X. *An Investigation on the Chemical Nature of Wax.*

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Communicated by Sir Benjamin C. Brodie, *Bart., F.R.S., &c.*

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I. *On Cerotic Acid, a new Acid contained in Bees'-Wax.*

In the summer of 1845, while studying at Giessen, in the laboratory of Professor von Liebig, I undertook, at the request of that distinguished chemist, the analysis of certain waxes which were the results of an experiment made by Herr Gundlach of Cassel, of feeding bees upon different kinds of sugar. It is not my intention to give those analyses here, and I mention them now only for the purpose of stating that it was this circumstance which first turned my attention to the inquiry of which I now offer the results to the Royal Society, and that it was in Professor von Liebig's laboratory that this investigation was begun.

Various chemists have before me undertaken a similar inquiry. The chemical history of a substance so abundant in nature and so useful to man as wax was always a curious question. Of late it has acquired a peculiar interest from our knowledge, derived from repeated experiments, that wax is formed in the organs of the bee, and that in the body of that insect that remarkable change of sugar into wax takes place, the knowledge of the true conditions of which would, we may hope, throw light upon the formation of fatty bodies, and on the way by which out of vegetable products the continual repair of the animal structure is effected. The first step to such a knowledge must be the accurate study of the chemical nature of those substances which are thus produced.

But little progress however has been made in this inquiry. I may sum up in a few words those results already known which, by my own experiments, I am able to confirm as true. It has been ascertained that wax is separable by alcohol into two portions, which have been called cerin and myricin; that, by the action of potash upon wax, an acid or acids may be obtained, and also an unsaponifiable body, cerain; and that by the distillation of wax we obtain volatile oils, solid hydrocarbon, and an acid which has been surmised to be margaric acid, from its resemblance to that substance.

I say that these are the ascertained facts. The high atomic weight of these bodies, and the unavoidable errors of analysis, have rendered it easy to find formulæ for them, and to speculate as to their nature. If, however, the views which, in the following pages, I offer to the Royal Society are correct, their true chemical relations and constitution have been undiscovered.

It would be useless, and it is by no means my intention, to comment upon all the ideas which other chemists have entertained upon this matter. There is however one theory, which has been advanced by certain chemists in France, of which it would be unbecoming in me to take no notice, both because it has a certain apparent amount of fact to support it, and because the originators of it, and others also, believe that they have finally settled the question of the true place which wax should hold in our classification of chemical substances*. M. Lewy has stated that cerin, that portion of the wax which is the more soluble in alcohol, is converted by oxidation by means of lime and potash into stearic acid. The method he pursued was that used by Dumas with such success for the conversion of alcohol into acetic acid; of potatoe oil into valerianic acid; and for other similar transformations. He has explained the reaction by giving to the cerin the formula $C_{68}\,H_{68}\,O_4$. On this hypothesis, the cerin, by conversion into stearic acid, loses three equivalents of hydrogen and takes up three equivalents of oxygen into its constitution, the reaction being expressed by the equation

$$C_{68}\,H_{68}\,O_4+3HO=C_{68}\,H_{68}\,O_7+H_3=\left[\begin{array}{c}\text{stearic acid}\\ +H_3\end{array}\right],$$

the cerin being considered the aldehyde of stearic acid. M. Gerhardt has taken up and extended this idea. Proceeding on the belief that the myricin and cerin are isomeric—a belief, I may observe, not justified by experiment, although almost universally adopted by chemists—he has stated that the myricin, of which by far the larger portion of the wax consists, corresponds to the metaldehyde of the same acid, and in a paper which he entitles, "Faits pour servir à l'histoire de la cire des abeilles†," has explained on this hypothesis the origin of the products of the dry distillation of that substance. The theory of M. Lewy agrees sufficiently well with his analyses of the substances in question and with the relations of his formulæ. I must however observe, that any person who will take the trouble of reckoning out those analyses on which the formula of stearic acid depends, according to the atomic weight of carbon now almost universally adopted by chemists, carbon 6, hydrogen 1, will see that this formula itself demands a new inquiry before we can accept it. These results of M. Lewy are in many ways at variance with my own experiments; but I confess that if the agreement of the analysis and of the melting-point of the substance he obtained by oxidation of the cerin with the analysis and the melting-point of stearic acid were in truth a sufficient proof of the identity of the bodies, this difference in our results would be to me very difficult to explain. Wax certainly stands in a remarkable relation to fat, but I do not believe that relation to be of the nature M. Lewy has conjectured, and I cannot but think that, in

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* Annales de Chimie, vol. xiii. p. 439; and Jahres-Bericht, Berzelius, vol. xxiv. p. 468.

† Ibid. vol. xv. p. 236.

his desire to establish this relation, he has rested content with insufficient proofs of his theory. Any person who has had a little experience in these inquiries, must know how deceptive this melting-point and analysis are as criteria of the purity or identity of bodies. The separation of this class of substances by crystallization is difficult, and often the composition per cent. of two substances of entirely different chemical formulæ will agree within the unavoidable errors of the method of analysis. The reasons will hereafter appear why I am justified in saying that, in the cerin which M. Lewy analysed, he did not work on a pure chemical substance; and that consequently any theory founded on the reactions of this body must fall to the ground; I believe that by more careful inquiry he might have procured that substance of a different melting-point and constitution to that which he found. I have also in vain searched the papers which M. Lewy and M. Gerhardt have published upon this matter, to find some account of the preparation and the analysis of a salt of this so-called stearic acid, an easy and satisfactory experiment, and one which alone, in the case of acids of such high atomic weight, can justify the chemist in pronouncing on their constitution. Until such a salt is made, I cannot but consider that the evidence is insufficient, that the remarkable oxidation in question has ever been effected.

I propose to give to the Society, in three papers, the results of an investigation on the nature of wax. The present paper will contain an inquiry as to the constitution of the so-called cerin; I mean that portion of the bees'-wax which is the more soluble in boiling alcohol. The second paper will treat of the chemical constitution of a wax from China, a substance which, although it considerably differs in its appearance and properties from bees'-wax, in the form in which it comes before us in nature, is nevertheless, chemically speaking, closely analogous to that body. In a third paper I propose to consider the nature of myricin, the other constituent of the bees'-wax itself. I may here state, that to ensure the purity of the wax used in the following experiments, I prepared it myself from the comb. It was made by bees in the county of Surrey in the years 1845 and 1846. This wax I have always used for the first preparation of a substance. For further experiment I have sometimes used wax procured in other ways.

Cerotic Acid.

If wax melting at about 62° or 63° Centigrade be treated with boiling alcohol, a considerable portion will be dissolved. If this operation be repeated, the quantity of substance dissolved the fifth or sixth time will be evidently less than that dissolved in the first operation. But however often this operation be repeated, there will always be a portion of wax dissolved. This fact alone might lead us to suspect that any absolute separation of these two portions of the wax, by boiling with alcohol and subsequent crystallization out of that liquid, was impossible.

A partial separation can, however, be readily effected, and by this method a substance can be obtained melting at 70° and even 72° Centigrade, much harder than the residue of the wax, brittle, and slightly crystalline in its structure. If this substance be boiled with a solution of caustic potash, it is saponified with the greatest facility. If the soap be decomposed by an acid, a baryta salt formed of the acid produced, and this salt be dried and washed out with ether, a certain portion of a substance will be taken up by the ether, which is but very slightly acted on by potash. This is that substance which has been called cerain. I remarked that while from the residue of the wax this matter could be procured in considerable quantities, but a very small portion was obtained from the cerin; a portion very small in relation to the acids formed, and the quantity of which diminished with the purification of the substance. The analysis also of the unsaponified cerin agreed closely with that of the acid as separated from the baryta salt, and the melting-points only differed by four or five degrees Centigrade. Further experiment showed me that the same cerin, when boiled with caustic baryta, entered with the greatest facility into combination with that substance. These facts led me to suspect that the formation of the unsaponifiable body was due to the presence of a certain portion of the other substances of the wax, and was no true product of the decomposition of the cerin itself; but that this substance was in truth no other than the acid itself existing, in a free state, in the wax. The experiments which follow are inconsistent with any other hypothesis.

To prepare this acid bees'-wax is to be boiled out with strong alcohol, and the hot solution poured off from the undissolved residue. This operation may be repeated with advantage three or four times. The precipitates which are formed on the cooling of the alcohol are to be collected together and treated repeatedly with alcohol in the same manner as the wax itself, until the melting-point of the precipitate is raised to about 70° C., after which point the further purification of the body by this method of crystallization is extremely difficult. This substance is now to be dissolved in a large quantity of boiling alcohol, care being taken perfectly to effect the solution. To this solution is to be added a boiling solution of acetate of lead in alcohol, by which a voluminous precipitate is produced, which does not redissolve in the boiling mixture. The solution is to be boiled and filtered hot, by means of a hot water apparatus, from the precipitate. The precipitate while moist is to be taken from the filter, placed again in the flask, and boiled out with strong alcohol, and afterwards with ether. This operation is to be repeated several times until the fluid which passes through the filter carries no substance with it. The first portions of alcohol will contain considerable portions of a wax matter having a lower melting-point than the cerin, and having the appearance of the residue undissolved by the hot alcohol.

The lead salt is to be decomposed by very strong acetic acid. The substance which separates, after having been well-washed with boiling water, is to be dissolved in absolute alcohol, and the solution, while hot, filtered. On the cooling of the alcohol a substance will crystallize out in fine granular crystals. This substance melts at about 78° C. It is highly crystalline on cooling from the melted state. Very carefully prepared, it gave to analysis the following numbers. The analysis was made with chromate of lead.

0·26 grm. of substance gave 0·753 grm. of carbonic acid and 0·307 grm. of water.

These analyses give in 100 parts—

Carbon	78·98
Hydrogen . . .	13·12
Oxygen	7·90
	100·00

This corresponds to the formula $C_{54}H_{54}O_4$.

	Atomic weight.	Calculated in 100 parts.
C_{54} . . .	324	79·02
H_{54} . . .	54	13·17
O_4 . . .	32	7·81
	410	100·00

It is very difficult to wash this lead salt perfectly out. Even in the present case, after the greatest care, I obtained a trace of a substance, soluble in ether, on attempting further to purify the substance by combining it with baryta and washing out its baryta salt. This makes no difference in the numbers or the melting-point. But it is advisable to prepare the pure acid by boiling the acid as separated from the lead salt with caustic potash, precipitating the baryta salt by a large excess of chloride of barium, and carbonate of soda; washing this well out with ether; decomposing with an acid, and crystallizing the resulting substance repeatedly out of alcohol and ether. The acid prepared in this manner melted at 78°, 79° C., being the same melting-point as the acid separated from the lead salt; it gave to analysis the following numbers:—

I. 0·263 grm. gave 0·7583 carbonic acid and 0·3085 water.

II. Another preparation. 0·2615 grm. gave 0·7558 carbonic acid and 0·307 water.

III. 0·2612 grm. gave 0·7562 carbonic acid and 0·308 water.

These analyses correspond in parts per cent. to—

	I.	II.	III.
Carbon	78·63	78·82	78·95
Hydrogen . . .	13·04	13·04	13·10
Oxygen	8·33	8·14	7·95
	100·00	100·00	100·00

The silver salt of this acid was made by precipitating the ammoniacal solution of the acid in alcohol with nitrate of silver. It is desirable to take an excess of ammonia, and the solution must be precipitated boiling by a hot alcoholic solution of the nitrate. The salt is to be washed with water and dried, first *in vacuo*, then in a water-bath.

I. 0·469 grm. of this salt gave 1·067 carbonic acid and 0·4315 water.

II. 0·4663 grm. of this salt gave 1·0675 carbonic acid and 0·4273 water, giving in 100 parts,—

	I.	II.
Carbon	62·04	62·43
Hydrogen	10·22	10·18
Oxygen and silver . .	27·74	27·39
	100·00	100·00

I. 0·6566 grm. of this salt gave 0·1413 grm. of silver.

II. 0·6508 grm. of this salt gave 0·1388 grm. of silver.

III. 0·6147 grm. of this salt gave 0·1292 grm. of silver.

IV. 0·6641 grm. of another preparation gave 0·1396 grm. of silver.

V. 0·665 grm. of the same preparation gave 0·1396 grm. of silver.

These determinations correspond in 100 parts to—

	I.	II.	III.	IV.	V.
Silver	21·52	21·33	21·02	21·02	20·99

The above analyses agree with the formula $C_{54}H_{53}O_3$, AgO.

	Atomic weight.	Calculated in 100 parts.
C_{54} . . .	324·0	62·66
H_{53} . . .	53·0	10·25
O_4 . . .	32·0	6·19
Ag . . .	108·1	20·90
	517·1	100·00

Cerotic Ether.

The combination of this acid with the oxide of ethyle is readily obtained by dissolving the acid in absolute alcohol, and passing hydrochloric acid gas through the solution. This substance has the appearance of a soft wax, and melts at 59°–60° C.

I. 0·2628 grm. gave 0·765 carbonic acid and 0·3094 water.

II. 0·2638 grm. gave 0·7695 carbonic acid and 0·3105 water, giving in 100 parts,—

	I.	II.
Carbon	79·38	79·55
Hydrogen . . .	13·08	13·08
Oxygen	7·54	7·37
	100·00	100·00

To obtain these numbers the action must be long continued. They correspond to the formula of the ether, $C_{58}H_{58}O_4 = C_{54}H_{53}O_3 + C_4H_5O$.

	Atomic weight.	Calculated in 100 parts.
C_{58}	348	79·45
H_{58}	58	13·24
O_4	32	7·31
	438	100·00

Chlor-Cerotic Acid.

Cerotic acid is readily acted on by chlorine if melted in that gas. Hydrochloric acid is formed, and a substitution of chlorine for hydrogen in the substance takes place. The following substance was made by passing a current of chlorine over the acid, melted in a small flask in a water-bath. The action must be continued for several days. I considered the action as terminated when no more vapour of hydrochloric acid could be perceived. The substance had now undergone a remarkable transformation in appearance, a transformation similar to which may be effected in all the wax substances with which I have experimented.

It was perfectly transparent, slightly yellow, and of the consistency of a very thick gum, more than viscid, and yet capable of being drawn out in threads.

I. 0·382 grm. of this substance gave 0·5581 carbonic acid and 0·1752 water.

II. 0·401 grm. of this substance gave 0·5848 carbonic acid and 0·184 water.

These analyses give in 100 parts—

Carbon	39·82	39·77
Hydrogen	5·10	5·09
Chlorine and oxygen	55·08	55·14
	100·00	100·00

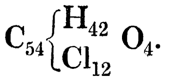
I. 0·486 grm. by the usual method of analysis gave 1·012 grm. chloride of silver, containing 0·249 chlorine.

II. 0·6715 grm. by the usual method of analysis gave 1·3915 grm. chloride of silver, containing 0·344 chlorine.

These analyses give as the per-centage of chlorine—

	I.	II.
Chlorine	51·40	51·28.

These analyses lead us to the formula



$$C_{54}\begin{cases}H_{42}\\Cl_{12}\end{cases}O_4.$$

	Calculated in 100 parts.
C_{54}	39·45
H_{42}	5·10
Cl_{12}	51·50
O_4	3·95
	100·00

Chlor-Cerotic Ether.

This last substance has the properties of an acid, and gives with soda a salt almost insoluble in water. I prepared this salt but did not analyse it, as the substance was lost in attempting to dry it on a water-bath, in which case it is decomposed. The compound ether, however, of the acid may be obtained in a similar way to that in which is obtained the compound ether of the cerotic acid itself. The numbers which this ether gave to analysis, taken with those of the chlor-cerotic acid, and of the cerotic acid, are conclusive as to the formulæ of these bodies. The appearance of this ether is similar to that of the acid from which it is derived.

0·454 grm. gave 0·6815 carbonic acid and 0·214 water,
which analysis gives in 100 parts—

Carbon.	40·94
Hydrogen.	5·24
Oxygen and chlorine . . .	53·82
	100·00

0·650 grm. of the substance gave 1·332 grm. of chloride of silver, which contains 0·3294 grm. of chlorine, and corresponds to chlorine 50·68 parts per cent.

The formula of the ether $C_{58}\left\{\begin{matrix}H_{46}\\Cl_{12}\end{matrix}\right. O_4$ requires in 100 parts—

	Calculated.
C_{58}.	41·11
H_{46}	5·40
Cl_{12}	49·99
O_4	3·50
	100·00

which agree remarkably with the numbers found; it being remembered that the body cannot be crystallized or indeed in any way purified.

Distillation of Cerotic Acid.

Cerotic acid is volatile. If the acid as separated from the lead salt by acetic acid be distilled, the acid separated from the distillate and purified by boiling with potash and washing the baryta salt with ether, it will again be procured with a melting-point nearly corresponding to that of the original acid.

0·251 grm. of this substance gave 0·7254 carbonic acid and 0·2977 water,
giving in 100 parts—

Carbon.	78·80
Hydrogen.	13·19
Oxygen	8·01
	100·00

being precisely the same numbers as the substance gave before distillation.

A question suggests itself, If it be true that this acid is volatile, and it be also true that it exists in the wax in an uncombined state, how has it happened that it has never been discovered among the products of the distillation of wax which have been so often examined?

In truth, it is a remarkable fact, that while this acid, when heated in a nearly pure state, as separated from the lead salt, distils over nearly unaltered, the same substance, when distilled in an impure state, as separated, namely, by alcohol from the wax, and mixed, as in this case, with other wax matter, which is decomposed by heat, itself suffers decomposition. In the course of this investigation other examples have occurred to me of similar facts.

About 3 oz. of the cerin, melting at 70° C., from which this acid can be precipitated by acetate of lead, was distilled. The first portions of the distillate consisted entirely of oil. Towards the end a small quantity of solid matter appeared. The oil, on standing, separated into two portions: the lower part was withdrawn by a pipette, being but a small portion, say one-twentieth of the whole. The upper portion was boiled with potash, only a very small portion of acid however was separated in this manner. The soap was drawn off by a syphon, and the oil washed out with water. On being washed with strong alcohol the oil dissolved, almost entirely, leaving only a small portion of solid matter of the appearance of paraffin. This oil consists of a mixture of oils of different boiling-points, which were separated as far as possible by rectification, but during the distillation the boiling-point kept constantly rising, and I could obtain no oil in which it was absolutely constant.

Three of these oils, of the respective boiling-points of 210° to 220° C., 230° to 250° C., and 250° to 274° C., were analysed. By far the greater portion of this whole distillate went over between 230° and 250° C. The results of these analyses were—

In the case of the first oil,

(1). 0·2676 grm. gave 0·826 carbonic acid and 0·3307 water.

In the case of the second oil,

(2). 0·2629 grm. gave 0·8127 carbonic acid and 0·3325 water.

In the case of the third oil,

(3). 0·2697 grm. gave 0·8443 carbonic acid and 0·341 water,

giving in 100 parts—

	I.	II.	III.
Carbon	84·17	84·30	85·37
Hydrogen . . .	13·73	14·05	14·05
Oxygen	2·10	1·65	0·58
	100·00	100·00	100·00

The amount of oxygen therefore diminishes as the boiling-point rises in these oils, the last oil being nearly pure hydrocarbon. It is useless to reckon out formulæ for them: I give however the analyses to point out the source of the oils in the wax distillate, and to account for the disappearance of the cerotic acid in that product.

The products of this distillation prove also that we must look to some other body than the cerin for the source of the margaric acid, or the acid resembling that substance which has been found in the wax distillate, and for the origin also of the paraffin, of which only traces can be found even on the distillation of the impure cerin.

The existence of a free acid in wax is a fact to which we have no parallel in the constitution of any known fat, and although the reactions, which I have given, left little doubt upon my mind that in the wax the acid was in this condition, it yet appeared to me desirable to procure it from the wax by simple crystallization. By patience this may be accomplished. The cerin analysed by M. Lewy melted at 62°·5 C. I have stated that by means of alcohol this substance may be procured o a melting-point of 72°. If this substance of 72° melting-point be repeatedly dissolved and crystallized out of a large quantity, not of alcohol, but of ether, the melting-point can be raised to 78°, in which state the substance is highly crystalline, and has all the appearance of the acid as procured by other means.

0·25625 grm. of this gave 0·7435 CO_2 and 0·3005 HO,

which gives in 100 parts—

Carbon	79·13
Hydrogen . . .	13·20
Oxygen	7·67
	100·00

Both the melting-point and the analysis perfectly agree with the melting-point and analysis of cerotic acid, which have been already given, and with its formula.

It is certainly a strange fact that the presence of this body in the wax should so long have escaped the notice of chemists. The wax however is a complex substance, and the cerotic acid to be obtained in purity has to be separated from many other bodies which disguise its nature and reactions.

Should any chemist be induced to verify the results which I have given, I must beg him also rigidly to observe the methods I have laid down for the preparation and purification of the substances, for errors which are slight in the analysis of the substance and which neither the analysis nor melting-point detect, become of great importance when the transformations of the substance are investigated, and its atomic weight is to be determined.

The alcoholic extract, out of which the cerotic acid has crystallized, contains, although in very small quantities, yet another acid. If to the solution an alcoholic solution of acetate of lead be added, a precipitate of a lead salt is produced: this salt is readily distinguished from the salt of the cerotic acid as it is dissolved on boiling the alcoholic solution, out of which, on cooling, it will separate in crystalline grains. This substance is contained in very small quantity in the wax. It resembles in appearance margaric acid. I have analysed this acid and one of its salts. These experiments showed that it approached margaric acid in its constitution: but I have never been able to procure the quantity necessary to its sufficient purification, and the analyses led to no conclusions as to its formula which deserve to be recorded.

It is a matter of interest to know in what proportions, relative to its other constituents, the cerotic acid is contained in the wax. This may readily be determined by precipitating by acetate of lead the solution of a known quantity of wax and determining the quantity of the lead salt produced. It is necessary however, in order to know to what quantity of acid in the wax the found quantity of lead salt corresponds, to know the atomic weight of the lead salt itself. There is great difficulty in washing out this lead salt so as perfectly to remove from it the myricin. In order therefore to effect any satisfactory purification of it, I was obliged to operate on a smaller quantity of the salt than I should otherwise have chosen. My experiment, however, was sufficient to show that the salt is the neutral salt containing one equivalent of lead.

0·1445 grm. of the lead salt gave when ignited 0·032 grm. of solid residue. This residue, extracted with acetic acid and dried, left 0·0065 grm. of residue, and lost 0·0255 grm., which, reckoned as oxide, contains 0·0236 grm. lead. This gives 0·0296 as the whole quantity of lead in the salt. Reduced to parts per cent. this gives 20·48 as the per-centage of lead. The formula $C_{54} H_{53} O_3 + PbO$ requires 20·26 per cent.; this therefore is the formula of the salt.

To determine the proportion of the acid in the wax itself, a portion of pure yellow wax was dissolved in ether and filtered from adhering impurities, then dissolved in naphtha-ether and precipitated by acetate of lead dissolved in alcohol; an additional portion of ether was afterwards added to ensure the entire precipitation of the salt, the solution was filtered hot, and the lead salt was carefully washed out on the filter.

1·0905 grm. of wax treated in this manner gave 0·3015 grm. of the lead salt, which, assuming it to be the neutral salt, is equivalent to 0·24 grm. of the acid $C_{54} H_{54} O_4$. This reduced to parts per cent. gives 22·0 of the cerotic acid in every 100 parts of bees'-wax.

Although this was the proportion of cerotic acid in the bees'-wax I had prepared, it by no means followed that other specimens of wax when examined would give a similar result. Various chemists have stated that the proportions of the cerin varied in different specimens of wax; and although the estimate of the cerin was a mere matter of guess, no criterion of its presence or absence being known, yet nevertheless the great difference in the results of the different chemists who have attempted to determine this point led me to suspect that the quantity of the cerotic acid in the wax did in truth vary; and that it might be possible, if so, to find a wax which even did not contain this body. I have found this acid in all the bees'-wax made in this part of the world, bleached or otherwise, which I have examined*. It occurred to me

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* I should except a wax made by wild bees in Wiltshire, which I tested with acetate of lead for this acid, but could find none. The quantity of the wax however was so small that I was unable to make many experiments with it.

however that wax made under very different conditions of climate and vegetation to ours might possibly have a different constitution. With this view I procured, through the kindness of a friend who was resident in Ceylon, some bees'-wax from that island. The wax as I received it was white, having in all respects the appearance of English wax, and melting at 63° C. In other points also, as I shall show in another paper, its chemical nature was the same as that of English wax. The cerótic acid however was entirely absent. When extracted in the boiling alcohol a portion of the wax dissolves; but on the addition of acetate of lead to the alcoholic solution hardly a trace of precipitate is formed.

Such a variation in the nature of an insect-secretion under different conditions of life is a remarkable fact, which we may place by the side of the curious difference in the nature of the constituents of butter in different years, discovered by Lerch. In his excellent investigation on the nature of the volatile acids of butter, this chemist discovered* that the butyric and caproic acids of one year were in another year replaced by vaccinic acid, an acid from which, by deoxidation, the two former acids might readily be formed.

$$\overbrace{C_{20}H_{20}O_7}^{\text{Vaccinic acid.}}=\overbrace{C_8H_8O_4}^{\text{Butyric acid.}}+\overbrace{C_{12}H_{12}O_4}^{\text{Caproic acid.}}-O.$$

The cerotic acid, $C_{54}H_{54}O_4$, although far removed in the series of fatty acids from these volatile acids of butter, yet nevertheless belongs to the same chemical series of bodies, to that series, namely, which contain carbon and hydrogen in equal equivalent proportions, and which, theoretically at least, are capable of being produced by deoxidation from sugar or from starch.

Any fact is of importance which can throw light upon the law by which these substances are truly convertible, one into the other, and it would be highly interesting to investigate, in those waxes where the cerotic acid is not found, by what bodies, if any, it can be replaced.

13 *Albert Road, Regent's Park,*
February 28*th*, 1848.

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* Annalen d. Ch. und Pharm. vol. xlix. p. 230.