NITRATION OF 8-HYDROXYQUINOLINE WITH DILUTE NITRIC ACID AND NITROUS ACID

T. URBAŃSKI and W. KUTKIEWICZ
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Abstract—It was found that 8-hydroxyquinoline and 8-hydroxy-5-nitroquinoline can be nitrated with 0·5% nitric acid to yield 5,7-dinitro-8-hydroxyquinoline. Nitrous acid (*ca.* 0·5%) can also yield the same product.

The formation of the dinitro compound cannot be explained in terms of the conventional mechanism of nitration of phenols involving a nitroso intermediate.

IT IS known that phenols can be nitrated with very dilute nitric acid. Cumming, Hopper and Wheeler[1] have reported that phenol can be converted into nitrophenol by 3% nitric acid. Urbański[2] has found that 8-hydroxyquinoline can be converted to the 5,7-dinitro compound by boiling with 8% nitric acid and the present authors found that the same result can be obtained by prolonged boiling of 8-hydroxyquinoline with nitric acid of concentration as low as 0·5%. No mononitro derivatives of 8-hydroxyquinoline were formed.

However, the reaction occurred only after a certain induction period which ended with evolution of nitrous fumes. When sodium nitrite was added to nitric acid, the reaction started immediately. Nitration of 8-hydroxy-5-nitrosoquinoline leads readily to the same nitration product without the induction period.

This would apparently indicate that the nitration of 8-hydroxyquinoline with very dilute nitric acid follows the conventional mechanism of nitration of phenols involving the catalytic action of nitrous acid,[3-6] and formation of a nitroso intermediate compound.[7,8]

The facts observed by the present authors agree with this view only to a certain point. The existing theories can only explain the formation of mono-

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nitro-derivatives of monophenols. Thus, the introduction of the 5-nitro group into 8-hydroxyquinoline can easily be explained by nitrosation in position 5 and subsequent oxidation. No similar explanation can be given with regard to the mechanism of the introduction of the second nitro group, in position 7, as no nitrosation of nitrophenols is known and the formation of "8-hydroxy-5-nitro-7-nitrosoquinoline" seems to be impossible. A simultaneous dinitration to form "5,7-dinitroso-8-hydroxyquinoline" as an intermediate is also improbable because no instance of the introduction of two nitroso groups into monophenol is known.

The authors found that 8-hydroxy-5-nitroquinoline can also be nitrated by prolonged boiling with 0·5% nitric acid to yield 5,7-dinitro-8-hydroxyquinoline. This also seem to exclude nitrosation as an intermediate step of the nitration for the reason mentioned above.

The problem of the mechanism of the nitration discussed cannot be explained in terms of the action of the NO ion as the presence of this cation in very dilute nitric acid is very improbable.

The authors also found that 8-hydroxyquinoline boiled with dilute solution of sodium nitrite (*ca.* 0·5%) in the presence of hydrochloric acid yielded the same product—5,7-dinitro-8-hydroxyquinoline. It is known that nitrous acid can act as a nitrating agent[9-11].

It seems that the mechanism can be explained by the known fact of formation of nitric acid from nitrogen dioxide evolving from nitrous acid:

$$2\,NO_2 + H_2O \longrightarrow HNO_3 + HNO_2$$

Dilute nitric acid would then act as nitrating agent according to our experiments described above.

EXPERIMENTAL

Reactants. Commercial pure 8-hydroxyquinoline was purified by steam distillation and double crystallization from alcohol.

5-Nitroso-8-hydroxyquinoline was prepared in the usual way[12] by acting with sodium nitrite on a solution of 8-hydroxyquinoline sulphate (24·3 g) in dilute sulphuric acid; m.p. 244–247° with decomposition.

5-Nitro-8-hydroxyquinoline was obtained by oxidation of 5-nitroso-8-hydroxyquinoline with aqueous 50% nitric acid[13]; m.p. 168–172°.

Nitric acid free of nitrogen oxides was prepared from pure approx. 66% nitric acid, by distillation at 20 mm Hg in the presence of urea, and immediate dilution

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of the distillate with distilled water to obtain 20% or 4% solutions. Such nitric acid solution stored in a stoppered orange glass flask, was free of nitrogen oxides for no longer than fortnight.

Commercial sodium nitrite was purified twice by crystallization.

Nitration of 8-hydroxyquinoline with dilute nitric acid. Equal amounts of nitrogen oxide-free nitric acid and 8-hydroxyquinoline were heated to boiling in two flasks with reflux condensers. To one flask, aqueous sodium nitrite (0·07 g, 0·001 mole per 1 g 8-hydroxyquinoline) was introduced through the reflux condenser. The boiling was maintained for 15 min, the mixture was allowed to cool, and 5,7-dinitro-8-hydroxyquinoline crystals were separated (Table 1).

TABLE 1. NITRATION OF 8-HYDROXYQUINOLINE WITH DILUTE NITRIC ACID

8-Hydroxy-quinoline	HNO_3			5,7-Dinitro-8-hydroxyquinoline	
g	g	concen-tration, %	excess	g	yield %
2	87	20	10	2·00	62·9
2	116	15	10	1·95	60·0
2	174	10	10	1·90	58·7
2	348	5	10	1·65	51·0
1	348	2·5	10	0·70	43·0
0·5	400	1	9·2	0·27	33·4
0·5	800	0·5	9·2	0·13	16·5

The reaction proceeded similarly with 5-nitroso-8-hydroxyquinoline, in the presence of sodium nitrite.

Addition of sodium nitrite to the flask caused immediate evolution of nitrogen oxides (if the acid concentration was not too low) and precipitation of 5,7-dinitro-8-hydroxyquinoline. In some cases, the compound precipitated on cooling.

Nitration of 8-hydroxyquinoline with 20% nitric acid at room temperature. 8-Hydroxyquinoline (2 g) was suspended in 20% nitric acid (10 ml). The reaction began after a few minutes. On agitation the colour changed on the solution surface. Soon the whole solution turned brown. Temperature of the solution increased and nitrogen oxides were evolved.

When crude 8-hydroxyquinoline was used, the reaction started after a few seconds. 5,7-Dinitro-8-hydroxyquinoline, m.p. 305–306° (1·6 g, 50%) was obtained.

Nitration of 8-hydroxyquinoline with 1% nitric acid at room temperature. Two parallel experiments were carried out: in the first, 8-hydroxyquinoline (0·1 g) and 100 ml 1% nitric acid were placed in a sealed tube. In the second

sealed tube, the same reagents and 0·007 g (0·0001 mole) $NaNO_2$ were placed. Both tubes were stored in the dark.

After 4 weeks, the first crystals of 5,7-dinitro-8-hydroxyquinoline appeared in the second tube (containing $NaNO_2$), whereas in the first tube no visible changes occurred in 3 years.

Nitration of 5-nitroso-8-hydroxyquinoline with 1% nitric acid. 5-Nitroso-8-hydroxyquinoline (0·2 g) was dissolved in 100 ml 1% nitric acid by gentle warming. Usually at 60° the solution changed the colour from yellow to orange and brown, and nitrogen oxides evolved. The solution was heated to boiling for 15 min. 5,7-Dinitro-8-hydroxyquinoline precipitated upon cooling (*ca.* 0·1 g, 32–36%). No reaction initiation was necessary.

Nitration of 5-nitro-8-hydroxyquinoline. Two parallel tests were carried out, one as a control. 5-Nitro-8-hydroxyquinoline (0·6 g) and 200 ml 1% nitric acid were refluxed for 15 min. $NaNO_2$ (0·07 g, 0·001 mole) was added to one flask. The colour changed from orange through green to brown. Heating was continued for another 15 min. 5,7-Dinitro-8-hydroxyquinoline (0·40 g, 54%) precipitated upon cooling. In five of six cases the control was unchanged. In one case the reaction was initiated.

Nitrosation of 5-nitro-8-hydroxyquinoline. 5-Nitro-8-hydroxyquinoline (1 g) was suspended in 300 ml 10% hydrochloric acid and $NaNO_2$, 0·4 g in 10 ml of water, was added dropwise for 30 min at 0–10° with stirring. Stirring was continued for 2 hr. No reaction took place and the reactant was recovered unchanged.

The above procedure was changed in the following way: to the boiling solution of 5-nitro-8-hydroxyquinoline (5 g) in 150 ml 10% hydrochloric acid, $NaNO_2$ (0·6 g) in aqueous solution was added dropwise. The colour changed from yellow through green to brown. A brown precipitate formed. Additional yellow needles crystallized upon cooling. The separated crystals were extracted with methanol. In the alcohol-insoluble fraction 5,7-dinitro-8-hydroxyquinoline was found (0·20 g, 3%). The alcohol-soluble fraction contained 5-nitro-8-hydroxyquinoline unchanged.

5,7-Dinitro-8-hydroxyquinoline was successfully obtained from 5-nitro-8-hydroxyquinoline by nitrosation at room temperature in hydrochloric acid solution.

To obtain the measurable quantities of the dinitro-compound by nitrosation at room temperature it was enough to add sodium nitrite in small portions for three days. The latter compound was used in triple excess.

To exclude atmospheric oxygen from the reaction medium a few nitrosations of 5-nitro-8-hydroxyquinoline were carried out in acidic sodium nitrite solution in sealed tubes under a hydrogen atmosphere. Procedure applied: a 50 ml tube contained 5-nitro-8-hydroxyquinoline (0·1 g) in 30 ml 10% hydrochloric acid and a small sealed ampoule. The ampoule contained sodium nitrite (0·1 g) under

hydrogen. Before sealing the tube was "purged" with hydrogen for 4 hr at 60°. After sealing, the ampoule was broken mechanically and the tube was heated on a water bath for 2 hr. 5,7-Dinitro-8-hydroxyquinoline precipitated even while on the water bath. Upon cooling, yellow crystals of the reactant precipitated. The supernatant liquid was pale yellow. The gas phase was colourless. When the tube was opened (overpressure!), brown fumes of nitrogen oxides evolved on contact with air. The methanol-extracted precipitate was identified as 5,7-dinitro-8-hydroxyquinoline (0·08 g, 60%).

Nitrosation of 8-*hydroxyquinoline.* According to the aforementioned procedure, 8-hydroxyquinoline was nitrosated with sodium nitrite in the presence of 10% hydrochloric acid solution. Even then, 5,7-dinitro-8-hydroxyquinoline was obtained in *ca.* 50% yield.

(Note: 5,7-dinitro-8-hydroxyquinoline was identified by the m.p. determination. In some cases, elemental analysis was carried out).

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