

These conclusions indicate that the electronic state of these compounds is mainly dependent upon the type of the ring fusion, and it is closely analogous to the case of polycyclic aromatic compounds.⁸⁾ Concerning the biological activity of polycyclic aromatic compounds, it is known that carcinogenic activity is found in some of angular series and not in linear series. It is of interest whether or not the similar relation between ring system and biological activity will be found in these benzochromone series.

Experimental

Apparatus and condition : Hitachi Recording Spectrophotometer ESP-2U; period 1, photomultiplier sensitivity 1, scale AB 0~1 and 1~2, scanning speed 4 and 2.

Solvent : 99% EtOH. Samples : analytical grade.

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Summary

The ultraviolet spectra of benzochromones and the related compounds were measured and compared with those of natural benzochromones. The spectra of linear benzochromones are distinguished from those of angular compounds by their characteristic absorption bands. In each series, regular shift were observed by replacement of substituents.

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8) W. V. Mayneord, E. M. F. Roe : Proc. Roy. Soc. (London), A 152, 299 (1935); A 158, 634 (1937).

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47. Haruyuki Ito : Synthesis of Nitro Compounds by Means of Oxidation of Acylamino Compounds. K.*¹ On the Reaction Mechanism.

(Shizuoka College of Pharmacy*²)

A new reaction which affords nitro compounds by hydrogen peroxide oxidation of acylamino compounds has been described and developed by Kosuge.¹⁾ In the part IV²⁾ of this series, the reaction was assumed to proceed with an initial oxidation of the acylamino group to acylamine N-oxide, followed by the hydrolysis of the acyl group to a free amine N-oxide due to the low electron density of carbon-nitrogen bond with an N-oxide formation and the amine N-oxide is oxidized to a nitro compound with an additional hydrogen peroxide as shown in Chart 1.

*¹ Part VIII. T. Kosuge, S. Miyashita : This Bulletin, 2, 397 (1954).

*² Oshika, Shizuoka (伊藤晴之).

1) T. Kosuge : Kenkyu Nenpo (Faculty of Pharm., Univ. of Kanazawa) 2, 3 (1952).

2) *Idem* : *Ibid.*, 2, 22 (1952).

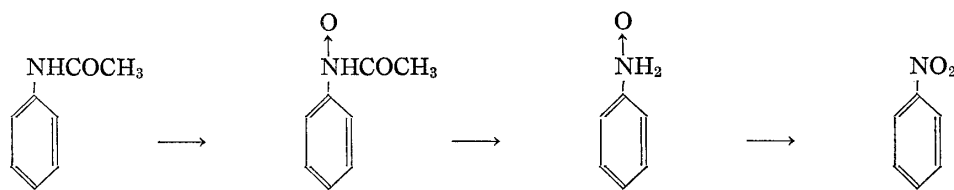


Chart 1.

As the free amine N-oxide is equivalent to the hydroxylamine compound, the latter should be readily oxidized to the nitro compound with hydrogen peroxide, according to the above reaction mechanism. However, the nitro compound could not be obtained in satisfactory yield by the oxidation of the hydroxylamine compound with this oxidation reagent. In oxidations of N-(*p*-tolyl)hydroxylamine and *p*-hydroxyaminobenzenesulfonamide, it was found that *p,p'*-dimethylazoxybenzene and 4,4'-azoxydibenzenesulfonamide were isolated in yields of 60 and 64% of the theoretical amount, respectively, but the formation of *p*-nitrotoluene was observed only in 9.5% and none of 4-nitrobenzenesulfonamide could be obtained. These yields were much lower than those of the corresponding nitro compounds (33 and 57% respectively) for the oxidation of 4'-methylacetanilide and *p*-acetamidobenzenesulfonamide. Based on the above results, it was concluded that the formation of a free amine N-oxide is out of the main course of this oxidation and the reaction from the acylamine N-oxide to the nitro compound may proceed in the different fashion from the mechanism previously proposed. The purpose of this paper is to set up the reasonable reaction mechanism for this reaction.

It is necessary, at first, to confirm that the first step of Chart 1 is really taking part in the oxidation reaction. No acylamine N-oxide, which is the intermediate of the first step could be isolated from the reaction mixture, but the corresponding 4-(N-hydroxyacetamido)benzenesulfonamide³⁾ was oxidized to *p*-nitrobenzenesulfonamide in almost theoretical yield of 97% by the hydrogen peroxide oxidation. This fact indicates that the acylamine N-oxide, if it is present, is oxidized quite easily to the corresponding nitro compounds and it can be assumed that the reaction proceeds through N-oxidation of acylamino compounds.

When the reaction was cut off before its termination, nitroso compounds were obtained in good yields. For example, the oxidation of 4'-methylacetanilide was stopped after twenty minutes and glacial acetic acid employed as the solvent was neutralized with ammonia and then the reaction mixture was subjected to the steam-distillation. *p*-Nitrosotoluene was obtained as green oily distillate, which was condensed with *p*-aminobenzoic acid to *p*-(*p*-tolylazo)benzoic acid. Its characterization was performed by means of both the mixed melting point determination and the infrared spectral comparison with the authentic sample. Thus the nitroso compound is rigorously proved to be the intermediate, for it was oxidized to the corresponding nitro derivative in 84% yield in this case. N-Acetylhydroxylamine N-oxide (III) is assumed to be one of the reasonable intermediate between N-hydroxyacetamido and nitroso compounds and the reaction mechanism for this oxidation is considered as shown in Chart 2.

The main limitation for the preparation of nitro compounds from free amino compounds by oxidation procedure in general would be the easy formation of azo or azoxy compounds due to the condensation of amino or azoxy compounds with nitroso compounds. However, in this reaction, the amine and hydroxylamine functions are protected by the acyl group and free from the condensation with most of the nitroso compounds. Consequently the nitroso compound produced is converted into the nitro compound without any side reaction. This would be the most significant point of this reaction.

3) H. Bauer, S.M. Rosenthal: J. Am. Chem. Soc., **66**, 611 (1944).

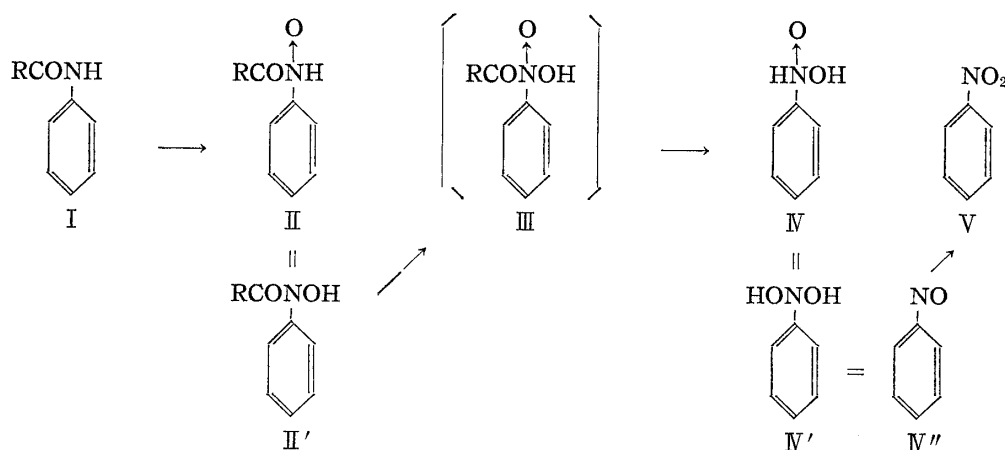


Chart 2.

In the part III⁴⁾ of this series, it has been described that yields of oxidation increase when the acylamino compounds possess the strong electron-attracting groups in the benzene nuclei. On the other hand, the increase of electron density of amino nitrogen atom may result the increase of the reaction rate and yield, according to the reaction mechanism cited above, and this consideration seems to be disagreeable with the fact of part III. Details for this explanation will be described in the next paper.

Experimental^{*3}

Oxidation of N-(*p*-Tolyl)hydroxylamine—A mixture of N-(*p*-tolyl)hydroxylamine (2 g.), 30% H₂O₂ (5.2 g.) in AcOH (32 ml.) was heated on a steam bath for 5 hr., 1.7 g. of 30% H₂O₂ was added further to the reaction mixture and the reaction was continued for 2 hr. Then, the mixture was neutralized with conc. NH₄OH under ice-cooling, and steam-distilled. Yellowish needles (1.06 g.), m.p. 51~52°, were obtained, which were identified as *p*-nitrotoluene by admixture. Yield, 9.3%. The mother liquor of steam-distillation was allowed to stand overnight, brownish yellow needles (1.06 g.) precipitated, m.p. 68~70°. This substance was recrystallized from EtOH to yellowish needles, melting point and mixed melting point with *p,p'*-azoxytoluene were 70~70.5°.

Oxidation of 4-Hydroxyaminobenzenesulfonamide—A mixture of 4-hydroxyaminobenzenesulfonamide (1 g.) and 30% H₂O₂ (3.1 ml.) in AcOH (14.6 ml.) was heated on a steam bath, the mixture was concentrated *in vacuo* and 0.52 g. of yellow crystals, m.p. 280~285°, was obtained. Recrystallization from EtOH gave yellow needles, whose melting point and mixed melting point with 4,4'-azoxydibenzene-sulfonamide showed 288~289°. *Anal.* Calcd. for C₁₂H₁₂O₅N₂S₂: C, 40.44; H, 3.39; N, 15.72. Found: C, 40.62; H, 3.56; N, 15.50.

Oxidation of 4-(N-Hydroxyacetamido)benzenesulfonamide—A mixture of 4-(N-hydroxyacetamido)benzenesulfonamide (1 g.) and various amount of 30% H₂O₂ in AcOH (6.5 ml.) was heated on a steam bath. The mixture was concentrated under reduced pressure and the residue was neutralized with 10% NH₄OH.

TABLE I.

30% H ₂ O ₂		Time (hr.)	Yield	
(ml.)	(mole)		(g.)	(%)
2.9	6.5	6	0.78	82
3.5	8.0	5	0.84	89
3.5	8.0	2		
3.5	8.0	7	0.93	97
3.5	8.0	2		

^{*3} All melting points are uncorrected.

4) T. Kosuge, M. Sato, S. Miyashita: Kenkyu Nenpo (Faculty of Pharm., Univ. of Kanazawa) 2, 19 (1952).

The precipitate, m.p. 174~177°, was recrystallized from H₂O to yellowish needles (m.p. 177~178°), which was undepressed on admixture with 4-nitrobenzenesulfonamide. The yields corresponding to various conditions, were shown below.

Formation of *p*-Nitrosotoluene by Oxidation of 4'-Methylacetanilide—A mixture of 4'-methylacetanilide (5 g.) and 30% H₂O₂ (28 ml.) in AcOH (48 ml.) was heated on a steam bath for 0.5 hr., and then neutralized with conc. NH₄OH under ice-cooling. 85% HCOOH (15 ml.) was added and the solution was submitted to steam-distillation, the distillate was extracted with Et₂O and the Et₂O solution was dried (Na₂SO₄) and evaporated to dryness, 0.8 g. of a green oily material was obtained. A mixture of this substance (0.2 g.) and *p*-aminobenzoic acid (3.0 g.) in AcOH (2 ml.) was heated on a steam bath for 10 hr., and it was evaporated *in vacuo* to dryness, the residue was dissolved in 10% Na₂CO₃ and the Na₂CO₃ solution was acidified with dil. HCl. Reddish brown precipitate (0.05 g.) was collected by filtration. This substance was recrystallized from EtOH to orange needles, m.p. 283°(decomp.), which was undepressed with *p*-(*p*-tolylazo)benzoic acid, IR spectra of both substances were superimposable. *Anal.* Calcd. for C₁₄H₁₂O₃N₂: C, 69.99; H, 5.03; N, 11.66. Found: C, 69.76; H, 5.08; N, 11.54.

Formation of *p*-Nitrotoluene by Oxidation of *p*-Nitrosotoluene—A mixture of *p*-nitrosotoluene (0.17 g.) and 30% H₂O₂ (0.6 ml.) in AcOH (2.5 ml.) was heated on a steam bath for 1 hr. The mixture was neutralized with conc. NH₄OH under ice-cooling and submitted to steam-distillation, yellowish needles (0.16 g.) m.p. 50~51°, was obtained as distillate. This substance was identified as *p*-nitrotoluene by admixture.

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Summary

A new reaction mechanism of the oxidation of acylamino compounds by hydrogen peroxide to afford nitro compounds was proposed.

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48. Haruyuki Ito : Synthesis of Nitro Compounds by Means of Oxidation of Acylamino Compounds. X*¹. Reinvestigation of Reaction Conditions of Oxidation of Acylamino Compounds to Nitro Compounds.

(Shizuoka College of Pharmacy*²)

In the Part X*¹ of this series, a suggestion of the new mechanism has been made for the oxidation of acylamino compounds to nitro compounds by means of hydrogen peroxide in glacial acetic acid. Based on this mechanism, it was considered that the introduction of electron-releasing groups to the benzene nucleus would increase the yields of the resulting nitro compounds and electron-attracting groups, on the other hand, would decrease the formation of the nitro compounds. However, the opposite experimental results to this consideration have been reported in the previous paper¹⁾ and therefore, it was necessary to explain the reasons of this disagreement. This paper

*¹ Part X : This Bulletin, 12, 326 (1964).

*² Oshika, Shizuoka (伊藤晴之).

1) T. Kosuge, *et al.* : Kenkyu Nenpo (Faculty of Pharm., Univ. of Kanazawa), 2, 22 (1952).