β-type of picolinamide was supposed to have similar crystal structure to β-type of pyrazinamide.

The author's thanks are due to Prof. Miyazawa of Osaka University for helpful discussions and suggestions. The author is also indebted to Messrs. Amakasu and Higuchi for IR measurements and to Miss Sasaki for her kind assistance.

Summary

Infrared absorption spectra of benzamide, *p*-substituted benzamide, pyridinecarboxylic acid amides, pyrazinamide and their homologs were measured in Nujol mull and in solution, and the assignment of the characteristic absorption has been made. The infrared absorption spectral data suggested the crystal structure of isonicotinamide, α- and β-type of pyrazinamide and β-type of pyrazinamide.

1) Benzamide, *p*-substituted benzamides, picolinamide (β-type), and pyrazinamide (β-type) showed a similar absorption tendency and are therefore supposed to have a similar crystal structure. β-Type of picolinamide and pyrazinamide is different in symmetric center.

2) Nicotinamide and isonicotinamide showed the same absorption tendency and, therefore, the same crystal structure was formed.

3) Pyrazinamide (α-type) and picolinamide (α-type) showed the same absorption tendency and is supposed to form the same crystal structure.

(Received June 22, 1962)

UDC 547.538.2.07

111. Issei Iwai and Tetsuo Hiraoka: Studies on Acetylenic Compounds. XXXI.[*1] Intramolecular Cyclization Reaction of the Acetylenic Compounds.

(*Takamine Laboratory, Sankyo Co., Ltd.*[*2])

There are few examples available[1] concerning the intramolecular condensation of a triple bond to an aromatic nucleus. This time it was found that this condensation can be carried out more effectively to a variety of acetylenic derivatives by the treatment with polyphosphoric acid (PPA) under a mild condition.

Heating of 1,4-diphenyl-1-butyne (I)[2] with PPA gave 2-phenylnaphthalene (IV), m.p. 100~101° and a liquid of b.p_5 162~170° (bath temp.). The latter exhibited ultraviolet absorption bands at 220 and 285 mμ, very similar to that of 1-phenylnaphthalene (III). However, it showed an aliphatic C-H stretching absorption at 2900 cm^{-1} region in infrared spectrum. When the oily liquid, b.p_5 162~170° was heated with powdered sulfur, it gave a colorless oil, b.p_2 145~150° (bath temperature) in good yield, which was identified as 1-phenylnaphthalene (III) by comparing its infrared and ultraviolet spectra with

*1 Part XXX: This Bulletin, **11**, 524 (1963).

*2 Nishi-shinagawa Shinagawa-ku, Tokyo (岩井一成, 平岡哲夫).

1) F. G. Baddar, E. H. Ghaly, M. F. El-Neweihy: J. Chem. Soc., **1961**, 2528. I. Iwai, J. Ide: This Bulletin, **10**, 926 (1962).

2) I. Iwai, Y. Okajima: Yakugaku Zasshi, **78**, 1404 (1958).

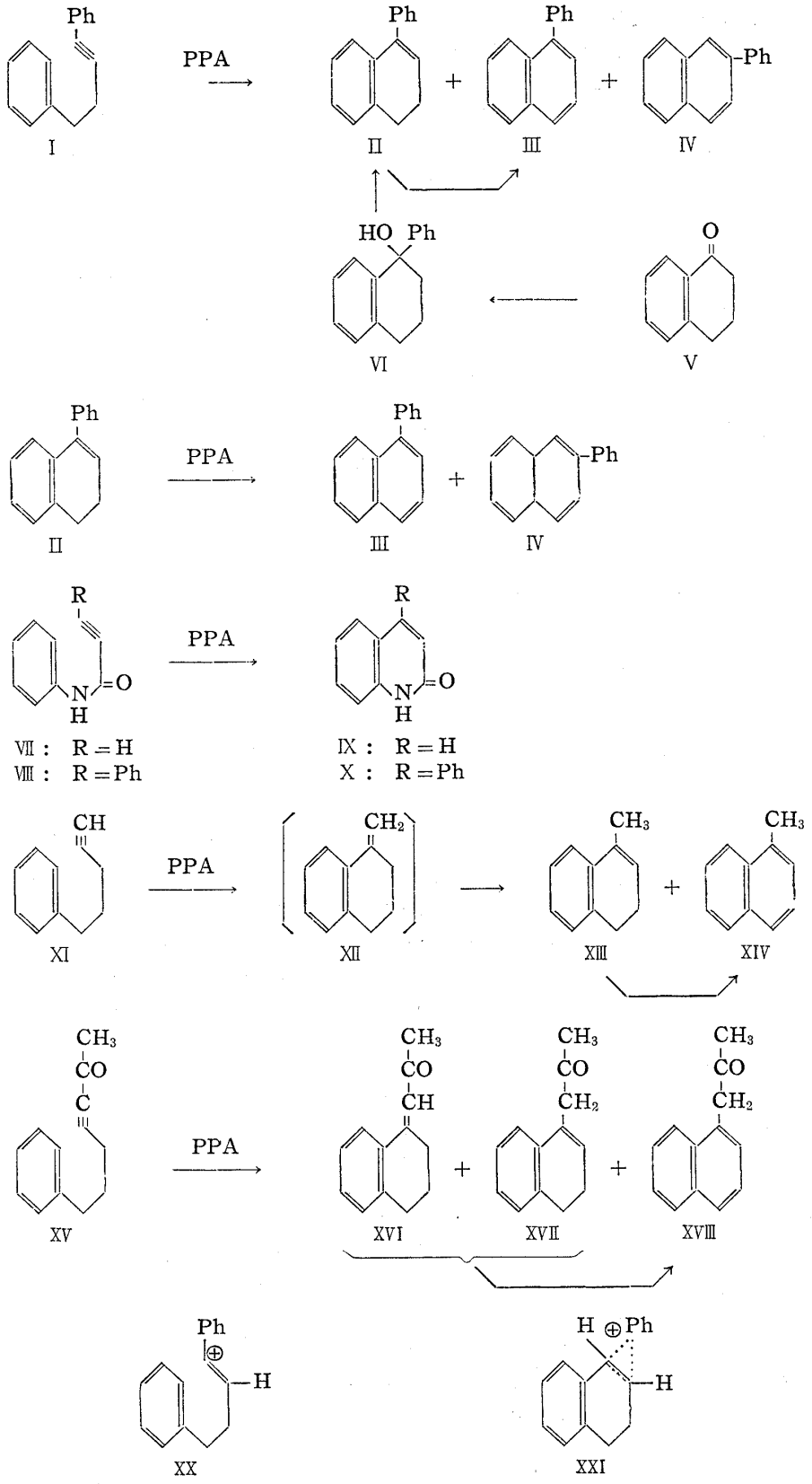
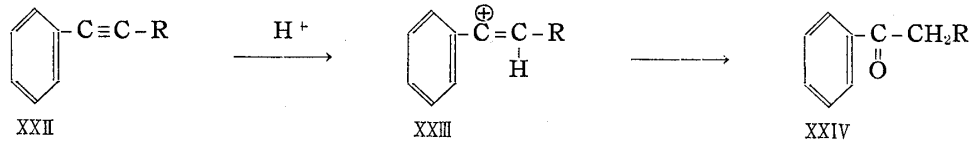


Chart 1.

those of an authentic sample prepared from α-tetralone and phenylmagnesium bromide according to the known method.[3] From these results, the oily product was considered to be a mixture of 1-phenylnaphthalene (III) and 1-phenyl-3,4-dihydronaphthalene (II). The dehydrogenation action of PPA with dihydronaphthalene derivatives has never been reported. In order to confirm this fact, 1-phenyl-3,4-dihydronaphthalene (II) prepared from α-tetralone and phenylmagnesium bromide, was heated with PPA. As expected, 1-phenylnaphthalene (III) and 2-phenylnaphthalene (IV) were obtained. Considering from these results, the first cyclization product of 1,4-diphenyl-1-butyne must be 1-phenyl-3,4-dihydronaphthalene (II) which may have been converted through an intermediate (XXI) by protonation with PPA, to dehydrogenated products, 1-phenylnaphthalene (III) and 2-phenylnaphthalene (IV).

In the cyclization of I, if the phenyl substituent acts as an electron-attracting group, it has to result into a five-membered ring compound. However, practically only a six-membered ring compound was obtained. Therefore, the intermediate for II is presumed to be XX which agrees with the intermediate proposed by Petrov, *et al.*[4] in hydration reaction of an alkylphenyl-acetylene (XXII).



XXII XXIII XXIV

XXV XXVI

Contrary to our expectation, 1-phenyl-3-butyn-2-one (XXV) and 1,4-diphenyl-3-butyn-2-one (XXVI) did not afford β-naphthol derivatives by the similar procedure.

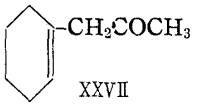
On heating with PPA propiolanilide (VII)[5] and 3-phenylpropiolanilide (VIII)[6] could be converted into carbostyril (IX), m.p. 196~198° and 4-phenylcarbostyril (X), m.p. 259~261°, respectively, in high yields. 3-phenylpropiolanilide (VIII) was found to be more reactive than propiolanilide (VII), because of easy protonation due to the presence of its phenyl group.

By the similar treatment with PPA, 5-phenyl-1-pentyne (XI)[7] gave an oily mixture, b.p_{15} 110~115° (bath temperature) which showed a very similar ultraviolet absorption spectrum to that of 1-methylnaphthalene, and when this was reacted with powdered sulfur, it accompanied with the evolution of hydrogen sulfide gas to afford 1-methylnaphthalene (XIV) b.p_{20} 127~129° (bath temperature). From these facts, the oily product was considered to be a mixture of 1-methyl-3,4-dihydronaphthalene (XIII) and 1-methylnaphthalene (XIV). A compound of type (XII) possessing the exo-methylene group could not be obtained, therefore, it was regarded as the intermediate of this reaction.

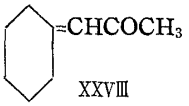
An action of PPA on 7-phenyl-3-heptyn-2-one (XV) prepared from 5-phenyl-1-pentynylmagnesium bromide and acetic anhydride, afforded a liquid of b.$p_{0.001}$ 100~110° (XIX) in rather low yield. The oily liquid (XIX) was confirmed to be a mixture of (1,2,3,4-tetrahydro-1-naphthylidene)-2-propanone (XVI), 1-(3,4-dihydro-1-naphthyl)-2-propanone

3) R. Weiss: Org. Synth. Coll., Vol. III, 729.
4) A.A. Petrov, B.S. Kupin: Zhur. Obshchei Khim., **31**, 2958 (1961).
5) F. Straus, W. Voss: Chem. Ber., **59**, 1681 (1962).
6) J.V. Braun, H. Ostermayer: *Ibid.*, **70**, 1002 (1937).
7) E.F. Jenny, K.D. Meier: Angew. Chem., **71**, 245 (1959).

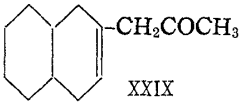
(XVII) and (1-naphthyl)-2-propanone (XVIII) from the following data; (i) XIX was dehydrogenated with sulfur into (1-naphthyl)-2-propanone (XVIII) which was identified as its 2,4-dinitrophenylhydrazone (m.p. 174~175°). (ii) XIX showed in infrared spectrum 1710 and 1680 cm^{-1} bands which are characteristic for a saturated and α,β-unsaturated ketone, respectively. Dickins, *et al.*[8] have reported an equilibrium reaction of (1-cyclohexen-1-yl)-2-propanone (XXVII) and cyclohexylidene-2-propanone (XXVIII) with an acid or an alkaline catalyst. Similar phenomenon was also observed between (*trans*-1,4,4a,5,6,7,8,8a-octahydro-2-naphthyl)-2-propanone (XXIX) and (*trans*-decahydro-2-naphthylidene-2)-propanone (XXX).[9]



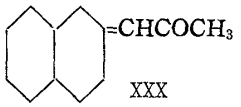
XXVII



XXVIII



XXIX



XXX

Considering from these facts, the oily liquid must contain XVI and XVII. (iii) If the liquid (XIX) is only a mixture of XVI and XVII it should absorb 1 mole of hydrogen gas on hydrogenation but it practically absorbed about 0.7 moles of hydrogen gas in the presence of palladium-carbon. This fact suggests that the liquid (XIX) also contains some amounts of an aromatic compound (XVIII) besides XVI and XVII. The liquid (XIX) showed in ultraviolet spectrum almost similar absorptions to that of 1-alkylnaphthalene. Then it was concluded that the liquid (XIX) contains (1-naphthyl)-2-propanone (XVIII) besides XVI and XVII.

Experimental*3

1-Phenyl-3,4-dihydronaphthalene (II), 1-Phenylnaphthalene (III) and 2-Phenylnaphthalene (IV) from 1,4-Diphenyl-1-butyne (I)——To PPA prepared from P_2O_5(15.7 g.) and 85% H_3PO_4(10 cc.) as usual, was added 1,4-diphenyl-1-butyne (I)[2] (1 g.) and the reaction mixture was heated in an oil bath at 135° for 12 hr. The resulting viscous solution was poured into ice-water and extracted with Et_2O. The combined extracts were washed with $NaHCO_3$ solution and water, until neutral to litmus, dried over andyd. Na_2SO_4 and evaporated. The residue was carefully distilled under reduced pressure and the following fractions were collected : (i) b.p_5 162~170° (bath temperature) (330 mg.) (ii) b.p_5 180~190° (bath temperature) (223 mg.). The fraction (i) is confirmed to be a mixture of 1-phenyl-3,4-dihydronaphthalene (II) and 1-phenylnaphthalene (III) from its conversion into 1-phenylnaphthalene and from comparison of IR and UV spectra with that of the authentic sample prepared according to the known method.[3] II and III could not be separated by distillation. So, the fraction (i) was treated with S without purification into 1-phenylnaphthalene as follows : The fraction (i) (250 mg.) was heated at 250° (bath temperature) in a distillation flask for 30 min. The resulting syrupy oil was distilled from the same flask to give a liquid of b.$p_{2.5}$ 145~150° (bath temperature) (200 mg.). This showed the same IR and UV spectra as that of the authentic 1-phenylnaphthalene (III). *Anal.* Calcd. for $C_{16}H_{12}$: C, 94.08; H, 5.92. Found : C, 94.09; H, 6.02. UV λ_{max}^{EtOH} mμ (log ε) : 224 (5.18), 286 (4.34). The fraction (ii) crystallized on standing. Recrystallization from MeOH gave 2-phenylnaphthalene (IV) of m.p. 100~101°, on admixture with the authentic sample, no depression in melting point was observed. *Anal.* Calcd. for $C_{16}H_{12}$: C, 94.08; H, 5.92. Found : C, 94.21; H, 6.01. UV λ_{max}^{EtOH} mμ (log ε) : 249.5 (4.74), 285 (4.10).

Reaction of 1-Phenyl-3,4-dihydronaphthalene (II) with PPA——To PPA prepared from P_2O_5 (23.2 g.) and 85% H_3PO_4(14.8 cc.) as usual, was added 1-phenyl-3,4-dihydronaphthalene (II)[3] (1.5 g.) and the reaction mixture was heated at 135~140° for 14 hr. Then it was poured into ice water and extracted with Et_2O. The combined extracts were washed with $NaHCO_3$ solution and water. After drying over anhyd. Na_2SO_4, Et_2O was evaporated and the residue was carefully distilled under reduced pressure to give the following fractions : (i) b.p_5 163~170° (bath temp.) (0.79 g.) (ii) b.p_5 182~190° (bath temp.) (0.50 g.).

*3 All melting points are uncorrected.

8) A.H. Dickins, W.E. Hugh, G.A.R. Kon : J. Chem. Soc., **1928**, 1630.

9) R.S. Thakur : *Ibid.*, **1932**, 2120.

The fraction (i) showed the same UV and IR spectra as those of the fraction (i) obtained above from I which is a mixture of II and III. The fraction (ii) crystallized on standing to afforded flakes of m.p. 90～93°. Recrystallization from MeOH gave pure 2-phenylnaphthalene (IV) of m.p. 101～102° (0.31 g.). *Anal.* Calcd. for $C_{16}H_{12}$: C, 94.08; H, 5.92. Found: C, 94,09; H, 5.90.

Carbostyril (IX)——To PPA prepared from P_2O_5 (12.1 g.) and 85% H_3PO_4 (7.7 cc.) as usual, was added propiolanilide (VII)[5] (0.5 g.) and the reaction mixture was heated on an oil bath (135°) with mechanical stirring for 5.5 hr. The hot solution was poured into ice-water (about 60 cc.). After standing overnight a small amount of precipitate (practically negligible amount) was filtered off, and the filtrate was neutralized with 10% NaOH solution until pH value of the solution became about 4. After a while, slightly yellow needles appeared, which were collected, washed with water and dried. It showed m.p. 189～192° with previous softening (415 mg.). Twice recrystallization from water afforded pure carbostyril (IX) of m.p. 196～198°. *Anal.* Calcd. for C_9H_7NO: C, 74.47; H, 4.86; N, 9.65. Found: C, 74.16; H, 5.00; N, 9.64. UV λ_{max}^{EtOH} mμ (log ε): 229.5 (4.58), 268 (3.84), 275 (shoulder), 328 (3.79).

4-Phenylcarbostyril (X)——PPA was prepared from P_2O_5 (12.6 g.) and 85% H_3PO_4 (7.2 cc.) by heating at 100° for 2 hr. To this hot PPA was added 3-phenylpropiolanilide (VIII)[6] (0.5 g.) and the mixture was heated at 115～120° (bath temperature) with mechanical stirring for 30 min. The hot solution was poured into crushed ice and after 1 hr., the precipitate was collected and washed well with water until the filtrate became neutral to litmus. Recrystallization from 95% EtOH gave 4-phenylcarbostyril (X) of m.p. 250～255° with previous softening (406 mg.). One more recrystallization from the same solvent afforded plates of m.p. 259～261°. *Anal.* Calcd. for $C_{15}H_{11}ON$: C, 81.43; H, 5.01; N, 6.33. Found: C, 81.47; H, 4.72; N, 6.16. UV λ_{max}^{EtOH} mμ (log ε): 225.5 (4.57), 278 (3.89), 331 (3.79).

1-Methyl-3,4-dihydronaphthalene (XIII) and 1-Methylnaphthalene (XIV)——To PPA prepared from P_2O_5 (15.6 g.) and 85% H_3PO_4 (9.9 cc.) as usual, was added 5-phenyl-1-pentyne (1.8 g.)[7] and the reaction mixture was heated at 150° (bath temperture) under continuous mechanical stirring for 14 hr. Then it was poured into ice-water and extracted with Et_2O. The combined Et_2O extracts were washed with $NaHCO_3$ solution and water, dried over anhyd. Na_2SO_4, and evaporated. Distillation of the residue gave a liquid of $b.p_{15}$ 110～115° (bath temperature). It weighed 1.1 g. This liquid was confirmed to be a mixture of 1-methyl-3,4-dihydronaphthalene (XIII) and 1-methylnaphthalene (XIV) from the UV and IR spectra and the following dehydrogenation reaction.

The liquid obtained above (832 mg.) was heated with powdered S (194 mg.) in the distillation flask at 245° (bath temperature) for 10 min. and then at 235° (bath temperature) for further 10 min. Then the reaction mixture was distilled under reduced pressure from the same flask to give 1-methylnaphthalene (XIV) of $b.p_{20}$ 127～129° (bath temperature), which showed the same IR and UV spectra as those of the authentic sample. It weighed 778 mg. It afforded picrate of m.p. 138～140° after recrystallization from 95% EtOH. *Anal.* Calcd. for $C_{11}H_{10}$: C, 92.91; H, 7.09. Found: C, 92.68; H, 7.20. UV λ_{max}^{EtOH} mμ (log ε): 223.5 (4.92), 271 (3.71), 281 (3.76), 290 (shoulder).

7-Phenyl-3-heptyn-2-one (XV)——Ethylmagnesium bromide solution was prepared from Mg (2.4 g.), EtBr (10.9 g.) and tetrahydrofuran (50 cc.) as usual. To this solution was added 5-phenyl-1-pentyne[7] (14.4 g.) in tetrahydrofuran (20 cc.) under ice-water cooling. After addition, the reaction mixture was heated at 50° for 2 hr. Then, this Grignard solution was transferred to the dropping funnel and was dropwise added to Ac_2O (20.4 g.) in tetrahydrofuran (150 cc.) at −10° (inner temperature) during 1.5 hr. After addition, the reaction mixture was stirred under ice-water cooling for 2 hr. Then H_2O was carefully added under ice-water cooling and aqueous layer was separated, which was extracted with Et_2O. The combined organic solutions were washed with $NaHCO_3$ solution and water. After drying over anhyd. Na_2SO_4, the organic solvents were removed under reduced pressure. Distillation gave 7-phenyl-3-heptyn-2-one (XV) of $b.p_{0.2}$ 98～100° (13.4 g.). *Anal.* Calcd. for $C_{13}H_{14}O$: C, 83.83; H, 7.58. Found: C, 83.29; H, 7.69. IR λ_{max}^{liquid} μ: 4.54 (-C≡C-), 5.98 (C=O).

(1, 2, 3, 4-Tetrahydro-1-naphthylidene)-2-propanone (XVI), (3,4-Dihydro-1-naphthyl)-2-propanone (XVII) and (1-Naphthyl)-2-propanone (XVIII)——To PPA prepared from P_2O_5 (73.8 g.) and 85% H_3PO_4 (47 cc.) as usual, was added 7-phenyl-3-heptyn-2-one (XV) (8.5 g.) and then the reaction mixture was heated at 100° (bath temperature) for 1.25 hr. The solution was poured into ice-water and extracted with Et_2O. The combined extracts were washed with $NaHCO_3$ solution and water, dried over anhyd. Na_2SO_4 and evaporated. Distillation gave a liquid of $b.p_{0.001}$ 100～110° (2.3 g.). IR λ_{max}^{liquid} μ: 5.85 (C=O), 5.99 (-CH=CH-CO-). It was confirmed to be a mixture of (1,2,3,4-tetrahydro-1-naphthylidene)-2-propanone (XVI), (3,4-dihydro-1-naphthyl)-2-propanone (XVII) and (1-naphthyl)-2-propanone (XVIII) as described before from UV and IR spectra and the following dehydrogenation reaction.

The liquid obtained above (0.3 g.) was heated with powdered S (52 mg.) at 240° in the distillation flask for 25 min. Then the reaction mixture was distilled under reduced pressure to give (1-naphthyl)-2-propanone[10] (XVIII) $b.p_{0.04}$ 105～110° (bath temp.) (150 mg.). It gave 2,4-dinitrophenylhydrazone[11] of m.p.

10) M. S. Newman, Fr. T. J. O'Leary: J. Am. Chem. Soc., **68**, 258 (1946).
11) N. Campbell, W. Anderson, J. Gilmore: J. Chem. Soc., **1940**, 819.

174~175°. *Anal.* Calcd. for $C_{19}H_{16}O_4N_4$(2,4-dinitrophenylhydrazone): C, 62.63; H, 4.43; N, 15.38. Found: C, 62.91; H, 4.36; N, 15.55.

The authors are grateful to Mr. M. Matsui, Director of this Laboratory, and Prof. K. Tsuda of the University of Tokyo for encouragement throughout this work. The measurement of infrared and ultraviolet spectra were carried out by Messrs. H. Higuchi, N. Higosaki and Miss N. Sawamoto. Microanalyses were made by Messrs. T. Onoe, K. Ono, H. Nagashima and Misses H. Ohtsuka and K. Saito to whom the authors' thanks are also due.

Summary

Intramolecular condensational cyclization of the acetylenic compounds to the aromatic nucleus was achieved with polyphosphoric acid, and this reaction was accompanied with dehydrogenation to give naphthalene derivatives. This method can also be used to nitrogen containing acetylenic compounds to prepare carbostryril derivatives.

(Received July 5, 1962)

UDC 547.02 : 543.422.25[539.143.43]

112. Toshihiko Okamoto and Yutaka Kawazoe: Application of Nuclear Magnetic Resonance to Stereochemistry. III.*1 The Spatial Interaction Effect of the Hydroxyl Group to Proton Resonances. (2).*2

(*Faculty of Pharmaceutical Sciences, University of Tokyo**3)

As previously reported,[1] methyl proton resonances have been proved to shift to the lower field by the spatial interaction with the neighbouring hydroxyl group. This spatial relationship was exemplified by 1,3-diaxial position on a cyclohexane or a cyclopentane ring, deduced using a number of steroidal compounds. It was shown, furthermore, that the methyl group spatially interacted by a hydroxyl group could be identified by acetylation of the hydroxyl group, resonating at a remarkably higher field than that of the original hydroxyl derivative. These characteristic features of the methyl signals can be usefully applied to determining the configurations of methyl groups and hydroxyl groups.

Now, this paper concerns the scope and limitations in the application of this relationship. Methin and vinyl protons are also taken into consideration instead of methyl protons. In this paper, the spatial relationships are represented by the distances from the oxygen atom to the carbon or hydrogen atoms concerned (Chart 1) and, in some cases, by the angles between C-OH and C-H bonds. Although these measurements can not clearly elucidate this spatial interaction effect, they will be able to give us

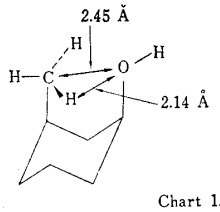


Chart 1.

---

*1 Part II: This Bulletin, **11**, 328 (1963).

*2 Part I: *Ibid.*, **10**, 338 (1962). This paper constitutes Part III of a series entitled "Nuclear Magnetic Resonance Studies" by T. Okamoto and Y. Kawazoe.

*3 Motofuji-cho, Bunkyo-ku, Tokyo (岡本敏彦, 川添 豊).

1) Y. Kawazoe, Y. Sato, M. Natsume, H. Hasegawa, T. Okamoto, K. Tsuda: This Bulletin, **10**, 388 (1962).