UDC 547.831.6.07

# 75. **Shozo Kamiya** : Azidoquinoline and Azidopyridine Derivatives. II. Reactions of 4-Azidoquinoline 1-Oxide.

(*National Institute of Hygienic Sciences**)

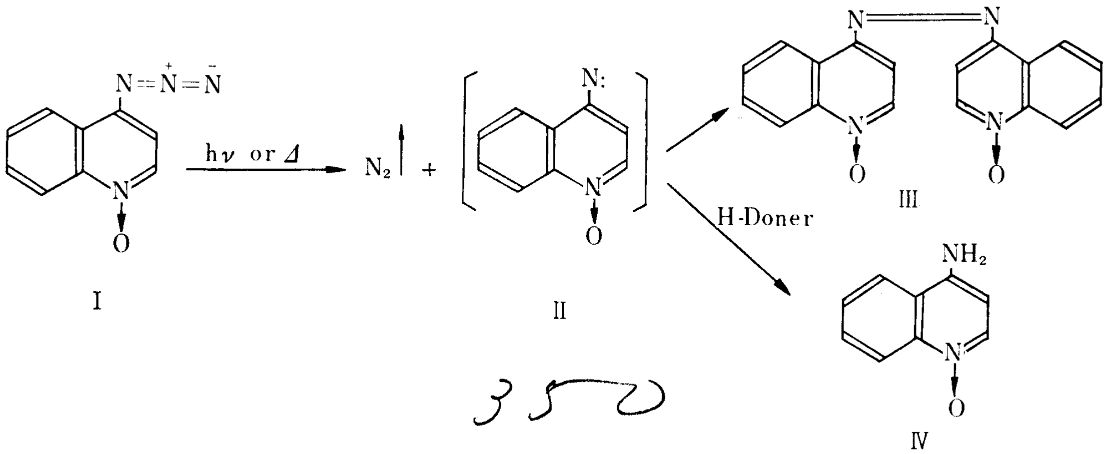
In the previous work,[1] 4-azidoquinoline 1-oxide (I), 4-azidopyridine 1-oxide and their derivatives had been prepared, and their photolysis was examined preliminarily. The products were proved as 4,4′-azo- or 4,4′,-azoxy compounds, owing to the conditions at the decomposition.

It has been known that the reactions of an azido group in solution are as follows. 1. A radical reaction after releasing two nitrogen atoms. 2. A substitution reaction. 3. An addition into triazole. Besides, it has been also reported that reactions by radicals may be classified into four categories[2),3)], 1.1. Dimerization, 1.2. Addition reaction, 1.3. Hydrogen abstraction reaction, and 1.4. Disproportionation.

Some reactions of aliphatic and aromatic azido compounds have already been examined,[4)] but a few reports on heterocyclic compounds, and none with N-oxide. Therefore, author investigated further the reactivity of the azido groups of 4-azidoquinoline and its 1-oxide in several reactions, i.e. photolysis, pyrolysis, addition reaction, substitution reaction etc., the results of which are reported in this paper.

## (1) Thermal Decomposition of 4-Azidoquinoline 1-Oxide in Solution

(I) as solid is stable at room temperature, but detonates on rapid heating. When solutions of (I) were heated at temperatures between 80 and 200°, 4,4′-azodiquinoline 1,1′-dioxide (III) and 4-aminoquinoline 1-oxide (IV) were obtained, according to the conditions. At the boiling point of benzene or toluene solution, (III) was a main product, attributable to reaction 1.1. On the other hand, at the boiling point of xylene or decaline solution (IV) was a principal product, by reaction 1.3. It seemed likely the products could H-donor was the used solvent. But, on account of the difficulty of purification, the products could not been isolated. Further investigation has not yet been done.

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*1 Tamagawa-Yogamachi, Setagaya-ku, Tokyo (神谷庄造).

1) Part I. T. Itai, S. Kamiya : This Bulletin, **9**, 87 (1961).
2) J. W. Cook : "Progress in Organic Chemistry," **1**, 219 (1952). Butterworths Scientific Publications, London.
3) S. J. Lapporte : Angew. Chem., **72**, 759 (1960).
4) J. H. Boyer, F. C. Canter : Chem. Rev., **54**, 26 (1954).

Table I. Thermal Decomposition of (I) in Several Solvents at their Boiling Points for 5 hr.

| Solvent | Yield of (III) | Yield of (IV) | Recovery |
|---|---|---|---|
| Benzene | 12% | 0% | 60% |
| Toluene | 60 | 0 | 30 |
| Xylene | 4 | 58 | 7 |
| Decaline | trace | 23 | 0 |

**(2) Photolysis of 4-Azidoquinoline and its 1-Oxide in Solutions**

As mentioned in the previous paper,[1] (I) occurs as pale yellowish needles when recrystallized from acetone in diffused light, but usually turned to brown or red by light. In the case of (I), it may be presumed that (I) dissociates thermally at moderate temperature into an imino diradical (II), but the effect of light is more significant.

In solutions (I) changed into (III) under the sun, evolving nitrogen. Any other reaction product was not detected except a small amount of resinous substance. Under the sun, photolysis proceeds rapidly, but less under ultraviolet (by high pressure mercury lamp) and infrared lights. It was found out that the reaction proceeded more quickly in acetone than in other solvents, i.e. benzene, ethanol and water.

Table II. Formation of 4,4′-Azodiquinoline 1,1′-dioxide by Photolysis of 4-Azidoquinoline 1-oxide by Sun in Solution

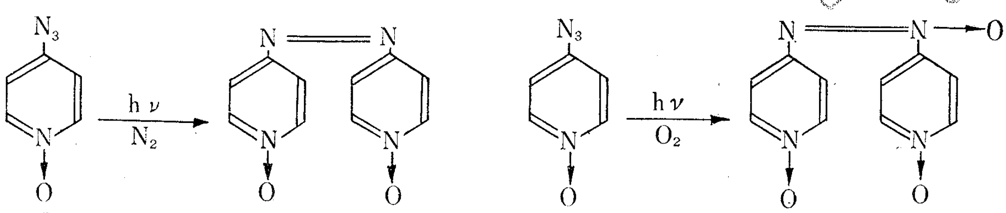
| Solvent | Irradiation hrs. | Concentration mg./cc. | Yield % of (III) |
|---|---|---|---|
| Acetone | 5 | 4 | 78 |
| Benzene | 3 | 4 | 64 |
| Ethanol | 3 | 8 | 42 |
| Water[a] | 5 | 8 | 21 |

*a*) Hydrochloride of 4-azidoquinoline 1-oxide was used.

4-Azidoquinoline (V) was rather inactive in photolysis, and gave 4,4′-azodiquinoline (VI) in poor yield, recovering 64% of the starting material.

In connection with this, (III) was also prepared by oxidation of 4-hydroxyaminoquinoline 1-oxide with ferric chloride in acetic acid.*2

When (I) was decomposed either under oxygen or under nitrogen atmosphere, only (III) was obtained in both cases. But 4-azidopyridine 1-oxide (VII) is different from (I), for it gave rise to 4,4′-azodipyridine 1,1′-dioxide (VIII) in nitrogen atmosphere, and 4,4′-azoxydipyridine 1,1′-dioxide (IX) under oxygen atmosphere.

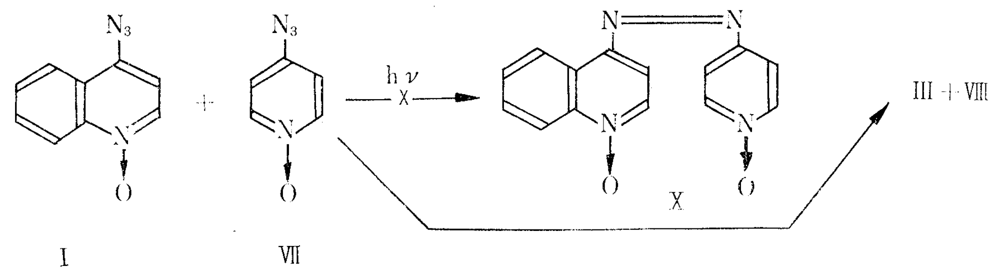



VII VIII VII IX

In order to synthesize an asymmetric azo compound, an acetone solution of (I) and (VIII) was decomposed under the sun, but (III) and (VIII) were only isolated, and, against my expectation, no quinoline-4-yl-4′-azopyridine 1,1′-dioxide (X) could be obtained.

*2 4,4′-Azoxydiquinoline 1,1′-dioxide was prepared by Ochiai[5] and his collaborator from 4-hydroxyaminoquinoline 1-oxide with Fehling's solution.

5) E. Ochiai, A. Ohta, H. Nomura: This Bulletin, 5, 310 (1957).



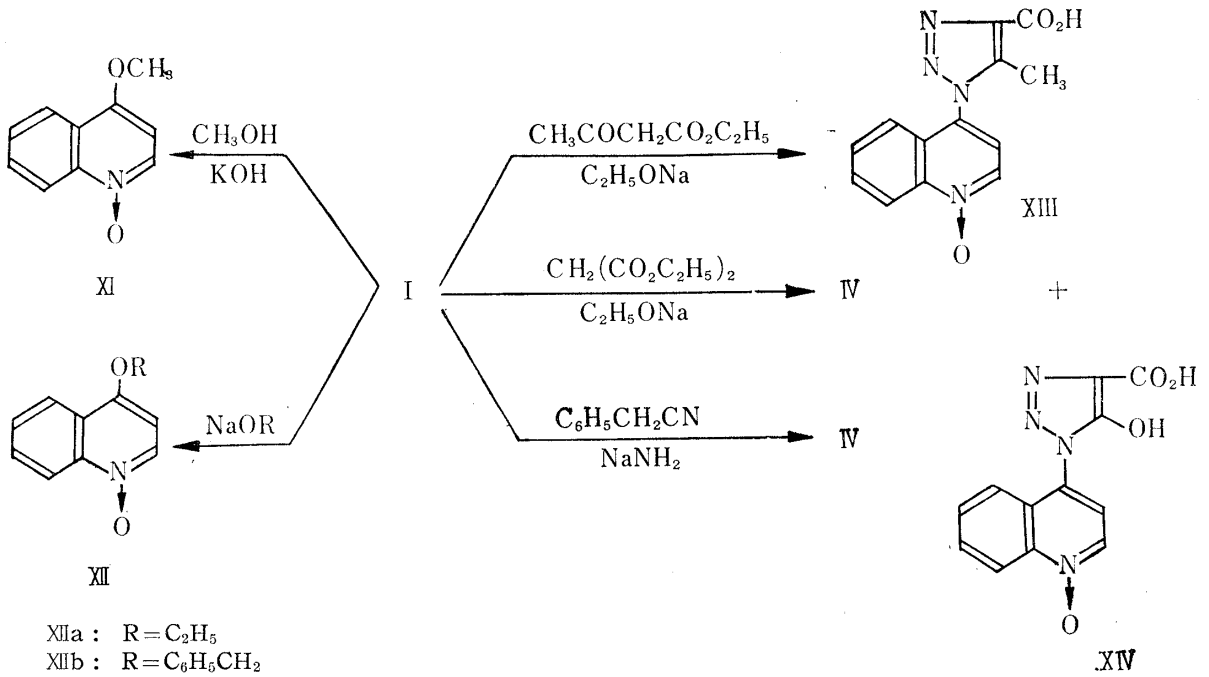

In these reactions it was presumed that an imino diradical (II) was produced from (I) by thermal or photochemical decomposition. Some physical methods are known to detect free radicals in solutions. But widely used radical detector in solutions is 1,1-diphenyl-2-picrylhydrazyl (DPPH),[6,7] and DPPH is a stable color monoradical. If other radicals are released in a solution of DPPH, both of radicals combine each other and, the sequence, the characteristic violet color will gradually fade or disappear.

When a benzene solution of (V) and DPPH was refluxed for five hours, the color of the solution did not fade at all. Its concentration was observed photometrically using the absorption at 530 mμ. With (I), the characteristic color disappeared within a few minutes on heating or on irradiation, which was perceptible visually.

In these thermal and photochemical decompositions of (I), the contribution of the effect of 1-oxide seems very large to the reactivity of the azide group in 4-position.

**(3) Reactions of 4-Azidoquinoline 1-Oxide with Several Sodium Alkoxides and with Compounds containing an Active Methylene Group**

When phenylazide was heated with sodium ethoxide in ethyl alcohol under ordinary pressure, phenyltriazole and aniline were formed. Similar triazole formations of phenylazide or other aryl azides were observed with acetophenone, phenylacetonitrile, cyanoacetate, malonic ester, and other compounds which contain enolizable methylene group.



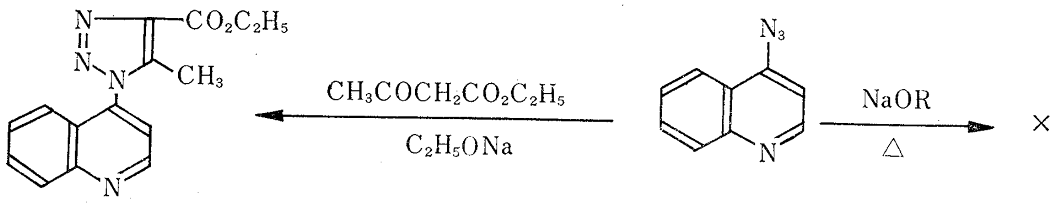

XIIa : $R=C_2H_5$
XIIb : $R=C_6H_5CH_2$
XIIc : R=H

6) K. E Russel, A. V. Tabolsky : J. Am. Chem. Soc., **75**, 5052 (1953).
7) G. S. Hammond, J. N. Sen, C. E. Boozer : *Ibid.*, **77**, 3244 (1955).

Treatment of (I) with sodium alkoxides resulted in the formation of the corresponding ethers, (XI) and (XII), with the elimination of sodium azide in nearly quantitative yields. By a reaction of I and 10% sodium hydroxide, 4-quinolinol 1-oxide (XIIc) was obtained quantitatively. These are different from the reaction of phenylazide and (V). It may be concluded that the polar effect of the N-oxide group markedly increases the activity of 4-azido group.

Ethyl acetoacetate in the presence of sodium ethoxide, brought about the formation of a triazolo compound (XIII) by addition of its enol form upon the azido group. But the reaction with sodium diethyl malonate afforded two compounds. One of them was identical to amine (IV) in 77% yield, reaction 1.3, the other was the corresponding triazolo compound (XIV,) but the yields of (XIII) and (XIV) were poor. Consequently diethyl malonate and benzyl cyanide reacted as H-donor in the presence of sodium ethoxide or sodium amide.

On the contrary, (V) afforded a corresponding triazolo compound (XV) with ethyl acetoacetate in 33% yield, but with sodium ethoxide no ionic reaction took place, recovering most of the starting material. The carboxyl groups in triazolo rings of (XIII), (XIV), and (XV) might be presumed to be located at 4-position, analogous to the reaction of phenylazide with compounds having an active methylene group.




(XV) (V)

### (4) Hydrogenation and Some Reactions of 4-Azidoquinoline 1-Oxide

Azide groups of (I) and (V) were hydrogenated over palladium charcoal to amino groups (IV) and 4-aminoquinoline in nearly quantitative yields.

(I) also reacted with hydrazine hydrate to liberate nitrogen and gave rise to (IV).

Then some attempts were made to prepare 4-nitroquinoline 1-oxide by oxidation with 30% hydrogen peroxide in acetic acid or with fuming nitric acid. A careful examination of all products in the reactions by infrared spectroscopy revealed no evidence for the presence of nitro compound. In each case, only 4,4′-azodiquinoline 1,1′-dioxide was produced.

## Experimental[*3]

**4,4′-Azodiquinoline 1,1′-Dioxide from 4-Hydroxyaminoquinoline 1-Oxide**——To a solution of 1.0 g of 4-hydroxyaminoquinoline 1-oxide dissolved in warm AcOH, 3 drops of conc. HCl and 0.5 g. of pulverized $FeCl_3$ were added, and the mixture was boiled for 10 min. The mixture was diluted with $H_2O$, made slightly alkaline with 28% $NH_4OH$, then allowed to stand with frequent stirring for 3 hr. The resulted solid was collected, washed with $H_2O$ and then extracted with about 3 L. of benzene. After the benzene extract was dried over anhyd. $Na_2SO_4$, it was concentrated under reduced pressure to about 20 cc. and allowed to stand over night. The brilliant reddish black pillars were collected, and dissolved in a small amount of AcOH and then diluted with much $H_2O$. The resulting black precipitate was collected, washed with $H_2O$, and dried over $P_2O_5$ *in vacuo*. Yield, 0.21 g. (23%). Black purple powder, m.p. 235～236° (decomp.). *Anal.* Calcd. for $C_{18}H_{12}O_2N_4 \cdot H_2O$: C, 64.66; H, 4.22; N, 16.76. Found: C, 64.85; H, 3.98; N, 16.52. After drying over $P_2O_5$ for 40 hr. at 130°, reddish drown scales, m.p. 248° (decomp.) were obtained. *Anal.* Calcd. for $C_{18}H_{21}O_2 N_4 \cdot \frac{1}{2}H_2O$: C, 66.45; H, 4.04; N, 17.23. Found: C, 66.38; H, 4.16; N, 17.02.

*3 All melting points are uncorrected.

**Thermal Decomposition of 4-Azidoquinoline 1-Oxide (I) in Solution**——1. In toluene : A solution of 0.30 g. of anhyd. toluene was refluxed gently in an oil bath for 5 hr. The precipitation of azo compound (III) began gradually with the evolution of nitrogen. After cooling. back fine needles were collected, washed with benzene, and dried *in vacuo*. Pure 4,4′-azodiquinoline 1,1′-dioxide (0.14 g.), m.p. 234~236°(decomp.) was obtained. The filtrate was chromatographed on alumina column and developed with benzene-MeOH (50 cc.+0.2~0.5 cc.). Thus, 12 mg. of (III) and 30% of (I) were recovered. Yield, 0.15 g. (60%).

2. In Xylene : A 0.30 g. of (I) was refluxed gently in anhyd. xylene as described in 1. The evolution of $N_2$ began at about 100°. Black fine needles were collected, washed with benzene, and recrystallized twice from EtOH to yellowish green dice, m.p. 267°(decomp.). The IR spectrum was entirely identical with that of 4-aminoquinoline 1-oxide, synthesized by catalytic reduction of (I). Yield, 0.15 g. (58%). The filtrate was chromatographed on alumina column, and reddish band was eluted with a mixture of benzene-MeOH (50 cc.+0.2 cc). After evaporation of the solvent, 0.02 g. (7%) of (I) was recovered from the residue by extraction with $Me_2CO$ and the insoluble material was recrystallized from benzene as reddish powder, m.p. 225° (decomp.). The IR spectrum was identical with that of 4,4′-azodiquinoline 1,1′-dioxide. Yield, 10 mg. (4%).

3. In decaline : A 0.30 g. of (I) was heated in 50 cc. of anhyd. decaline. The mixture explosively decomposed as the temperature reached to about 150°, and this was gently refluxed further for 1 hr. The solvent was evaporated under reduced pressure. The residue was extracted with a mixture of $CHCl_3$-benzene (1:1), and 0.13 g of tar was obtained after evaporation of the solvent. The insoluble substance was recrystallized from a mixture of MeOH-AcOEt to pale brownish dice, m.p. 265° (decomp.). The IR spectrum was identical with that of 4-aminoquinoline 1-oxide. Yield, 0.06 g. (23%).

**Photolysis of 4-Azidoquinoline 1-Oxide (I) and 4-Azidoquinoline in Solution**——The photochemical decomposition of all azides were carried out under similar conditions, of which example is mentioned as follows. The results are shown in Table II.

1. In benzene : A solution of 0.5 g. of (I) in 100 cc. of anhyd. benzene was exposed to sun. The evolution of $N_2$ bubles began in a few minutes, and irradiation was stopped after 3 hr. The black purple fine needles were collected by suction, washed with benzene and dried *in vacuo*, m.p. 239~241°(decomp.). The IR spectrum was identical with that of 4,4′-azodiquinoline 1,1′-dioxide. Yield, 0.27 g. (64%). The combined mother solution was concentrated to about 5 cc. and this, on standing, afforded 38 mg. (8%) of (I), m.p. 136~138°(decomp.).

2. 4-Azidoquinoline in $Me_2CO$ : A solution of 0.50 g. of 4-azidoquinoline in 25 cc. of $Me_2CO$ was exposed to sun for 10 hr. A pale yellowish precipitate was formed gradually, collected and washed with benzene. Twice recrystallization from benzene gavea sma llamount of orange colored powder, m.p. 188°. *Anal.* Calcd. for $C_{18}H_{12}N_4$ : C, 76.04; H, 4.25. Found : C, 75.89; H, 4.11. The product was identical with that prepared by G. M. Badger's method.[8] The mother solution separated from 4,4′-azodiquinoline gave 0.32 g. (64%) of starting material and 0.15 g. of a tarry residue.

**Photolysis of 4-Azidopyridine 1-Oxide in Acetone**——1. Under $O_2$ : A solution of 0.40 g. of 4-azidopyridine 1-oxide in 40 cc. of $Me_2CO$ was exposed to sun for 20 hr. under $O_2$ atmosphere. Reddish orange precipitates were collected, washed with $Me_2CO$, dissolved in a mixture of benzene-$CHCl_3$ (1:1) and chromatographed on $Al_2O_3$ column. Orange band was eluted by a mixture of benzene-MeOH (50 cc.+1.0 cc·). The solvent was evaporated, and the residue was recrystallized from EtOH to orange needles, m.p. 235°(decomp.), undepressed on admixture with 4,4′-azoxydipyridine 1,1′-dioxide. Yield, 0.09 g. (27%).

2. Under $N_2$ : A solution of 0.40 g. of 4-azidopyridine 1-oxide in 35 cc. of $Me_2CO$ contained in a stoppered vessel under $N_2$ atmosphere was exposed to sun and irradiation was stopped after 5 hr. The reddish fine needles were collected and washed with $Me_2CO$. Recrystallization from EtOH gave 0.12 g. (37%) of 4,4′-azodipyridine 1,1′-dioxide, m.p 241°(decomp.).

**Reactions of 4-Azidoquinoline 1-Oxide (I) with Sodium Alkoxides and with Compounds containing Active Methylene Groups**——1. Methanolic alkaline solution : To a solution of 0.30 g. of (I) in 30 cc. of MeOH, 10 cc. of 2% aq. KOH was added, and the alkaliue solution was refluxed for 30 min. Again, 10 cc. of the alkaline solution was added and the mixture was heated for 30 min. MeOH was evaporated to dryness and the residue was extracted with $CHCl_3$. The solvent was evaporated after drying over anhyd. $Na_2SO_4$, the residue was recrystallized from benzene to white needles, m.p. 54~56°. No depression of m.p. was observed on admixture with 4-methoxyquinoline. 1-oxide. Picrate : m.p. 158~159° (from EtOH). Yield, quantitative. 2. Sodium ethoxide : To a solution of 62 mg. of Na in 30 cc. of abs. EtOH, 0.50 g of (I) was added. and the mixture was heated on a boiling water bath for 3 hr. The reaction mixture was evaporated under reduced pressure and the residue was extracted with hot benzene. After benzene was distil led off under reduced pressure, the residue was extracted

8) G. M. Badger : J. Chem. Soc., **1955**, 2816.

with $CHCl_3$ again. To the $CHCl_3$ extract, same amount of benzene was added, the mixture was chromatographed on alumina column and eluted with a mixture of benzene-MeOH (50 cc.+2.0 cc.). After removal of the solvent by evaporation, yellowish needles were remained, m.p. 39~42°. Picrate: m.p. 164~165°. No depression was observed on admixture with 4-ethoxyquinoline 1-oxide. Yield, 0.38 g. (75%). The $NaN_3$ which formed wasidentified as under-mentioned. The white crystalline residue, insoluble in hot benzene, wasexplosive on rapid heating. Its aqueous solution showed a deep blood reddish color with 10% $FeCl_3$ solution.

3. Sodium benzylate: To a solution of 37 mg. of Na in 20 cc. of benzyl alcohol, 0.30 g. of (I) was added, the solution was heated at 130~150° for 2 hr. The reaction mixture was evaporated under reduced pressure, and extracted with AcOEt. The extract was concentrated to about 5 cc., then 5 cc. of $Et_2O$ and 1 cc. of water were added to this solution. The yellowish that separated out were recrystallized from aqueous AcOEt. Slightly yellow needles m.p. 132~134°. The IR spectrum was identical with that of 4-benzyloxyquinoline 1-oxide. Yield, 0.30 g. (74%).

4. Sodium hydroxide: A 0.20 g. of (I) was heated in 10 cc. of 10% aq. NaOH on a boiling water bath for 1 hr. Upon slight acidification with AcOH, pale fine needles were precipitated on standing, collected, washed with water and recrystallized from MeOH to needles, m.p. 231.° The IR spectrum was identical with that of 4-quinolinol 1-oxide. Yield, 0.17 g. (quantitative).

5. Ethyl acetoacetate: To a solution of 0.44 g. of Na dissolved in 30 cc. of abs. EtOH, 2.5 g of ethyl acetoacetate was added. 0.50 g. of (I) was added in the solution, and allowed to stand over night at room temperature. Yellowish amorphous precipitates were collected, washed with AcOEt and dried in a desiccator. Yield, 0.11 g. This was dissolved in a small amount of water and acidified slightly with 5% HCl. With vigorous foaming, pale yellowish dice were precipitated, collected, washed with water and dried. Yellowish dice (from EtOH), m.p. 205° (decomp.). Yield, 0.03 g. *Anal.* Calcd. for $C_{13}H_{10}O_4N_4$: C, 57.77; H, 3.73; N, 20.73. Found: C, 58.26; H, 3.73; N, 20.89. IR: $\nu_{max}^{KBr}$ 1720 $cm^{-1}$ (CO).

6. Diethyl malonate: To a mixture of 40 cc. of anhyd. benzene, 10 cc. of diethyl malonate and 0.10 g. of Na, 0.50 g. of (I) was added with stirring. After heating for 3 hr. a yellowish brown amorphous precipitate that separated out was collected. The precipitate was dissolved in a small amount of 5% HCl and concentrated on a boiling water bath. Then 0.39 g. (77%) of 4-aminoquinoline 1-oxide hydrochloride was obtained on standing. Pale yellowish needles, m.p. 268~269° (decomp.) were obtained from EtOH. *Anal.* Calcd. for $C_9H_8ON_2 \cdot HCl$: C, 54.96; H, 4.65. Found: C, 54.78; H, 4.36. The filtrate separated from 4-aminoquinoline 1-oxide was extracted with $GHCl_3$. After drying over anhyd $Na_2SO_4$, the extract was evaporated and the residue was extracted again with a mixture of benzene-$CHCl_3$ (1:1). Then the extract was chromatographed on an alumina column, washed with benzene, and eluted with a mixture of benzene-MeOH (50 cc.+1.0 cc.). The solvent was evaporated and the residue was recrystallized twice from petroleum benzine to cream colored leaves, m.p. 151~152°. Yield, 0.01 g. *Anal.* Calcd. for $C_{12}H_8O_4N_4$: N, 20.58. Found: N, 20.69. IR: $\nu_{max}^{KBr}$ 1710 $cm^{-1}$ (CO).

7. Benzyl cyanide: To a mixture of 5.0 cc. of anhyd. benzene, 2.0 cc of benzyl cyanide and 0.20 g. of $NaNH_2$, 0.5 g. of (I) was added and refluxed for 3 hr. The black precipitate was collected and purified over an alumina column in a mixture of benzene and MeOH. 0.38 g. (88%) of 4-aminoquinoline 1-oxide was obtained.

**Reaction of 4-Azidoquinoline and Ethyl Acetoacetate**——To a mixture of 20 cc. of abs. EtOH, 60 mg of Na and 0.4 g of ethyl acetoacetate, 0.13 g. of 4-azidoquinoline was added, and the mixture was refluxed for 8 hr. The reaction mixture was evaporated under reduced pressure to dryness. The residue was dissolved in 10 cc. of 5% HCl and extracted with $Et_2O$. The aqueous solution was basified with $Na_2CO_3$, extracted with $CHCl_3$, then dried over anhyd. $Na_2SO_4$. After evaporation of solvent, 0.38 g. (33%) of brownish oily residue was obtained. Picrate: Yellowish prisms (from EtOH), m.p. 189~191° (decomp.). *Anal.* Calcd. for $C_{15}H_{14}O_2N_4 \cdot C_6H_3O_7N_3$: C, 49.32; H, 3.55; N, 19.15. Found: C, 49.71; H, 3.35; N, 19.18.

**Catalytic Hydrogenation of 4-Azidoquinoline and its 1-Oxide**——1. 4-Azidoquinoline: A solution of 0.25 g. of 4-azidoquinoline in 20 cc. of MeOH was submitted to reduction over Pd-C, prepared from 8.4 cc. of 1% $PdCl_2$ and 0.2 g. of charcoal. After $H_2$ was absorbed, the catalyst was filtered off, washed with MeOH, and filtrate was evaporated to dryness under reduced pressure. The residue was solidified with 1 drop of water, recrystallized from benzene and dried over $P_2O_5$ to give white needles, m.p. 153°. The IR spectrum was identical with that of 4-aminoquinoline. Yield, 0.16 g. (76%).

2. 4-Azidoquinoline 1-Oxide: Similarly, 0.40 g. of (I) was reduced in 30 cc. of EtOH over Pd-C, prepared from 4.2 cc. of 1% $PdCl_2$ and 0.1 g. of charcoal as described above. Recrystallization from a mixture of AcOEt -MeOH afforded 0.31 g. (90%) of 4-aminoquinoline 1-oxide, m.p. 268° (decomp.). *Anal.* Calcd. for $C_9H_8ON_2$: C, 67.48; H, 5.04; N, 17.49. Found: C, 67.29; H, 5.12; N, 17.51.

**Reaction of 4-Azidoquinoline 1-Oxide and Hydrazine Hydrate**——To a solution of 0.50 g. of (I) in

20 cc. of abs. EtOH, 2 cc. of 80% hydrazine hydrate was added, then evolution of $N_2$ began. The reaction mixture was evaporated under reduced pressure after standing over nignt. The residue was dissolved in a mixture of $CHCl_3$–EtOH (50 cc.+20 cc.), chromatographed over $Al_2O_3$ and developed with same solvent. After evaporation of the solvent, a orange crystalline solid was obtained, m.p. 262°(decomp.). The IR spectrum was identical with that of 4-aminoquinoline 1-oxide. Yield, 0.23 g. (53%).

The author expresses his deep gratitude to Prof. Emeritus E. Ochiai, Prof. T. Okamoto of the University of Tokyo, and Dr. T. Itai of this Institute for their kind and helpful guidance through the course of this work, and to Dr. T. Kariyone, the Director of this Institute for his encouragement. He is also thankful to Dr. T. Oba and Mr. G. Kawabata for the measurement of IR spectra, and to Miss Y. Urushibata and Miss E. Shimizu of Kowa Chemical Laboratories for elemental microanalysis. This investigation was supported in part by a scientific research grant in aid of the Ministry of Health and Welfare.

## Summary

Several reactions of the azido group in 4-azidoquinoline 1-oxide were examined. It was found out that they could generally be classified under-mentioned three groups. 1. A radical reaction after the loss of the two nitrogen atoms, i.e., dimerization and hydrogen abstraction reactions of produced diradical. 2. A substitution reaction with the loss of azido group, i.e., ionic reaction. 3. An addition reaction to formation of tetrazole.

(Received March 29, 1961)

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*UDC 547.979-07*

## 76. **Shoji Shibata,**[*1] **Junzo Shoji,**[*1] **Norio Tokutake,**[*2] **Yoshiyuki Kaneko,**[*2] **Hiroshi Shimizu,**[*1] **and Hsüch-Ching Chiang**[*1] : Decomposition of Usnic Acid. VI.[*3] Studies on the Ozonolytic Products of O,O-Diacetylusnic Acid.

(*Faculty of Pharmaceutical Sciences, University of Tokyo*[*1])

Usnic acid, whose structure (III) had long been discussed[1] was synthesized by Barton *et al.*[2] by oxidative coupling of methylphloroacetophenone (I) in an analogous way of formation of Pummerer's ketone from *p*-cresol. However, the condensation mechanism shows an alternative possibility of formation of a product formulated (IV).

The possibility of formula (IV) of usnic acid was suggested once by Yanagita,[3] though it would obviously be difficult, if not impossible, to explain the degradation products of usnic acid, most of which were synthetically established.

Nevertheless, the formula (IV) could not be ruled out until the ambiguity of ozonolytic products of O,O-diacetylusnic acid would have completely been solved. The present study

*1 Hongo, Tokyo (柴田承二, 庄司順三, 清水　博, 江　雪郷).
*2 Present Address : Shionogi & Co. Ltd., Imafuku, Amagasaki, Hyogo-ken (徳竹伯夫, 金子嘉之).
*3 Part V : S. Shibata, K. Takahashi, Y. Tanaka : Pharm. Bull., **4**, 65 (1956).

1) See Y. Asahina, S. Shibata : Chemistry of Lichen Substances, p. 172~197 (Japan Society of Promotion for the Sciences, Tokyo (1954); " Especial Compounds of Lichens " in Encyclopedia of Plant Physiology, Vol. X, p. 600~612 (Springer Verlag (Berlin-Göttingen-Heidelberg), 1958) cited earlier references.
2) D. H. R. Barton, A. M. Deflorin, O. E. Edwards : J. Chem. Soc., **1956**, 530.
3) M. Yanagita : Meeting of Pharm. Soc. Japan, Nov., 1958 (unpublished.).