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TAUTOMERISM AND SYN-ANTI ISOMERISM IN THE p-NITROSOPHENOL - p-BENZOQUINONE MONOXIME SYSTEM.

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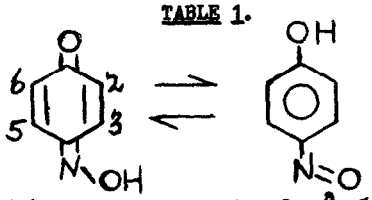
In a previous communication (1) we have described a combined n.m.r. and near-infrared spectroscopic method for the estimation of the position of equilibrium between the nitrosophenol and quinone monoxime forms of "p-nitrosophenols" and have established by n.m.r. the occurrence of syn-anti isomerism in the quinone monoxime form. Some of our results have been subsequently confirmed (2).

We now wish to report the study of a range of derivatives of "p-nitrosophenol" which gives some insight into the factors affecting the position of the tautomeric equilibrium , and reveals a novel type of long-range effect on the syn-anti equilibria.

An inspection of our previous data (1) together with the results summarized in Table 1, reveals a number of regularities:

1)The quinone monoxime form predominates in the majority of cases studied so far , with the exception of entries XVI - XVIII With these compounds , the predominance of the nitroso form is presumably

TABLE 1.



Number.	Substituent. C-2	C-6	% Syn isomer in oxime form.[a] Dioxan	$CDCl_3$	Anion.	% Nitroso form[b]	λ_{max} (mμ)
I	H	H	50	-c	50	16	735
II	CH_3	H	64	63	61	2.1	731
III	C_2H_5	H	70±3	-	73	1.4	726
IV	i-C_3H_7	H	60±4	60±4	60±4	1.2	730
V	t-C_4H_9	H	55	50	d	0.6	729
VI	CH_3	CH_3	50	c	50	≤ 0.1	-
VII	Cl	H	60	c	60	3.8	731
VIII	Br	H	59	c	60	3.7	730
IX	I	H	-	-	57	-	-
X	Cl	CH_3	48	c	48	≤ 0.2	-
XI	Br	CH_3	46	c	46	≤ 0.2	-
XII	OCH_3	H	86	c	87	≤ 0.6	-
XIII	SCH_3	H	79	c	79	≤ 0.1	-
XIV	CN	H	e	c	e	31	729
XV	CN	OCH_3	c(e?)	c	c(e?)	4	725
XVI	COOH	H	e	c	e	100	724
XVII	$COCH_3$	H	-	e	e	100	720
XVIII	$COCH_3$	CH_3	-	e	e	100	725

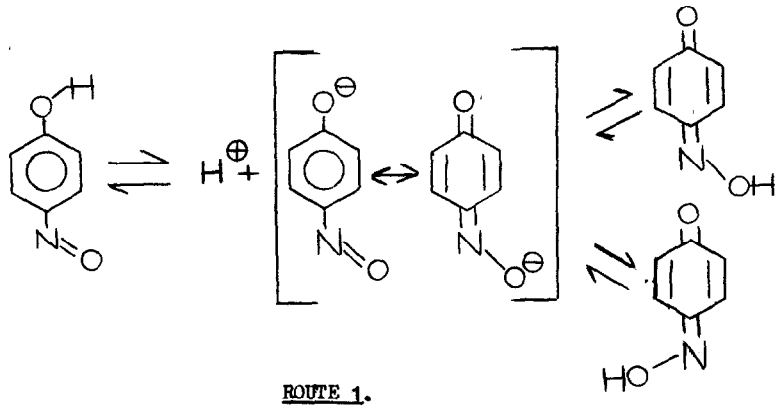
a : Syn configuration is defined with respect to the substituent at C-2; determined by n.m.r. ; accuracy ± 2% unless otherwise stated.
b : By n.m.r. for I; by near-infrared for II - XVIII.
c : Insufficiently soluble to allow accurate determination.
d : Overlap of signals does not allow determination.
e : Apparently a single species.

due to the strong intramolecular hydrogen bonding of the phenolic hydroxyl group with the adjacent carbonyl. It is possible that the presence of substituents, which are capable of mesomeric electron withdrawal, favour the nitrosophenol form per se, e.g. the 2-cyano compound (XIV) , but even in this last case the possibility of a weaker intramolecular interaction of the phenolic hydrogen with the cyano group (presumably a type of pi-bonding with the triple bond) exists, since the phenolic hydrogen of 2-cyanophenol itself (as a 4% solution in chloroform) resonates at $\delta = 6.6$, i.e. somewhat downfield of most phenolic -OH resonances. The two effects are, however, difficult to separate on the basis of presently available data. The effect of substituents on the equilibrium appears to be additive (c.f. in particular , entry XV.).

2) With a variety of substituents at C-2 , the syn forms of the quinone monoxime predominate, although, clearly, the differences in energy between the syn and anti forms are small. The "syn-directing"effect of substituents is approximately additive(c.f. entries X and XI) in the case of 2,6-disubstituted derivatives. It should also be noted that the directing of the -N-OH group into the syn configuration does not depend on the dipole along the bond joining the 2-substituent to the quinonoid ring and is apparently not affected by the solvent used (although, for reasons outlined elswhere, (1) the choice is limited). Perhaps the most striking feature is the remarkable similarity of the percentage of syn forms present in the neutral and anionic species. The effect thus appears to be of a novel type.

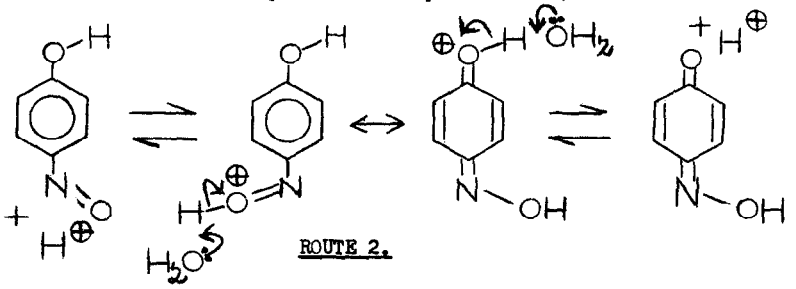
3) We have previously observed (1) that syn-anti isomerisation of quinone monoxime forms in dioxan solutions can be accelerated by the addition of aqueous hydrochloric acid, while Uffmann

(2) has found (and we have confirmed) that the addition of trifluoro-acetic acid resulted in the slowing down of the syn-anti interconversion. We have also found that aqueous trifluoroacetic acid has a similar effect to aqueous hydrochloric acid. These observations may be rationalised by proposing that in absence of added acid the isomerisation proceeds via the route (1) first postulated by Havinga (3) and adopted by ourselves (1) and Uffmann(2). The addition of trifluoroacetic acid slows down the syn-anti(and nitrosophenol - benzoquinone monoxime) interchange by suppressing the concentration of the ionised intermediate.

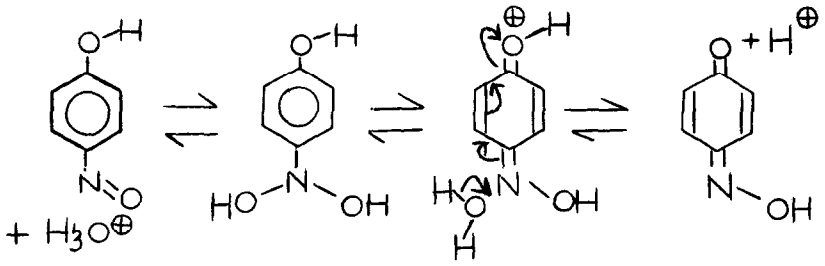


ROUTE 1.

In addition , it is possible to postulate at least two alternate routes (2 and 3) in the presence of aqueous acids.



ROUTE 2.



ROUTE 3.

The choice between these (or other alternatives) would, however, require accurate determinations of the acid-base strengths of the various species in each particular solvent system and a detailed kinetic study with rigourously dried solvents.

Acknowledgment.

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References.

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