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PHOTOLYSIS OF 1,6-NAPHTHYRIDINE 1,6-DIOXIDE AND ITS THEORETICAL CONSIDERATION

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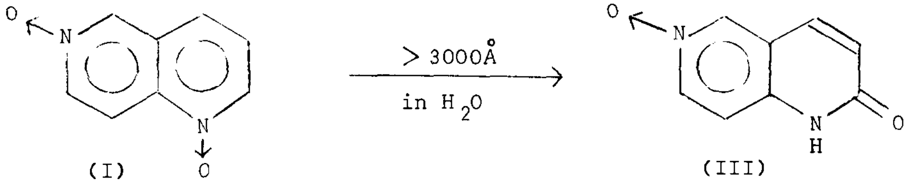
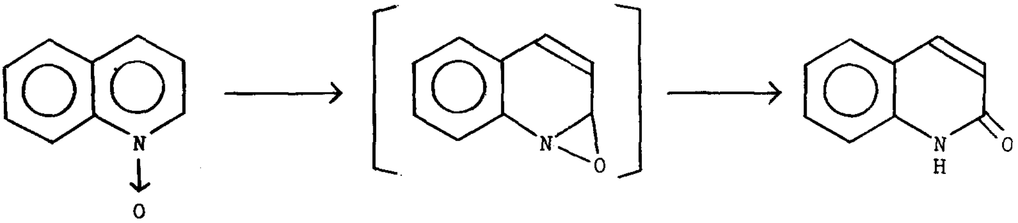
The two N-oxide groups in 1,6-naphthyridine 1,6-dioxide (I) and 1,6-phenanthroline 1,6-dioxide (II) are of different types; in I one is of quinoline 1-oxide type and the other is of isoquinoline 2-oxide type. It was, therefore, attractive to examine which N-oxide group would be isomerized faster in the photolysis.

Photolysis of I in water by a high-pressure mercury lamp with a Pyrex filter afforded 1,2-dihydro-1,6-naphthyridin-2(1H)one 6-oxide (III), mp 325° (decomp). This experiment suggested I has photo-selectivity in a protic solvent and that the photomigration of 1-oxide is faster than that of 6-oxide. Irradiation of II in ethanol-water by ultraviolet ray (Pyrex filter) does not afford any product nor recovers the starting material.



In the photolysis of quinoline 1-oxide, Kaneko <u>et al</u>. reported that the N-oxide was isomerized to 2-oxo compound in a protic solvent and to oxazepine in an aprotic solvent and proposed oxaziridine species as the first intermediate in these migrations (1). If such is the case, the reactivity to form 2-oxo compound will depend on the ease of bond formation between the oxygen atom in the N-oxide group (A-position) and the α-carbon (B-position) in this molecule. Therefore, we attempted to examine our experimental results by using simple Hückel molecular orbital theory. We noted the fact that the coefficients of A- and B-positions in the highest occupied MO were in the opposite signs and those in the lowest vacant MO were in the same sign with most aromatic amine N-oxides and that the migration of N-oxide should be allowed in photoreaction and forbidden in thermoreaction according to the Woodward-Hoffmann rule. Kaneko et al., independently of us, suggested the above facts, too (2).

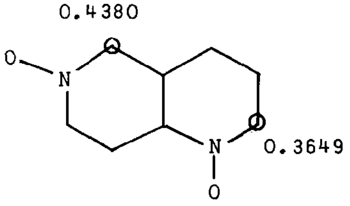


This theoretical consideration agreed with the fact that the oxygen rearrangement occurred in photoreaction but not in thermoreaction. This rule could be applied to our results, but could not tell which N-oxide group (1- or 6-oxide) migrated faster. The selectivity of I was not explained by either the quantity of the coefficient of the lowest vacant MO (C_B^*) at 2- or 5-position nor that of the product of the coefficients ($C_A^* C_B^*$) at 1-oxide and 2-position or 6-oxide and 5-position.

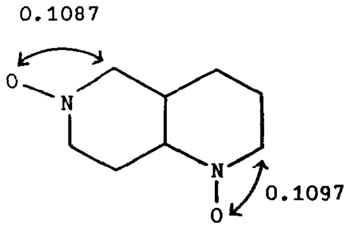
As stated before, the ease of photomigration should be estimated from the ease of bond formation between A and B. On the other hand, Fukui (3) suggested from the consideration of photocyclization of polyenes that the overlap stabilization between two π-atomic orbitals in a single conjugated system should be evaluated as the sum of the contributions from all occupied MO's and that the change in the π-electronic energy in the case of the overlapping of the first and k-th AO's is approximated by $\Delta E = 2P_{1k}\gamma$ (P_{1k} : bond order, γ: resonance integral) from the first-order perturbation calculation. In photoreaction, he assumed the jumping of one electron of HOMO into LVMO and the overlap stabilization, which is in this case denoted by P_{1k}^{*}.

We tried to apply this theory to our results; namely, we calculated the bond order between A- and B-positions in the excited state (P_{AB}^{*}) with I. These values satisfactorily explain the tendency of the photomigration in our results.

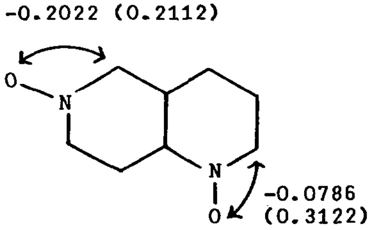
C_B^{*}



$C_A^{*}C_B^{*}$



$P_{AB}^{*}(\Delta P_{AB})$



The values of bond orders were, therefore, calculated for some of the other aromatic amine N-oxides and the data are shown in Table I with the experimental results.

As shown in Table I, photomigration occurred at the position of the positive or the less negative values. The agreement with the experimental results indicated that the application of the bond order was reasonable. This table also shows that the difference between the bond orders in the ground state and the excited state (ΔP_{AB}) is useful for prediction; photomigration occurred at the position of the larger ΔP_{AB}.

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Table I. The bond order in the excited state (P_{AB}^{*}) and the difference between the bond orders in the ground state and the excited state (ΔP_{AB}).

Amine oxide	B-position	P_{AB}^{*}	ΔP_{AB}	Experimental result
Pyridine 1-oxide	2 or 6	0.0356	0.3806	X
Quinoline 1-oxide	2	-0.0591	0.3287	X
	8a	-0.1439	0.1013	
Isoquinoline 2-oxide	1	0.0087	0.3926	X
	3	-0.2786	0.0018	
Phenanthoridine 5-oxide	6	-0.0156	0.4238	X
	4a	-0.1950	0.0073	
H-benzoquinoline 1-oxide	2	-0.0432	0.3261	X
	10b	-0.2201	0.0587	
1,6-Naphthyridine 1-oxide (4)	2	-0.0624	0.3246	X
	8a	-0.1294	0.1153	
1,6-Naphthyridine 6-oxide (4)	5	0.0165	0.4168	X
	7	-0.1831	0.0976	
1,6-Naphthyridine 1,6-dioxide (4)	2	-0.0786	0.3122	X
	8a	-0.1986	0.0564	
	5	-0.2022	0.2112	
	7	-0.2113	0.0753	
1,6-Phenanthroline 6-oxide (5)	5	-0.0245	0.4148	X
	6a	-0.1895	0.0212	
1,6-Phenanthroline 1,6-dioxide (5)	2	-0.1138	0.2528	
	10b	-0.2873	0.0001	
	5	-0.1586	0.2958	
	6a	-0.1694	0.0386	

X shows the position where the migration occurred.

REFERENCES

1. C.Kaneko, I.Yokoe, S.Yamada, and M.Ishikawa, Chem.Pharm.Bull. (Tokyo), 17 1290 (1969).
2. C.Kaneko, S.Yamada, and I.Yokoe, Abstract of Symposium on Photochemistry, Tokyo, 1969, 37.
3. K. Fukui, Bull.Chem.Soc.Japan, 39 498 (1966); idem, Tetrahedron Letters, 1965, 2009.
4. Y.Kobayashi, I.Kumadaki, and H.Sato, Chem.Pharm.Bull. (Tokyo), 17, 1045 (1969).
5. Y. Kobayashi, I.Kumadaki, and K.Morinaga, Chem.Pharm.Bull. (Tokyo), 17, 1511 (1969).