CCXLVII.—*The Polarimetric Study of Intramolecular Rearrangement in Inactive Substances. Part VII.*

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In some previous papers it has been shown that the rate of change of certain labile forms of inactive compounds into the more stable configuration could be followed by means of the polarimeter, by taking advantage of the different solvent influences of the two isomerides upon an active compound. In this way, by using ethyl tartrate as indicator, a study was made of (1) the rate of change of certain *syn*-oximes into the *anti*-forms, with ethyl tartrate alone and also in the presence of certain inactive solvents (*e.g.*, benzene), and (2) the transformation of the unstable into the stable form of ethyl formylphenylacetate (J., 1907, **91**, 519). It was found that other active esters of tartaric and malic acids could be used in a similar way (*Ber.*, 1907, **40**, 2564), and that the purity of the ethyl tartrate, as indicated by the number of distillations it had undergone,

made a great difference in the velocity of transformation : the purer the ethyl tartrate, the more slowly did the reaction take place. It was also found that the influence of temperature on the velocity of transformation of piperonal*syn*oxime was in accordance with the formula suggested by van 't Hoff. The method was used to follow the transformation of phenyl*iso*nitromethane into phenylnitromethane, of ammonium thiocyanate into thiocarbamide, and of ammonium cyanate into carbamide (J., 1908, **93**, 1041); and the influence of neutral solvents on the velocity of these transformations was likewise examined (J., 1912, **101**, 26, 2100).

In some of these experiments, an attempt was made to estimate the influence of ortho-, meta-, and para-substitution on the velocity of the oxime transformation (*Proc. Roy. Phil. Soc. Glasgow*, 1911—1912, **42**, 26), but since it is only in a few cases that *syn*aldoximes can be obtained from all three forms of substituted aromatic aldehydes, this could not be carried far. With the object of extending the investigation in this direction, but also in order to study the transformation of the acetyl derivatives and of the ethers of the oximes, we have recently taken the subject up again. We used ethyl tartrate as active indicator, and since it is of great importance that its behaviour should remain uniform throughout a series of experiments, which may easily occupy a fairly long time, we prepared a considerable quantity of it by the hydrochloric acid saturation method * and sealed up quantities of about 100 g. in several different flasks, with the idea that one of these small quantities was not likely to alter very much during the time in which experiments were being carried out with it, and that the others should alter very little or not at all, as was subsequently found to be the case.

m-Nitrobenz*syn*aldoxime, which is easily obtained and not too readily converted into the *anti*-form, was used as a standard by means of which each different sample of ethyl tartrate was checked, and it was found that the velocity coefficient was practically the same in each case within the limits of experimental error. A summary of the results obtained is given in Table I.

Our supply of ethyl tartrate was exhausted before the completion of the experiments we had contemplated, and therefore those with *m*-iodobenz*syn*aldoxime and *p*-tolu*syn*aldoxime were carried out with some ethyl tartrate prepared by Frankland and Aston's continuous method (J., 1901, **79**, 517). This ethyl tartrate had a somewhat higher coefficient for *m*-nitrobenz*syn*aldoxime ($k = 1{\cdot}75$)

* About 85% of the theoretical quantity of ethyl tartrate, once distilled, was obtained (compare Lowry and Cutter, J., 1922, **121**, 532, who could only obtain 56% as a maximum).

TABLE I.

Solutions examined in first specimen of ethyl tartrate.

Aldoxime.	Oxime, % (approx.).	Experiment. 1.	2.	3.	4.	5.	1000 k, mean.
Benz*syn*-	4	2·55	2·49	—	—	—	2·52
o-Nitrobenz*syn*- ...	1·5	0·345	0·345	—	—	—	0·345
m- ,, ,, ...	1·5	1·26	1·26	1·30	—	—	1·27
p- ,, ,, ...	1·5	1·33	1·40	1·32	1·28	—	1·35
o-Bromobenz*syn*- ...	4	0·707	0·756	0·728	—	—	0·73
m- ,, ,, ...	4	1·53	1·54	1·57	—	—	1·55
p- ,, ,, ...	4	2·18	2·42	2·25	2·37	2·28	2·30
m-Chlorobenz*syn*- ...	4	1·28	1·36	1·31	—	—	1·32
p- ,, ,, ...	4	1·72	1·84	1·92	—	—	1·82
p-Iodobenz*syn*-	2·5	2·86	2·87	2·93	—	—	2·88
β-*O*-Methyl-*m*-nitrobenz-	4	0·234	0·235	—	—	—	0·235
β-*O*-Methyl-*p*-nitrobenz-	4	0·179	—	—	—	—	0·179

than that previously used ($k = 1·27$), but in the last column of Table II allowance is made for this and the numbers are calculated as if they had been obtained with an ester of the latter coefficient. These values may therefore be compared directly with the values in the last column of Table I.

TABLE II.

Solutions examined in second specimen of ethyl tartrate.

Aldoxime.	Oxime, % (approx.).	Experiment. 1. 1000k.	2. 1000k.	3. 1000k.	Mean, 1000k.	Mean, calc. on basis of first specimen.
m-Nitrobenz*syn*- ...	4	1·74	1·76	—	1·75	1·27
m-Iodobenz*syn*- ...	2·5	1·79	1·71	1·77	1·76	1·27
p-Tolu*syn*-	4	2·20	2·10	2·27	2·19	1·58

We were, unfortunately, only able to prepare two sets of all three isomerides, the nitro- and the bromo-benz*syn*aldoximes, and the results will be most clearly appreciated from Table III.

TABLE III.

Benz*syn*aldoxime, 1000k = 2·52.

Effect of substituents as shown by values of 1000k.

	NO_2.	Cl.	Br.	I.	CH_3.
o	0·35	—	0·73	—	—
m	1·27	1·32	1·55	1·27*	—
p	1·35	1·82	2·30	2·88	1·58*

* These results were obtained with the second specimen of ethyl tartrate.

In earlier work regarding the nitro-derivatives (*Proc. Roy. Phil. Soc. Glasgow, loc. cit.*), data for the para-isomeride could not be

obtained; but it now appears that this was probably because *p*-nitrobenz*syn*aldoxime is soluble only with considerable difficulty in ethyl tartrate, and that, in the former experiments, an attempt having been made to use too concentrated a solution, transformation had taken place during the heating thus rendered necessary. In the present experiments, by use of a 1·5% solution of oxime, the rate of change could be measured. It will be observed that the ortho-derivative is transformed slowly, the meta-derivative about four times as rapidly, and the para-derivative still a little more rapidly.

In the bromo-derivatives the same sequence is followed, transformation being slowest in the ortho-, intermediate in the meta-, and fastest in the para-isomeride.

In the chloro- and the iodo-derivatives, the behaviour of the meta- and the para-compounds is very similar to that of the corresponding nitro- and bromo-substitution products, the para-compound being transformed more rapidly, in each case, than the meta-.

Comparison of the *p*-derivatives of chloro-, bromo-, and iodo-benzaldehyde shows that the first-named is transformed most rapidly and the last-named most slowly, the bromo-compound being intermediate.

It is a very curious fact that, although from these experiments it would seem likely that the ortho-isomeride should be transformed from the *syn*-form into the *anti*-form considerably more slowly than is the case with the meta- and the para-derivatives, the *syn*-forms of the ortho-esters are very much more difficult to prepare than the meta- and the para-; exactly the opposite might have been anticipated. *o*-Chlorobenz*syn*aldoxime has been described by Brady (J., 1925, **127**, 2428), but we were unable by his method to obtain a sufficient quantity of this compound to carry out the reaction. *o*-Iodobenz*syn*aldoxime has not yet been prepared at all.

We also prepared both forms of the *O*-methyl ethers of *m*- and of *p*-nitrobenz*syn*aldoxime, and we have found that the ethers prepared from the *syn*aldoximes affected the rotation of ethyl tartrate in much the same way as the parent oximes. For solutions of equivalent concentration, the change in rotation of the active indicator is much the same, but it is noticeable that the velocity of transformation is considerably slower than in the parent oxime, and that, in the two cases examined, the methyl ether of the para-derivative is transformed much more slowly than that of the meta-derivative. The methyl ethers, prepared from the *anti*-forms of the oximes, dissolved in ethyl tartrate gave rotations practically identical with the end values shown by the isomeric ethers, and they appeared to undergo no change with lapse of time.

We also prepared the *N*-methyl ether of *m*-nitrobenzaldoxime.

In similar concentration it gave a rotation of + 11·78°, which, however, showed no change with lapse of time. Further, we prepared the acetyl derivatives of both forms of benzaldoxime, and examined their rotations in ethyl tartrate solution. As will be seen from the data, there is a slight difference in the rotations of the two solutions, and when the acetyl*syn*oxime was heated the rotation was observed to change, but the total change was so small that the rate of transformation could not be observed.

The data relating to benz*syn*aldoxime are shown in detail in Table IV as an example of the degree of constancy in k, and the remainder are summarised in Table V :

p = g. of ethyl tartrate per 100 g. of solution;

t = time in mins. in Table IV, and duration of measurements in Table V;

α = change of rotation between $t = 0$ and $t = \infty$;

x = change of rotation at time t;

and $k = 1/t \,.\, \log_e \alpha/(\alpha - x)$.

TABLE IV.

Benz*syn*aldoxime.

(i) $p = 95{\cdot}97$; $\alpha = 3{\cdot}15°$.

t.	$\alpha^{25°}_{5461}$ (100 mm.).	$1000k$.
0	+14·18°	—
60	13·72	2·67
135	13·23	2·66
180	12·99	2·64
215	12·85	2·55
310	12·50	2·46
370	12·30	2·45
430	12·15	2·40
∞	11·03	—
	Mean	2·55

(ii) $p = 96{\cdot}14$; $\alpha = 3{\cdot}04°$.

t.	$\alpha^{25°}_{5461}$ (100 mm.).	$1000k$.
0	+14·02°	—
60	13·61	2·41
120	13·23	2·51
205	12·75	2·63
315	12·35	2·59
350	12·25	2·49
405	12·10	2·46
470	11·97	2·39
∞	10·98	—
	Mean	2·49

β-O-*Methyl*-m-*nitrobenz*syn*aldoxime*.—

(i) $p = 95{\cdot}81$; $\alpha^{25°}_{5161}$ (100 mm.), + 11·13° ($t = 0$), + 10·38° ($t = \infty$).
(ii) $p = 95{\cdot}80$; ,, ,, ,, + 11·15° ,, + 10·38° ,,

α-O-*Methyl*-m-*nitrobenzaldoxime*.—$p = 96{\cdot}12$; $\alpha^{25°}_{5461}$ (100 mm.) = +10·31°.

N-*Methyl*-m-*nitrobenzaldoxime*.—$p = 95{\cdot}72$; $\alpha^{25°}_{5461}$ (100 mm.) = +11·78°. No change in the rotation of the solution was observed over a period of 12 days.

β-O-*Methyl*-p-*nitrobenz*syn*aldoxime*.—$p = 95{\cdot}86$; $\alpha^{25°}_{5461}$ (100 mm.), + 10·64° ($t = 0$), + 9·79° ($t = \infty$).

α-O-*Methyl*-p-*nitrobenzaldoxime*.—$p = 96{\cdot}07$; $\alpha^{25°}_{5461}$ = +9·76°.

TABLE V.

Oxime.		p.	a.	t.	$k \times 10^3$. Limits.	Mean.
o-Bromobenz*syn*aldoxime	(i)	96·28	1·11°	1550	0·632—0·787	0·707
	(ii)	96·08	1·21	400	0·702—0·806	0·756
	(iii)	96·10	1·26	630	0·680—0·773	0·728
m- ,, ,, ,,	(i)	96·06	2·24	450	1·42 —1·61	1·53
	(ii)	96·10	2·30	300	1·47 —1·65	1·54
	(iii)	96·04	2·29	360	1·50 —1·66	1·58
p- ,, ,, ,,	(i)	95·02	2·53	370	2·02 —2·33	2·18
	(ii)	95·02	2·32	400	2·15 —2·53	2·37
	(iii)	95·01	1·89	350	2·10 —2·37	2·25
	(iv)	95·99	2·35	360	2·32 —2·60	2·42
	(v)	95·27	2·52	325	1·99 —2·54	2·28
o-Nitrobenz*syn*aldoxime	(i)	98·52	0·36	2880	0·28 —0·48	0·354
	(ii)	98·53	0·38	1620	0·30 —0·48	0·354
m- ,, ,, ,,	(i)	98·59	0·94	480	1·23 —1·31	1·256
	(ii)	98·54	1·00	420	1·21 —1·31	1·260
	(iii)	98·48	1·08	360	1·26 —1·33	1·296
p- ,, ,, ,,	(i)	98·66	1·23	360	1·24 —1·41	1·33
	(ii)	98·56	1·38	1460	1·29 —1·54	1·40
	(iii)	98·59	1·34	400	1·29 —1·36	1·32
	(iv)	98·51	1·38	420	1·21 —1·48	1·30
m-Chlorobenz*syn*aldoxime	(i)	95·8	2·82	1640	1·12 —1·33	1·28
	(ii)	95·85	2·70	1440	1·23 —1·42	1·36
	(iii)	95·73	2·04	475	1·28 —1·37	1·31
p- ,, ,, ,,	(i)	96·27	3·26	600	1·67 —1·84	1·72
	(ii)	96·06	2·74	480	1·80 —1·89	1·84
p-Iodobenz*syn*aldoxime	(i)	97·58	1·25	480	2·65 —3·06	2·86
	(ii)	97·60	1·26	370	2·77 —3·07	2·87
	(iii)	97·58	1·22	440	2·77 —3·07	2·93
**m*-Nitrobenz*syn*aldoxime	(i)	96·01	2·48	430	1·69 —1·78	1·74
	(ii)	95·98	2·42	460	1·69 —1·82	1·76
**m*-Iodobenz*syn*aldoxime	(i)	97·57	1·05	420	1·67 —1·82	1·79
	(ii)	97·59	1·12	420	1·66 —1·74	1·71
	(iii)	97·58	0·90	420	1·66 —1·87	1·77
**p*-Tolu*syn*aldoxime	(i)	95·94	3·06	470	2·09 —2·40	2·20
	(ii)	95·93	3·07	380	2·00 —2·18	2·10
	(iii)	95·95	2·93	375	2·11 —2·45	2·27
β-*O*-Methyl-*m*-nitrobenzaldoxime	(i)	95·81	0·75	7305	0·192—0·273	0·234
	(ii)	95·80	0·77	4480	0·231—0·239	0·235
β-*O*-Methyl-*p*-nitrobenzaldoxime	(i)	95·86	0·85	6070	0·150—0·202	0·179

* In second sample of ethyl tartrate.

α-*Acetylbenzaldoxime*.—$p = 97{\cdot}23$; $\alpha_{5461}^{21°}$ (100 mm.) $= +9{\cdot}39°$.

β-*Acetylbenzaldoxime*.—$p = 97{\cdot}28$; $\alpha_{5461}^{20{\cdot}8°}$ (100 mm.) $= +9{\cdot}51°$. After the solution had been warmed for some time and cooled again to room temperature, the rotation was lowered to + 9·37° and showed no further change.

The experiments with the two acetyl derivatives were carried out with a third sample of ethyl tartrate.

UNIVERSITY OF GLASGOW. [*Received, July 3rd*, 1929.]