

XCII.—*Nitrocamphor and its Derivatives.* V. *sesqui-Camphorylhydroxylamine, a Product of the Spontaneous Decomposition of Nitrocamphor.* VI. *Camphoryloxime-anhydride.* VII. β -*Bromo- α' -nitrocamphor.* β - and π -*Bromocamphoryloximes.**

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V. *sesqui*CAMPHORYLHYDROXYLAMINE.

In the year 1898, a quantity of nitrocamphor was prepared by reducing α -bromo- α' -nitrocamphor with an alcoholic solution of potassium hydroxide in the manner described in a previous paper (Trans., 1898, 73, 995). On acidifying the alkaline solution, the nitrocamphor separated as an oil which slowly deposited crystals; these were washed with water and alcohol, once recrystallised from alcohol, and stored in a stoppered bottle. A few months ago, Dr. Lapworth drew my attention to the fact that a small sample which I had sent him from this bottle no longer possessed the properties of nitrocamphor, but had in some way undergone a change. As a considerable quantity of material was available and a number of interesting changes had already been investigated (Trans., 1898, 73, 986, 991, and 999; 1899, 75, 211), it appeared desirable to ascertain what products might be formed from this new and unexpected decomposition. Before describing the results of the investigation, it may, however, be pointed out that, like so many other changes, the "spontaneous" decomposition of nitrocamphor is dependent on the presence of impurities. The main stock of material, which was found to have undergone change, was sufficiently purified for all ordinary purposes, but possessed a slight yellow colour and a sweet odour, similar to that of the oil from which it had separated. By crystallising again from alcohol and from benzene, hard, well-formed crystals can be obtained which are quite colourless and odourless. A few crystals which had been purified in this way were unchanged at the end of five years.

In order to ascertain the fate of the nitrocamphor, 20 grams of the changed material and 5 grams of sodium hydroxide were shaken with water and purified ether; a portion of the substance dissolved but a considerable amount of a neutral compound was left which was insoluble in alkali and only sparingly soluble in ether. When 175 grams of the material were treated in this way and the ether allowed to evapor-

* Preliminary notices of the results recorded in the present communication have appeared in the Proceedings, 1903, 19, 129, 156.

ate, 55 grams of the neutral substance were obtained, whilst the alkaline liquors yielded 85 grams of crystalline nitrocamphor and a few grams of a non-crystalline oil similar to the crude nitrocamphor prepared by reducing bromonitrocamphor in the manner already described.

When crystallised twice from alcohol, the decomposition product was obtained as a white, microcrystalline powder which melted at 256° to a brown oil; it dissolved in acetone to the extent of 3.22 grams in 100 c.c. of solution at 13° ; two independent determinations of the specific rotatory power in this solvent gave $[\alpha]_D +33^{\circ}$ at 13° . Its melting point, which is very high when contrasted with that of other camphor compounds, and its slight solubility, indicated that condensation of two or more molecules of nitrocamphor had taken place, and molecular weight determinations in boiling benzene solution, made at my request by Mr. F. G. Smith, proved the correctness of this view. Owing to the limited solubility of the substance, the largest rise in the boiling point was only 0.2° , and exact numbers could not therefore be expected, but the values obtained, $M = 562, 581, 565, 589, 524$, and 528 , mean, 558 , showed clearly that the decomposition product had been formed by the condensation of three molecules of nitrocamphor for which $M = 197$.

The values obtained on combustion suggested that the condensation had been effected by the elimination of two molecules of water from three molecules of nitrocamphor, but nitrogen determinations showed that one of the three atoms of nitrogen had been eliminated (probably by oxidation to camphoric acid), and that the formula of the substance could be deduced from the equation $C_8H_{14} \begin{smallmatrix} \diagup CO \\ \diagdown CO \end{smallmatrix} O + 2C_{10}H_{15}O \cdot NO_2 = C_{30}H_{42}O_8N_2 + H_2O$. The analytical data were as follows:

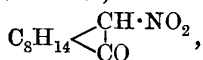
- I. 0.2171 gave 0.5129 CO_2 and 0.1470 H_2O . $C = 64.43$; $H = 7.47$.
- II. 0.2336 „ 0.5537 CO_2 „ 0.1573 H_2O . $C = 64.65$; $H = 7.40$.
- III. 0.1514 „ 0.3585 CO_2 „ 0.0995 H_2O . $C = 64.56$; $H = 7.35$.
 $C_{30}H_{41}O_7N_3$ requires $C = 64.53$; $H = 7.31$ per cent.
 $C_{30}H_{42}O_8N_2$ „ $C = 64.47$; $H = 7.58$ „
- IV. 0.3413 gave 16.0 c.c. moist nitrogen at 15° and 746 mm. $N = 5.28$.
- V. 0.4871 „ 22.2 c.c. „ „ 11° „ 759 mm. $N = 5.43$.
 $C_{30}H_{42}O_8N_2$ requires 5.02 per cent.

To ascertain whether the camphor nucleus had undergone change in any way, experiments were made on the oxidation of the decomposition product. In the first experiment, oxidation was effected by means of concentrated nitric acid (sp. gr. 1.42) diluted with about half its bulk of water. In spite of its high melting point, the substance

readily liquefied in the boiling acid and frothed up into a mass of minute bubbles, a colourless gas being liberated, although not in large quantities. The oxidation product remained liquid until quite cool, but solidified when washed with water and was recrystallised from acetic acid and from alcohol. It had a lower melting point (235°), a lower specific rotatory power ($+22^{\circ}$), and a greater solubility in acetone than the original material, and when recovered from the solution in acetone was burnt under the impression that a definite oxidation had occurred; the analysis, the third of those given above, agreed exceptionally well with those of the original substance, and it was then found that the final crystallisation from acetone had produced an altogether remarkable effect in freeing the substance from the impurities with which it was mixed, and had raised the melting point through 20° to that of the pure substance. This result is perhaps due to the "formation of a compound of camphoric acid with acetone" (Pope, Trans., 1896, 69, 1696) and proved of great service when the synthesis of the substance was attempted. Oxidation with concentrated nitric acid (sp. gr. 1.42) at 100° gave the desired result, and the well-crystallised camphoric acid which separated from the acid solution was identified by its appearance and melting point and also by conversion into the anhydride melting at 215° .

The formula deduced for the decomposition product may be obtained by subtracting one molecule of hydroxylamine from three molecules of nitrocamphor, $3C_{10}H_{15}NO_3 = C_{30}H_{42}N_2O_8 + NH_3O$, and it was therefore thought possible that this base might be present in the changed material. Tests by means of alkaline copper and Nessler solutions gave no indication of the presence of either hydroxylamine or ammonia, and it is therefore possible that the elimination of a nitrogen atom depends on a direct atmospheric oxidation in which elementary nitrogen is produced, and not on a process of hydrolysis.

More important is the fact that the substance has the empirical composition of a camphoric ester of nitrocamphor, for the oxidation experiments show that no profound decomposition has taken place, and the only formulæ that are reasonably possible are those which would represent it as the camphoric ester, either of nitrocamphor,



or of *pseudonitrocamphor*, $C_8H_{14} \begin{array}{l} \diagup C : NO \cdot OH^* \\ \diagdown CO \end{array}$, or of the isomeric cam-

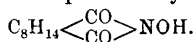
* The formula here employed may be conveniently used to express in a non-controversial manner the three formulæ that have been proposed for the *pseudo*-nitro-compounds, namely, $\begin{array}{c} >C:N \cdot O \cdot OH \\ >C:N \cdot O \cdot OH \end{array}$, and $\begin{array}{c} >C \cdot N \cdot OH \\ >C \cdot N \cdot OH \end{array}$.

phoryloxime, $C_8H_{14} \begin{smallmatrix} \text{C:NOH} \\ \diagup \quad \diagdown \\ \text{CO} \end{smallmatrix} O$.* Of these, the first is very improbable, for derivatives of normal nitrocamphor have only been prepared either by the action of halogens or by indirect methods, and there is no reason to suppose that in this case esterification would lead to the formation of the so-called "carbon ether."

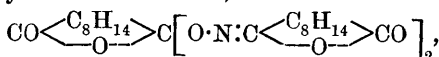
The second formula, although more worthy of consideration, cannot be reconciled with the low rotatory power of the substance, or with its great stability when heated alone or when boiled with alcoholic potash, as compared with the anhydride of *pseudonitrocamphor*, $O \left[NO:C \begin{smallmatrix} \text{C}_8H_{14} \\ \diagup \quad \diagdown \\ \text{CO} \end{smallmatrix} \right]_2$, which very readily yields camphorquinone under these conditions; the ester is also unchanged when heated with concentrated hydrochloric acid. The third formula is rendered very probable, not only by the process of exclusion, but also because on attempting to prepare acyl derivatives of *pseudonitrocamphor*, either by the action of benzoyl chloride on the potassium salt or by heating the nitro-compound with acetic anhydride and sodium acetate, derivatives of the isomeric camphoryloxime are always produced (Trans., 1898, 73, 999).

The constitution of the decomposition product having been thus clearly indicated, an attempt was made to prepare it synthetically by heating 1 gram of the oxime and 0.4 gram of camphoric acid at 170° during 2 or 3 hours; a dark product was obtained which was entirely soluble in alkalis, showing that no ester had been formed. In a second attempt, sulphuric acid was employed as a "condensing agent," and the mixture was heated until bubbles of gas were evolved; the product in this case was readily soluble, not only in alkalis, but also in water, and apparently both the acid and the oxime were converted into sulphocamphoric acid, $C_8H_{14} \begin{smallmatrix} \text{SO}_3H \\ \diagup \quad \diagdown \\ \text{CO}_2H \end{smallmatrix}$, carbon dioxide being eliminated. In a third and successful attempt, made to synthesise the compound by the Schotten-Baumann method from camphoryl chloride and camphoryloxime, the camphoryl chloride from 0.8 gram of camphoric acid was mixed with water and then with 1 gram (=1 mol. or half the theoretical quantity) of the oxime and enough sodium hydroxide to keep the solution alkaline. A solid soon separated, and the mixture was left for 5 days in order to remove the last traces of camphoryl chloride. The product was then drained, crystallised from spirit and from acetone, and found to be identical with the ester from nitrocamphor.

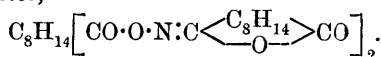
* Camphoryloxime might also be represented by the symmetrical formula



The substance, which is thus shown to be the camphoric ester of camphoryloxime, is a derivative of hydroxylamine in which the whole of the hydrogen is displaced by camphoryl radicles and is precisely analogous to tribenzoylhydroxylamine, $\text{NBz}_2\cdot\text{OBz}$; it is therefore proposed to call it *sesquicamphorylhydroxylamine*. The exact formula of the substance is, however, involved in the old controversy as to whether the derivatives of dibasic acids should be represented by symmetrical or by unsymmetrical formulæ, and it would be possible to adopt either the wholly symmetrical formula, $\text{C}_8\text{H}_{14}\left[\text{CO}\cdot\text{O}\cdot\text{N}\left\langle\begin{smallmatrix}\text{CO} \\ \text{CO}\end{smallmatrix}\right\rangle\text{C}_8\text{H}_{14}\right]_2$, or the wholly unsymmetrical formula,

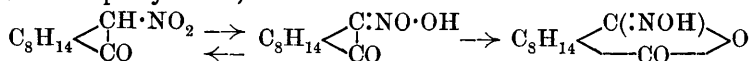


but as the esters of dibasic acids appear to be usually of the symmetrical type, and camphoryloxime is best represented by an unsymmetrical formula, a preference should perhaps be given to the mixed formula for the ester,

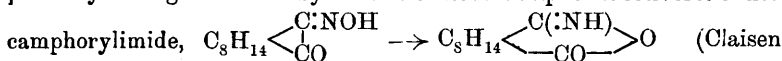


VI. CAMPHORYLOXIME-ANHYDRIDE.

When nitrocamphor is boiled with concentrated hydrochloric acid, the greater part passes into solution and is converted into the isomeric camphoryloxime,



(*Trans.*, 1898, 73, 999), by an isomeric change of the Beckmann type precisely analogous to that by which *isonitrosocamphor* is converted into



and Manasse, *Annalen*, 1893, 274, 73). But as Cazeneuve pointed out in the paper in which the isomeric change was first described (*Bull. Soc. chim.*, 1889, [iii], 1, 417), nearly 10 per cent. of the substance used is converted into a resinous product which is insoluble in water. When preparing the oxime from nitrocamphor with a view to establishing its constitution (*loc. cit.*), a considerable quantity of the insoluble material was accumulated, and this was recently examined in order to ascertain whether it might not be identical with the *sesquicamphorylhydroxylamine* described above.

The crude material dissolved readily in alcohol, and, on cooling, the solution deposited crystals of a sparingly soluble substance, which, when crystallised three times from alcohol, softened at 215° and melted at 220° . Its specific rotatory power was found to be $[\alpha]_D + 26.4^\circ$ at

15° in a solution in acetone containing 2.9 grams in 100 c.c. Analysis showed that this substance had the composition of an anhydride of nitrocamphor:

*0.1630 gave 0.3787 CO₂ and 0.1065 H₂O. C = 63.36; H = 7.31.

C₂₀H₂₈O₅N₂ requires C = 63.79; H = 7.50 per cent.

A nitrogen determination with the once crystallised substance gave a value slightly below the theoretical (found 6.9, calculated 7.46 per cent.). As normal nitrocamphor contains no hydroxyl group and the anhydride of *pseudonitrocamphor* has already been described (*loc. cit.*, p. 996), the compound of which the formation is now recorded must be regarded as the previously unknown anhydride of the camphoryloxime which forms the main product of the action. If the unsymmetrical formula be adopted for the oxime, the anhydride must be written CO<C₈H₁₄>_O:C:N·O·N:C<C₈H₁₄>_OCO. This formula is fully

in accordance with the properties of the substance, which differs from the isomeric anhydride of *pseudonitrocamphor* in that it yields no trace of camphorquinone either when heated alone or when warmed with alcoholic potash, and does not possess the high dextrorotatory power which characterises the derivatives of *pseudonitrocamphor*.

The formation of an anhydride from camphoryloxime takes place much less readily than in the case of nitrocamphor or *isonitrosocamphor* (Forster, this vol., p. 530), and it appeared possible that this anhydride had been formed by isomeric change from the anhydride of *pseudonitrocamphor*, a compound which might conceivably be produced in the initial stages. This isomeric change was, however, found not to take place under the conditions of the action, and the production of the anhydride cannot therefore be explained in this way. Neither can it have been formed by the dehydration of the oxime, for the amount of resin produced is not increased by prolonged heating of the strongly acid solution, and, moreover, no resin whatever is produced when the pure oxime is heated with concentrated hydrochloric acid. The production of the anhydride must therefore be ascribed to the condensation of some intermediate product of change, such, for instance, as the little understood hydrochloride described by Cazeneuve (*ibid.*, p. 243), unless, perchance, the violence of the action in its initial stages is capable of bringing about a condensation of camphoryloxime which does not take place under more usual conditions.

The analogy between camphoryloxime, C₈H₁₄<C(:NOH)>_{CO}O, and

- * This analysis was carried out with the help of the potash absorption apparatus recently described by Wetzel (*Ber.*, 1903, **36**, 162); the analysis was made exceedingly rapidly, and the combustion, in both air and oxygen, was completed within 25 minutes, a further time being allowed for displacing the oxygen by air.

isonitrosocamphor, $C_8H_{14} \begin{smallmatrix} \diagup & C:NOH \\ & | \\ & CO \end{smallmatrix}$, is perhaps more apparent than

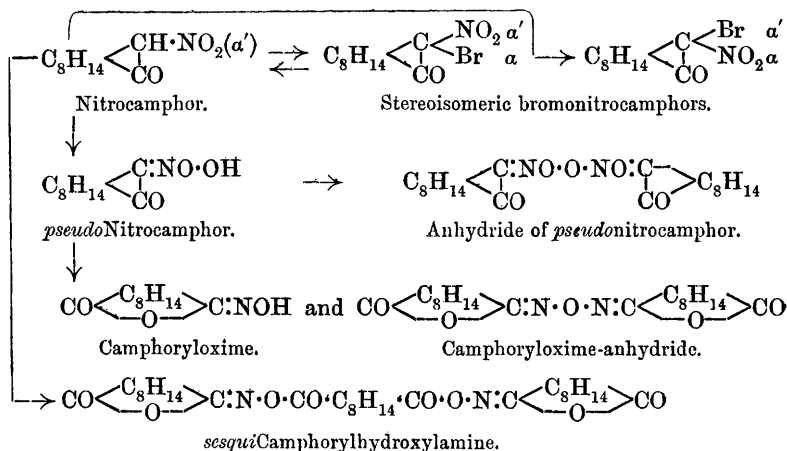
real, for the introduction or removal of the acidic oxygen atom entirely alters the chemical properties of the substance. It appeared, however, to be desirable to ascertain whether some of the many methods used by Forster for preparing the anhydride of *isonitrosocamphor* could be successfully applied to camphoryloxime. The method recommended by Forster as being the best for the purpose consists in boiling the benzoyl derivative and the potassium salt of the oxime together in a neutral solvent such as benzene; accordingly 5 grams of benzoylcamphorylhydroxylamine were dissolved in benzene and boiled during 12 hours with a slight excess of the potassium salt of camphoryloxime; on filtering the solution, the benzoyl derivative was recovered unchanged and no formation of anhydride had taken place. An attempt was also made to prepare the anhydride by shaking an aqueous solution of the sodium salt with a mixture of ether and acetic anhydride, but this also gave a negative result, the oxime being converted quantitatively into the acetyl derivative.

Another unsuccessful attempt was made to prepare the anhydride by the action of 1 mol. of phosphorus pentachloride on 2 mols. of the potassium salt of the oxime, as in the preparation of acetic anhydride; interaction took place, and the mixture became very viscid, but on diluting with water nearly the whole of the material dissolved, leaving behind only a small, flocculent precipitate, the amount of which was insufficient to allow of its being identified with the anhydride.

The successful preparation of the anhydride of the oxime was accomplished by an altogether unexpected method. In the course of the investigation of the constitution of camphoryloxime ("camphonitrophenol"), which has already been mentioned, an attempt was made to brominate the compound. The oxime (10 grams) was dissolved in an excess of potassium carbonate and bromine was added until it gave a permanent coloration; a white compound was precipitated which separated from alcohol in a viscous condition and was therefore redissolved and poured into water. Shortly afterwards, a clue was obtained as to the real nature of the oxime and the bromination product was put aside, and was not further examined until quite recently. It was then found that the crude material contained very little bromine, and separated as a crystalline deposit on allowing an alcoholic solution to evaporate. The separated solid was recrystallised three times from alcohol and was found to be identical with the anhydride obtained as a bye-product in the preparation of the oxime. The substance prepared by bromination melted in exactly the same manner as the latter, sintering over about 5° and melting indefinitely

with partial decomposition to a light brown liquid; when the two specimens were heated together, the bromination product melted about 3° higher than the other, but the specific rotatory powers of the two preparations agreed exceedingly closely, the bromination product giving $[\alpha]_D + 26.7^\circ$ at 14° in a solution in acetone containing 2 grams in 100 c.c., whilst the value given above for the bye-product from the preparation of the oxime is $[\alpha]_D + 26.4^\circ$.

The compound now described is of interest as affording yet another illustration of the extraordinary fertility of nitrocamphor in yielding new substances, often of unknown types, and undergoing changes for which no precedents are available. The most important of these changes are summarised in the scheme given below, but it may be added that the anhydride only forms about 10 per cent. of the resinous bye-product, or 1 per cent. of the weight of nitrocamphor used, and it is at least possible that the remaining 9 per cent. which is unaccounted for, may be found to yield other new derivatives.



VII. β -BROMO- α' -NITROCAMPHOR, β - AND π -BROMOCAMPHORYLOXIMES.

The results which have followed from the investigation of nitrocamphor, and especially the discovery of the method of studying dynamic isomerism by means of the mutarotation of freshly prepared solutions, have lent a great interest to all those optically active substances in which similar phenomena are likely to be observed. The method, introduced for the first time in the case of nitrocamphor, is easier to carry out, and is of wider applicability than any of the methods which are available for the study of optically inactive com-

pounds, and by its help it is possible to detect with certainty cases of isomeric change in which the velocity of change is so great that equilibrium is reached within a few minutes, or in which the extent of the change is so small that the presence of an isomeride could scarcely be detected by any other method. The camphor nucleus lends itself in a remarkable way to the production of substances representing nearly every type of dynamic isomerism, and with its help the method has already been successfully applied, not only to the study of the isomerism of the nitro-compounds, but also to that of the hydrazones and azo-compounds (Lapworth and Hann, *Trans.*, 1902, 81, 1508), the diketones (Forster, *Trans.*, 1901, 79, 987), and the oximes (Forster, this vol., p. 514), whilst Lapworth and Hann (*Trans.*, 1902, 81, 1491, 1499) have recently investigated the optically active analogues of ethyl acetoacetate and ethyl formylphenylacetate.

The isomerism of the nitro-derivatives of camphor has already been somewhat fully studied, but in view of the great advance which resulted from the extension of the investigation of nitrocampfor to that of its π -bromo-derivative, and the still greater differences which were observed between nitrocampfor, $C_8H_{14} \begin{smallmatrix} \text{CH} \cdot \text{NO}_2 \\ | \\ \text{CO} \end{smallmatrix}$, and nitrocamphe,

$C_8H_{14} \begin{smallmatrix} \text{CH}_2 \\ | \\ \text{CH} \cdot \text{NO}_2 \end{smallmatrix}$ (Forster, *Trans.*, 1900, 77, 251)—compounds which scarcely differ except in the replacement of the CO by the CH_2 group, and yet are altogether different in chemical behaviour and in the character of the equilibrium between the normal and pseudo-forms—it appeared to be very desirable to continue the investigation, and to prepare, if possible, the β -bromo-derivative of nitrocampfor.

$\alpha\beta$ -Dibromo- α' -nitrocampfor, $C_8H_{13}Br \begin{smallmatrix} \text{CBr} \cdot \text{NO}_2 \\ | \\ \text{CO} \end{smallmatrix}$, was prepared many years ago by Kachler and Spitzer (*Monatsh.*, 1882, 3, 218; 1883, 4, 566) by boiling $\alpha\beta$ -dibromocampfor, $C_8H_{13}Br \begin{smallmatrix} \text{CHBr} \\ | \\ \text{CO} \end{smallmatrix}$, with concentrated nitric acid, but for more than twenty years nothing further was done with the β -derivatives of camphor until new methods of preparation led to the discovery of the parent substance, $C_8H_{13}Br \begin{smallmatrix} \text{CH}_2 \\ | \\ \text{CO} \end{smallmatrix}$ (Armstrong and Lowry, *Trans.*, 1902, 81, 1464; Forster, *ibid.*, p. 264), and to the determination of its constitution. Unlike the π -bromo-compounds, the β -bromo-derivatives of camphor are very sensitive to the action of hydrolysing and reducing agents, so much so that the whole of the β -bromine can be eliminated by the action of alcoholic potash (Kachler and Spitzer, *loc. cit.*; Forster, *loc. cit.*, p. 270), and a considerable proportion is liberated when the substances are

oxidised with nitric acid (Armstrong and Lowry, *loc. cit.*, p. 1467). In attempting to reduce the dibromonitro-compound, it was therefore necessary to proceed very cautiously, and it was a matter of satisfaction when it was found that, by using the theoretical quantity of alcoholic potash or sodium ethoxide, the reduction could be readily effected, and gave a solid product as in the case of the isomeric π -bromonitrocamphor.

As might perhaps have been anticipated, β -bromonitrocamphor differs widely from nitrocamphor, but closely resembles the π -bromo-derivative. Thus the pseudo, not the normal, form separates from solution on slow crystallisation, whereas mixtures of the two forms are produced by rapid crystallisation; it has not been found possible, as yet, to isolate the normal form either by rapid evaporation of the solution and mechanical separation of the crystals, as in the case of π -bromonitrocamphor, or by making use of hydroxylic solvents, as in the case of the oximes described by Dr. Whiteley (this vol., p. 34). Again, the 'equilibrium temperature' (Trans., 1899, 75, 233) at which the solid pseudo-form is in stable equilibrium with the liquid mixture can be readily observed, as in the case of the π -bromo-compound, by fusing the substance, allowing it to crystallise by cooling, and noting the temperature at which the solid melts when again heated; nitrocamphor, as has already been pointed out (*loc. cit.*, p. 233), does not crystallise when cooled after fusion. Other points of resemblance will be noted later, and it is quite possible that the interesting results which have accrued from the study of β -bromonitrocamphor might have followed with equal readiness from π -bromonitrocamphor if there had been the same motive for resuming the study of this substance as there was for investigating its unknown β -isomeride.

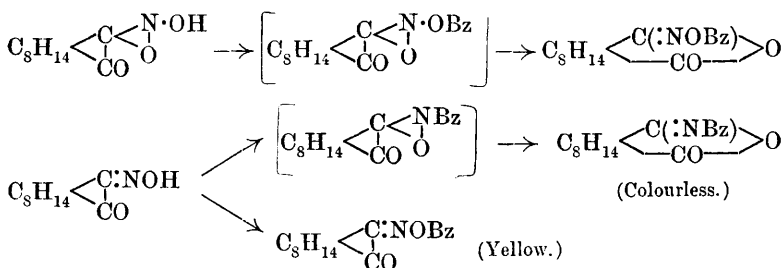
The remarkable isomeric change which nitrocamphor undergoes when heated with concentrated hydrochloric acid (Cazeneuve, *Bull. Soc. chim.*, 1889, [iii], 1, 417) and when benzoylated or acetylated (Trans., 1898, 73, 999) has already been shown to be a normal Beckmann change, the product being identified as an oxime of camphoric anhydride. A similar change has been observed by Lapworth and Kipping (Trans., 1896, 69, 318) in the case of π -bromonitrocamphor, although at the time the nature of the change was not understood; as the necessary material was available, and it was desirable to prepare the acetate and benzoate of Lapworth's compound for comparison with the isomeric β -compounds, the oxime of π -bromocamphoric anhydride was prepared synthetically, as well as from π -bromonitrocamphor, and its constitution was further established by hydrolysing it to hydroxylamine and π -bromocamphoric acid. β -Bromonitrocamphor undergoes a similar isomeric change, although

less readily than nitrocamphor; this difference might be explained as being due to the higher melting point of the substance, but it is more likely that the bromine atom has a definite action in retarding the isomeric change. This view receives support from the fact that whilst nitrocamphor can be acetylated or benzoylated without difficulty, yielding the acetyl or benzoyl derivative of camphoryloxime, Lapworth and Kipping have shown (*ibid.*, p. 314) that π -bromopseudonitrocamphor can be boiled with acetyl chloride or acetic anhydride without undergoing change, and it has also been found that β -bromopseudonitrocamphor yields no trace of a benzoyl derivative when an aqueous solution of its potassium salt is shaken with benzoyl chloride. A further illustration of the inhibiting effect of the bromine atom on the general reactivity of the compound is afforded by the impossibility of preparing an anhydride from β - or π -bromonitrocamphor, although nitrocamphor and isonitrosocamphor readily yield such compounds.

Mention must also be made of the important influence exercised by the ketonic group in this series of compounds. This will be brought out most clearly if a comparison be made between nitrocamphor and its bromo-derivatives on the one hand, and nitrocamphane on the other. The effect on the equilibrium between the normal and pseudo-forms is very striking, for whereas in the absence of a keto-group, pseudonitrocamphane is a labile compound and passes completely into the normal form in the course of a few hours, normal nitrocamphor undergoes in solution a partial isomeric change in the reverse direction, and in the β - and π -bromo-derivatives the effect of the keto-group is so far reinforced by the bromine atom that the pseudo-form is actually the one that is stable in contact with the solution. The keto-group also appears to be directly concerned in the isomeric change to camphoryloxime, for in the absence of this group the potassium salt of pseudonitrocamphane can be completely benzoylated without passing into the oxime. The suggestion (*Trans.*, 1898, 73, 1000) that in this case the pseudo, not the normal, form is that which undergoes change, receives support from the fact that normal nitrocamphane, which has no tendency to pass into the pseudo-form, can be dissolved in concentrated sulphuric acid, and reprecipitated unchanged by diluting with water.

The work on nitrocamphor and its derivatives acquires additional interest from the many opportunities that occur of comparing and contrasting their behaviour with that of the analogous isonitroso-compounds which are being investigated by Forster. The chief results of the comparison may be briefly stated as follows: (1) The production of two benzoyl derivatives from isonitrosocamphor places it in an intermediate position between pseudonitrocamphor, which undergoes complete isomeric change, and pseudonitrocamphane, which is

unchanged when benzoylated; the resemblance is most obvious if the formation of Forster's colourless benzoate is regarded as a sequel to the benzoylation of the *isooxime* thus:



(2) The comparison also raises the question as to the formulæ to be assigned to the *pseudonitro*-compounds, for if these be written as $>\text{C}:\text{N} \begin{array}{c} \text{O} \\ \parallel \\ \text{OH} \end{array}$ the *isooximes* ought also to be formulated as $>\text{C}:\text{NH}:\text{O}$, but if the *isooximes* be represented in the usual way, $>\text{C} \begin{array}{c} \text{NH} \\ \diagdown \\ \text{O} \end{array}$, then the *pseudonitro*-compounds should also be indicated by $>\text{C} \begin{array}{c} \text{N} \cdot \text{OH} \\ \diagdown \\ \text{O} \end{array}$.

(3) The question is also raised as to whether it is the normal or the pseudo-form of the oxime that undergoes the Beckmann isomeric change; the view usually taken is that the normal form is that which is directly concerned, but the alternative view is at least entitled to careful consideration. (4) Finally, it will be of interest to know whether the analogy can be extended to the mutarotatory form of *isonitroso*-camphor (Forster, this vol., 518) by regarding the two modifications as the normal and pseudo-forms of the oxime rather than as stereo-isomerides.

*β-Bromonitrocampa*h*or*.—Five grams of well-crystallised dibromonitro-camphor were dissolved in 50 grams of absolute alcohol and the theoretical quantity of potassium hydroxide was added in concentrated aqueous solution; the mixture was boiled during 2 or 3 minutes until potassium bromide separated, and was then poured into water. On the next day, a small amount of solid, afterwards found to be tribromocamphor, had separated, and, after extracting the alkaline solution with ether in order to remove a small amount of oily impurity, the nitro-compound was precipitated by hydrochloric acid, left for a day to separate completely, and then drained and crystallised from spirit. In the later experiments, the reduction was effected in absolute alcoholic solution by means of the calculated quantity of sodium ethoxide, but even when all possible precautions were taken a considerable loss of

material occurred; the yield of *crystalline* dibromonitrocampor obtained after brominating β -bromocampor, boiling with nitric acid, and crystallising the product of nitration from acetic acid is about 45 per cent. of the weight of bromocampor used, and the yield of bromonitrocampor is about one-third of the weight of dibromonitrocampor employed in the reduction. β -Bromonitrocampor, prepared in this way, was obtained as a crystalline powder, which was found to consist of a mixture of the normal and pseudo-forms, $C_8H_{13}Br \begin{smallmatrix} < \\ \text{CH} \cdot \text{NO}_2 \\ \text{CO} \end{smallmatrix}$

and $C_8H_{13}Br \begin{smallmatrix} < \\ \text{C} \cdot \text{NO} \cdot \text{OH} \\ \text{CO} \end{smallmatrix}$; it softened at 100° and melted indefinitely at about 114° , but when allowed to crystallise after fusion it remelted sharply at 100° ; this is, therefore, the 'equilibrium temperature' at which the solid pseudo-form is in stable equilibrium with the liquid mixture; the crystalline powder obtained by rapid crystallisation contained a slightly larger proportion of the pseudo-form than that which is normally present in the solution, and freshly-prepared solutions exhibited mutarotation.

0.2326 gave 0.1617 AgBr. Br = 29.6 (calc. 29.0 per cent.).

The *pseudo*-form was obtained in a pure state by slow evaporation of a solution of the nitro-compound in benzene or ethyl acetate; it melted at 132° , but decomposed slightly at this temperature, and remelted at or below 96° , according to the length of time during which it had been heated; the extent to which the decomposition had proceeded could be gauged by the increase in the intensity of the yellow colour of the material, which probably decomposes into β -bromocamporquinone. Attempts were made to isolate the *normal* form by crystallising from hydroxylic solvents, but these were not successful, for a solution in methyl alcohol yielded a mixture of the two forms on slow evaporation, and a solution in formic acid apparently gave rise to the isomeric oxime, for on diluting with water, after an interval of two or three weeks during which no crystallisation had taken place, the greater part of the material remained in solution, and the small amount which separated was entirely different in its properties from the original bromonitrocampor. A solution in acetic acid gave the pure pseudo-form on slow crystallisation.

The *potassium* salt, $C_{10}H_{14}NO_3K \cdot 2H_2O$, of the pseudo-form separated from water in glistening needles. The specific rotatory power of an aqueous solution containing 0.7043 gram of the dry potassium salt in 15 c.c. of solution was found to be $[\alpha]_D + 91^\circ$ at 12° ; or if the specific rotatory power be reckoned on the β -bromonitrocampor contained in the salt, the value for the *pseudonitro*-compound in this form would be $[\alpha]_D + 103^\circ$.

0.8010 lost 0.0791 moisture.

$H_2O = 11.0$ (on dry salt); calculated, 11.42 per cent.

An attempt to prepare the benzoate of β -bromopseudonitrocampfor by the Schotten-Baumann method gave only a negative result; the benzoyl chloride passed gradually into the solution, leaving no trace of an insoluble benzoyl derivative. Similarly, it was not found possible to prepare an anhydride of the pseudo-form by heating above the melting point. In both these respects, β -bromonitrocampfor differs from nitrocampfor, but behaves in the same way as the isomeric π -bromo-compound.

β -Bromocampfor-oxime, $C_8H_{13}Br \left\langle \begin{array}{c} C(:NOH) \\ \diagup \quad \diagdown \\ CO \end{array} \right\rangle O$, was prepared by heating β -bromonitrocampfor with concentrated hydrochloric acid in a water-bath during half an hour; nearly the whole of the substance passed into solution and was separated by filtration from a little resin which was formed as a bye-product (compare p. 957); on diluting the filtrate with water, the oxime, which is readily soluble in strong hydrochloric acid, but very sparingly so in water, was precipitated in minute needles which were drained and washed with a little cold water. Like campfor-oxime and the π -bromo-compound, β -bromocampfor-oxime crystallises from water with $1H_2O$:

0.9872 lost 0.0629 moisture.

$H_2O = 6.81$ (on dry substance); calculated, 6.50 per cent.

The hydrate melts at 111° with liberation of steam. The dry substance was dissolved in benzene, in which it is only sparingly soluble even on boiling, and crystallised, on cooling, in bright, glistening needles which melted at 112° ; a solution in chloroform saturated at 13° contained 2.20 grams in 100 c.c. of solution and gave $[\alpha]_D + 10.2^\circ$. In order to prepare the *acetyl* derivative, the oxime was boiled with acetic anhydride, and the solution diluted with alcohol and then with water; the acetate separated as an oil, but crystallised when stirred: the substance was then redissolved in the same liquor, filtered, allowed to crystallise, and then recrystallised from slightly dilute alcohol, from which it separated in very light, minute flakes, which melted at 112° , did not recrystallise when cooled after fusion, and gave $[\alpha]_D + 3^\circ$ at 15° in a solution in acetone containing 2.36 grams in 100 c.c.

0.1746 gave 0.1030 AgBr. $Br = 25.21$.

$C_{12}H_{16}O_4NBr$ requires 25.16 per cent.

The *benzoyl* derivative, prepared by the Schotten-Baumann method, is only moderately soluble in hot alcohol, and crystallises in needles as the solution cools; it melts at 134° and gave $[\alpha]_D + 11^\circ$ at 12° in a solution in acetone containing 1.57 grams in 100 c.c.

0.2096 gave 0.1041 AgBr. Br = 21.12.

$C_{17}H_{18}O_4NBr$ requires 21.05 per cent.

π-Bromocamphoryloxime.—In order to establish definitely the constitution of Lapworth's "*iso-π-bromonitrocamphor*" (Trans., 1896, 69, 318), the substance was hydrolysed by heating in a sealed tube with concentrated hydrochloric acid; the aqueous solution gave the usual tests for hydroxylamine, but the solid was too much charred to allow of its identification as *π-bromocamphoric acid*. As, however, a quantity of *π-bromocamphoric acid* had been obtained as a bye-product in the preparation of *π-bromonitrocamphor*, and it was desired to prepare the acetyl and benzoyl derivatives of the oxime for comparison with those of the *β-bromo-oxime*, the acid was converted into its anhydride and treated with hydroxylamine in the manner previously employed in the synthesis of camphoryloxime (Trans., 1898, 73, 1005); the synthetical oxime, its hydrate, acetyl and benzoyl derivatives agreed so closely with those of the substance prepared from *π-bromonitrocamphor* that they do not merit separate description. *Acetyl-π-bromocamphoryloxime*, $C_8H_{13}Br\langle\begin{smallmatrix} N:NOAc \\ CO \end{smallmatrix}\rangle O$, was prepared by Lap-

worth by boiling the oxime with acetic anhydride, but its physical constants were not given; it is only sparingly soluble in alcohol, and separates, like the *β-isomeride*, in minute, glistening scales; it melts at 171° (the *β-isomeride* melts at 112°) and gave $[\alpha]_D + 1.3^\circ$ at 13° in a solution in acetone containing 51.4 grams per 100 c.c.

The *benzoyl* derivative, which is much less soluble, about 50 c.c. of boiling alcohol being required to dissolve a gram, crystallises in flat needles united in feathery aggregates and melts at 185°. In a solution in acetone containing 3.4 grams per 100 c.c. it gave $[\alpha]_D + 46.3^\circ$ at 13°.

As the three series of compounds are now complete, a table is given showing the melting points of the more important derivatives of nitrocamphor and camphoric acid.

Parent substance.	Unsubstituted.		π -Bromo-derivative.		β -Bromo-derivative.	
	M. p.	$[\alpha]_D$	M. p.	$[\alpha]_D$	M. p.	$[\alpha]_D$
Camphoric acid, $C_8H_{14}<\overset{CO_2H}{\underset{CO_2H}{C}}>$	187°	+47° (alcohol)	216—217°	+41° (alcohol)	210°	+39° (alcohol)
Camphoric anhydride, $C_8H_{14}<\overset{CO}{\underset{CO}{C}}>O$	216	-1° (chloroform)	155—156	-37° (acetone)	142	-3° (acetone)
Camphoryloxime, $C_8H_{14}<\overset{C:NOH}{\underset{CO}{C}}>O$...	223	+7° (chloroform)	137—138	+53° (chloroform)	112	+10° (chloroform)
" hydrate	70	—	109—112	—	111	—
" acetyl derivative	115	+7° (chloroform)	171	+41° (acetone)	112	+3° (acetone)
" benzoyl derivative	138	+9° (chloroform)	185	+46° (acetone)	134	+11° (acetone)
Nitrocamphor :						
Normal	102	124° (benzene)	108	-51° (benzene)	—	—
Pseudo	—	—	142	+188° (benzene)	132	0° (benzene)
Equilibrium mixture	—	-104° (benzene)	126	-38° (benzene)	100	-80° (benzene)