feet in length, could be formed.

This mass I found to be of difficult solubility in water; the mere affusion of that menstruum being wholly insufficient, even after many days' maceration, to alter its character, or abstract the alkali from it. It was, therefore, practicable to wash its surface, so as to free it from any alkaline re-action upon turmeric or reddened litmus-paper. It bore a boiling heat, without losing its viscid consistence or transparency; and remained unaltered, in an open phial, for several weeks. Nitric acid, much diluted, only rendered its surface opalescent; but when added in a more concentrated form, caused a precipitate. Ammonia was equally efficacious as the fixed alkalies, in forming with the urinary sediment a tenacious transparent semi-fluid. This strongly retained the ammoniacal odour; and the compound bore a similarity so striking to natural ropy mucus passed under certain diseased states of the bladder, that I was induced to institute a more minute comparison between them. The opportunity of doing so was afforded me by a case of diseased bladder, with catarrh of that organ, under my care at the same period. The urine in this instance was of a deep colour, and not very clear: it had an ammoniacal odour, was highly alkaline, and deposited a viscid transparent amber-coloured mucus. This mucus was as ammoniacal in its re-action as the urine itself. It was difficultly soluble in water. The caustic alkalies rendered its odour more pungent, but did not affect its viscidity or general appearance. Nitric acid caused a copious precipitation of brown flocculi, insoluble in water. From these characters, this natural ropy mucus seemed to me closely to resemble, if not to be identical with, the artificial combination with ammonia which I had effected, in the first case, by the union of ammonia and the urinary sediment. That sediment I considered to be of a purulent nature; but coming, as it did, from a hidden source, direct proof of this was wanting; and my next endeavour, therefore, was to ascertain whether the same combination could be formed by a union of the pure alkalies with matter from other parts. Fresh pus, from an abscess in the groin, was made the subject of experiment. It was slightly acid; and on the addition of liquor potassæ, just sufficient for saturation, it began

to thicken, and become viscid. A further addition of alkali, brought in contact with it by agitation, effected its complete conversion into a semi-fluid transparent tenacious mass. Solutions of soda and of ammonia produced a similar change; the latter, indeed, in so remarkable a degree, that whilst the pus, when poured into a clean test-tube, was, in accordance with its usual characters, a thick opake creamy fluid, adhering, as it flowed, to the sides of the glass, on being agitated with liquor ammoniæ it immediately formed a tough transparent semi-solid, which could with difficulty be shaken towards the mouth of the tube at all; but on being caught and contorted as it protruded, the whole was completely brought away, even from the very bottom, so as to leave the internal surface of the tube as clean and free from moisture as before the pus was poured into it. The mucous expectoration in pneumonia will, in the same way, leave the surface of the vessel which contains it. The combination thus formed was very difficultly soluble in water, and retained its viscidity and alkaline qualities in its internal substance, although repeatedly washed: it also preserved its ropiness and transparency, even though surrounded by a weak acid solution more than sufficient to neutralize the alkali with which it was combined. A strong solution of nitric acid rendered the mass opake, and destroyed its elasticity. Upon the whole, this combination was of the same nature, though more concentrated than that which I had first obtained by the combination of alkalies with the purulent urinary sediment.

As it is often a matter of doubt with the medical man, whether a deposit in urine be of a purulent nature or not, it is a ready test, after pouring off the clear supernatant urine, to add liquor potassæ to the sediment collected in a phial or test-tube. If it be purulent, it will, on agitation, form, with the alkali, the transparent viscid compound which I have described. This I have more than once verified, since my attention was first drawn to the subject.

On diluting and agitating pure pus with four times its bulk of distilled water, the fibrinous particles subsided; and the albuminous fluid, in which they had been suspended, remained dissolved in the water, from which it could be

separated by coagulation, on the application of heat*. The fibrinous particles, thus washed, formed a combination with the alkalies far less tenacious than the pus itself; which led me to conclude that the albumen performed a more essential part in the change than the fibrine. This conclusion brought to my recollection, that many years ago† I had been struck with the result of adding some liquor potassæ to the white of an egg, and thus converting it into a transparent horny solid. The fact being new to me at the time, I searched chemical books, to ascertain whether it had been noticed; and found that Thompson was the only author by whom it had been mentioned. The following are his words:—"When alkalies are mixed with a solution of albumen in water, no apparent change takes place; but if a concentrated solution of pure potash be triturated with albumen for some time, and then allowed to remain at rest, the albumen gradually coagulates, or rather gelatinizes‡; for the coagulum has a striking resemblance to jelly. It gradually hardens; and at a particular period of its drying it resembles very exactly the lens of the eye. When quite dry, it is brittle and transparent." (*Thompson's Chemistry*, Sixth Edit. vol. IV. p. 403.)

Considering serum in the light of "a solution of albumen in water"—and I have little doubt that it was serum which Thompson had in his view when he made the remark—I should have been led, from its tenor, to expect that a solution of caustic alkali would produce no "apparent change" in it; and the more so, since it already contains alkali in a free state. The changes produced in pus induced me to doubt the accuracy of the observation; and experiment proved it to be erroneous. Solution of caustic potassa,

* The general notion (see *Turner's Chemistry*, Fourth Edit. p. 932), that pus is insoluble in water, is, therefore, partly erroneous; since the albuminous portion is completely soluble in that menstruum.

† The circumstance is alluded to in some notes of mine, written in 1827, and published in Sir Astley Cooper's Paper in the First Vol. of the Guy's Hospital Reports, p. 451.

‡ The resemblance to jelly is only in appearance; since it wants the most distinctive character of that principle, namely, that of liquefying by heat, and does not pass into a state of acid fermentation. The resemblance to the lens of the eye is also one of appearance only, as the lens is coagulable by heat.

soda, and ammonia, are all capable of converting serum into a thick tenacious fluid, very much resembling that formed by the same agents with pus, but less solid and concentrated. This fact seems hitherto to have escaped observation, from the circumstance that the change is not immediate. "No apparent change," to use Thompson's words, takes place at the moment; but if the fluid be agitated, and then set by, in the course of a few hours, or sometimes even minutes, if the serum be rich in albumen, it will be found thickened, and possessing the same kind of viscidity, though not in an equal degree, as in the case of pure pus. The slight degree of viscidity which serum of blood generally possesses, and the nearer approach to the physical characters of the compound of which I am treating, which is assumed by the albumen of egg, may, perhaps, be owing to the respective proportions of free alkali which they always contain; and their transparency may be attributable to the same cause. Milk, as being another instance of an albuminous solution, was made the subject of experiment, in combination with the alkalies. It becomes, to a certain degree, thickened, viscid, and translucent; the curd, as well as the albumen, entering into the compound, while the cream separates and floats above it. The change is not so striking as in serum, from its containing the animal principles in a state of greater dilution. The term *free* seems correctly applicable to the state in which the alkali exists in these combinations. Its caustic nature is not neutralized; and although it effects so striking an alteration in the physical qualities of pus or albumen, I am by no means certain that it undergoes itself any alteration. May it not be rather considered to furnish an example of that force, noticed by Berzelius, which some bodies exercise over others, so as to produce a change without being themselves affected; and to which he applies the term "catalytic force"? It must not, at all events, be supposed that these combinations are mere solutions—at least, when the alkalies are not highly concentrated; for this supposition would not at all account for the difficult solubility in water, the solidification, or the viscidity manifest in them. Coagulated albumen is an example of an animal substance soluble in strong solutions of

caustic alkali; but the result is, a liquid without any viscidity, from which the albumen may be at once precipitated by an acid, and which is miscible with water, in all proportions.

When the albuminous fluid, whether it be pus or serum, has passed, by the addition of an alkali, into the state of what may be called an artificial mucus, it answers all those conditions stated by Dr. Bostock to be characteristic of natural mucus. It is, as I have said, alkaline in its reaction; and I have found, notwithstanding the assertions of writers on animal chemistry to the contrary, that this is generally the case with natural mucus, provided it be tested when recently secreted. Bibulous paper*, tinged with litmus, and reddened by simple exposure or by a very dilute acid solution, is restored to its blue colour by fresh mucus. A little time is necessary to demonstrate the fact, from the tenacity with which the alkali is held in combination; but it is not the less manifest on this account. Thus, if we take a small pellet of translucent grey mucus (*crachats perlés Laennec*), such as many persons in health occasionally expectorate, we shall find, on pressing this between two folds of the reddened litmus-paper, that, although a very slight immediate change of colour is perceptible, yet that, in the course of a few minutes, as the moisture is abstracted from the mucus, its highly alkaline state is rendered evident. In the remarkably viscid mucous expectoration which takes place in pneumonia, and which, with the exception of the air-bubbles it contains, may very exactly be imitated by the combination of pus and solution of soda, I have sometimes failed in demonstrating the existence of free alkali, when the specimen taken for experiment has been several hours saved for inspection; but it has only been necessary to take the product of expectoration at the moment it is discharged, to be satisfied that, when first excreted, it is decidedly alkaline. This will be found to hold generally true of the secretions, not only from what are termed the mucous membranes, such as the nostrils,

* In the shops, they commonly tinge writing-paper for use; but the size it contains, which cannot be soaked out by cold water, diminishes its delicacy as a test.

the intestinal canal, the gall-bladder, and the vagina, but also of such other animal secretions as are ropy and viscid, from whatever source they may proceed. I have already instanced the albumen of egg; and I may add the seminal secretion, affirmed by Vauquelin (*Ann. de Chim.* Vol. IX. p. 65) to be highly alkaline, and the vitreous humor and crystalline lens of the eye. I learn that the constantly alkaline character of mucus has been demonstrated by Mr. Golding Bird, in a Paper read before the Physical Society of Guy's Hospital. That Paper I have not seen; but I can add my independent testimony to that of this accomplished chemist, in verification of the general fact.

A solution of bichloride of mercury, which is so delicate a test of the presence of albumen, produces no precipitate in artificial mucus. In this respect, it corresponds with natural mucus. The same remark holds true of infusion of gall-nut. The tritacetate of lead, on the contrary, which Dr. Bostock laid down (see *Nicholson's Journal*, Vol. XI. p. 252) as the proper precipitant of mucus, produces a similar precipitate in solutions of the artificial combination. When evaporated to dryness, there is the same transparency, and general resemblance to gum; and the same insolubility, or rather difficult solubility, in water. The only difference which I have remarked—and it is one of degree rather than of kind—is, that the artificial mucus is more easily precipitated by acids; which seems to shew a less intimate union than that which is effected by the chemistry of nature.

The combinations of which I have treated thus far, are those of the caustic alkalies, with pus and other albuminous fluids: but there is another set of combinations with pus, of equal interest, which seem still less to have attracted the attention of animal chemists. I refer to those which are affected by the agency of the neutral salts. Pus is stated, by John Hunter, to be coagulable by sal ammoniac, which no other animal secretion is; and this I believe is the sum of what has hitherto been observed*. The elementary

* I did not meet with Dr. Pearson's observations and experiments on Pus, contained in the Philosophical Transactions for 1810, until the revise o this Paper was put into my hands for final correction. Had I done so earlier, I should have curtailed, or perhaps suppressed it. Yet my facts are

chemical works do not even notice this fact. On making the experiment, I have found that it is not coagulation such as heat, alcohol, and acids effect with albumen, which is induced by the addition of this salt, but a combination bearing considerable analogy to that which I have described as taking place with the alkalies. The hydrochlorate of ammonia is entitled to no particular distinction, as possessing this power. Hydrochlorate of soda, nitrate of potassa, sulphate of magnesia, sulphate of soda, sulphate of potassa, all form viscid combinations with pus; and I have found in the case of the three former salts, that, after a lapse of three weeks, those combinations had not undergone any change; being still insoluble in water, and still so tenacious as to be capable, on being poured from a test-tube, of forming a continuous string several feet long. The combination with all the salts that I have named, seems, in its physical characters, to be much the same. I have only examined with minuteness, however, that which is formed with hydrochlorate of soda.

A saturated solution of hydrochlorate of soda added to healthy pus, in the proportion of one-third, and agitated with it so as to bring the particles of each liquid into intimate union, effects a complete change in its properties; and this seems, to a certain extent, progressive. Examined after an interval of a few hours, it is found to have lost its creamy appearance, to have become more diaphanous and homogeneous in texture, and to be so viscid and semi-solid, that if a test-tube of half an inch in diameter has been employed, and three-fourths filled, it may be inverted, and the contents will not gravitate towards the mouth of the tube. The combination is insoluble in water, and immiscible with it, unless by very violent and continued agitation; by which means it becomes diffused like mucus in flocculent portions, and it will remain in that fluid separate and viscid for many weeks. Solution of bichloride of mercury will not precipi-

are not altogether the same as his; and my conclusions, founded on a similarity of chemical re-agencies, establish, I trust, a sufficient degree of originality to entitle the Paper to perusal: and if it should have the effect of attracting more attention to a subject which is certainly not exhausted, it will have its use.

tate it from its mixture with water, but the tritacetate of lead in solution will readily do so. Infusion of galls will corrugate, but not precipitate it: and making a comparative experiment with pure pus, the difference is very striking. If a portion be placed in water, no apparent change takes place by raising it to a boiling heat: it is not hardened, but remains the same viscid mass as before. Alcohol, and the dilute mineral acids, condense it into a solid mass, which preserves a considerable share of tenacity; whereas when these agents are added to pure pus, it is precipitated in minute incoherent particles. If the compound of the alkalies and pus may be likened to pure mucous expectoration, that of hydrochlorate of soda and pus may with equal propriety be likened to expectoration of a muco-purulent character; and the resemblance is, to me, so apparent, that, if dropped into water in separate portions, I am persuaded that I could not distinguish those portions from the sputa of a phthisical patient. The saturated solution of hydrochlorate of soda does not produce any change analogous to that caused by the alkalies upon the serum of blood, or even upon the liquid portion of pus.

From what has been said, it may, I think, appear probable to others, as it does to me, that natural mucus is formed by some combination analogous to that which results from the action of a pure alkali, or of a neutral salt, on pus or albumen, either by actual chemical combination, or by catalytic force: in which latter case, the proportion of the alkali or salt may be of the less consequence.

The intimacy of the union, in the artificial combination, we have seen to be so great, that it is not destroyed by an acid, provided this be largely diluted, even though it be added in quantity quite sufficient to saturate the alkali, were it in an uncombined state. This holds true of natural mucus, when secreted in the bladder: for it is, I believe, to Sir Benjamin Brodie that we owe the remark, that the ropy mucus secreted under a morbid condition of that viscus is alkaline, whilst the urine secreted at the same time occasionally remains acid.

The utility of this power of resisting decomposition is manifest in a fluid which is destined to defend surfaces from the contact of injurious agents. For the purpose of lubrica-

tion, too, it is difficult to conceive any combination more smooth and slippery than are those containing a free alkali. Liniments and soaps are the compounds to which we have recourse, when we wish to obtain these qualities in the highest degree.

In the albuminous urine of renal dropsy I have endeavoured in vain to obtain, by the addition of alkalies, any approach to ropy mucus; but whether this is owing to some counteracting tendency in the other constituents of the urine, or to some alteration in the albumen itself, or whether the proportion is too small to render its viscidity palpable, I have not ascertained. To obviate the last cause of failure, I have concentrated such urine, by evaporation, at a temperature too low to produce coagulation; yet still I had no better success.