b) *p*-Anisic acid : Filt. 2 and 3 were combined and extracted with ether. The ether layer was dried and evaporated, leaving a crystalline residue (110 mg.), which was recrystallized from water to colorless needles, m.p. and mixed m.p. 179~181°.

c) 6-Hydroxy-2,4-diethoxyacetophenone : Cryst. 3 was twice recrystallized from EtOH-H_2O (1:1) to give colorless crystals, m.p. 78~81°, and identified by mixed sample and IR spectrum with a synthetic sample.

Degradation of Cryptomerin A Tetraethyl Ether by Barium Hydroxide——Cryptomerin A (100 mg.) was ethylated as described above to yellow crystals (60 mg.), m.p. 240~241°(softening at 238°). *Anal.* Calcd. for $C_{30}H_{13}O_5(OCH_3)(OC_2H_5)_4$: C, 70.47; H, 5.46. Found : C, 70.03; H, 5.36. Above ether (50 mg.) and *N*-methanolic $Ba(OH)_2$ solution (60 ml.) were treated as above and *p*-anisic acid (7 mg.), m.p. 179~180° was obtained as colorless needles and identified by admixture and IR spectrum.

Degradation of Hinokiflavone Diethyl Trimethyl Ether by Barium Hydroxide——Hinokiflavone diethyl trimethyl ether (300 mg.) and *N*-methanolic $Ba(OH)_2$ solution (360 ml.) were treated as described in case of the degradation of cryptomerin B triethyl ether and the following compounds were obtained from the corresponding parts. (a) A phenolic acid, $C_{18}H_{18}O_7$, m.p. 160° from the corresponding precipitates (110 mg.), which was identified with the above described acid by admixture. (b) *p*-Anisic acid (30 mg.), m.p. 179~180° and (c) 2-ethoxy-4-methoxy-6-hydroxyacetophenone (7 mg.), m.p. 127~130°, which were identified with synthetic samples respectively.

Summary

Cryptomerin A (II) and B (III) were isolated from the leaves of *Cryptomerin japonica* D. Don and their structures were established by the alkaline degradation of their ethyl ethers as the first examples of naturally occurring hinokiflavone methyl ethers.

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191. Tetsuji Kametani,[*1] Hiroshi Sugahara, and Setzu Asagi[*2] : Studies on the Syntheses of Heterocyclic Compounds. CLIX.[*3] The Reaction of 2-Nitro-1-indanone Oxime with Formalin and Hydrochloric Acid.

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The nitrosation[1] of indene with the nitrous acid was shown to give indenepseudonitrosite,[2] which was converted into 2-nitro-1-indanone oxime (I) when refluxed in an excess of ethanol for a long time. On being treated with ethanolic hydrochloric acid, 2-nitro-1-indanone oxime (I) undergoes a novel isomerization in which it is converted into the ring-expanded isocarbostyril derivatives, 2-hydroxy-3-chloroisocarbostyril (II) and N-hydroxyhomophthalimide (III) unexpectedly.[3] The purpose of the present investigation was to study the deoximation of the oxime (I) with formalin and concentrated hydrochloric acid in acetone, however unexpected compounds were obtained.

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[*3] Part CLVII, Tetrahedron Letters, **1966**, 4849 ; Part CLVIII, J. Chem. Soc., **1966**, 2010.

1) T. Kametani, H. Sugahara : Yakugaku Zasshi, **84**, 399 (1964).

2) K. Kigasawa, M. Hiiragi, T. Hayasaka, H. Sugahara, T. Kametani : Yakugaku Zasshi, **84**, 402 (1964).

3) T. Kametani, H. Sugahara : J. Chem. Soc., **1964**, 3856.

Attempted deoximation of I with formalin and hydrochloric acid according to the literature[4,5] gave a resinous substance or recovered starting material. However, the reaction of the oxime (I)with 37% formalin in concentrated hydrochloric acid and acetone afforded three compounds, namely, 2-hydroxymethyl-2-nitro-1-indanone oxime (Ⅳ), 2-hydroxymethyl-2-nitro-1-indanone (V), and 2-nitro-1-indanone (Ⅵ). The elemental analyses and infrared spectra (IR) of compounds, Ⅳ and Ⅵ, agreed with the formulations.

The IR spectrum of compounds (Ⅳ) showed maxima at 3500 and 3300 (OH), 1650 (C=N stretching), and 950 cm^{-1} (N-O). Acetylation with acetic anhydride and sulfuric acid gave the compound (Ⅶ), which lacks OH absorption but has maxima at 1785 and 1745 cm^{-1} (acetyl C=O). The nuclear magnetic resonance (NMR) spectrum of compound (Ⅶ) in deuterochloroform lacks the signal of the X portion (C_2-H) of the ABX system which was recongized as quartet at 3.92τ ($J_{AX}=4$ c.p.s.; $J_{BX}=8$ c.p.s.) in the case of compound (I). Moreover, the ring methylene protons at 3-position, being coupled geminally with splitting of -18 c.p.s., gave rise to two pairs of doublet at 6.01τ and 6.56τ. The methylene protons of the 2-hydroxymethyl group were also shown in the down field AB pattern as one pair of doublet at 4.84τ and 5.42τ. These protons became nonequivalent by virture of the restricted rotation around the bond of C_2-hydroxymethylene group caused by steric hindrance of 2-nitro group; the geminal coupling constant was -12.5 c.p.s. Furthermore, oxidation of Ⅳ with potassium permanganate gave phthalic acid (Ⅷ). Attempted catalytic hydrogenation of compound (Ⅳ) in methanol in the presence of 30% palladium charcoal and hydrochloric acid gave unexpected compounds, ammonium chloride and 2-methyl-1-indanamine (Ⅸ), which lacks OH absorption. Acetylation of Ⅸ with acetic anhydride gave compound (X), which has maxima at 3300 (NH) and 1645 cm^{-1} (amide C=O). The NMR spectrum of the hydrochloride of compound (X) showed the protons of the 2-methyl group at 1.31 and 1.41 p.p.m. as a doublet in trifluoroacetic acid. This fact revealed that hydrogenolysis of amino group occurred at the 2-position. If the amino group at 1-position had been hydrogenolated to give the degradation product (Ⅸa), the signal of 2-methyl group would appear as a singlet.

The compound (V) was obtained as a viscous oil whose IR spectrum showed maxima at 3350 (OH), 1705 (C=O), and 1535, 1360 cm^{-1} (NO_2), but could not be purified by distillation under reduced pressure because of decomposition. Therefore, attempted acetylation of V with acetic anhydride and sulfuric acid gave the compound (Ⅺ) as an oil which was purified by distillation. The IR spectrum of compound (Ⅺ) lacks OH absorption but has maxima at 1745 (ester C=O) and 1725 cm^{-1} (ketone C=O). Furthermore, hydrolysis of compound (Ⅺ) with hydrochloric acid also yielded 2-hydroxymethyl-2-nitro-1-indanone (V).

The NMR spectrum of Ⅺ showed the presence of the methylene of the 2-acetoxymethyl group and the ring methylene at 2-position as a quartet. The latter signals are shown at 5.02τ and 5.46τ ($J_{AB}=-12.5$ c.p.s.), and the former ones at 5.96τ and 6.53τ ($J_{AB}=-18$ c.p.s.) respectively. Furthermore, the protons of the methyl radical of the acetyl group are observed at 8.0τ as a singlet, and aromatic protons at $2.08\sim2.62\tau$ as a multiplet.

The IR spectrum of compound (Ⅵ) showed maxima at 1725 (ketone C=O), and 1545, 1360 cm^{-1} (NO_2). This fact reveals that the structure of this compound (Ⅵ) is correct. Catalytic hydrogenation of compound (Ⅵ) in ethanol in the presence of 10% palladium charcoal and an excess of concentrated hydrochloric acid afforded 2-indanamine (Ⅻ) as its hydrochloride, m.p. 235~238° (decomp.) which was identical with an authentic sample.[2] The same catalytic hydrogenation of Ⅵ as above in the presence

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[4] J. A. Barltrop, A. J. Johnson, G. D. Merkins : J. Chem. Soc., **1951**, 181.
[5] M. P. Cava, R. L. Litle, D. R. Napier : J. Am. Chem. Soc., **80**, 2257 (1958).

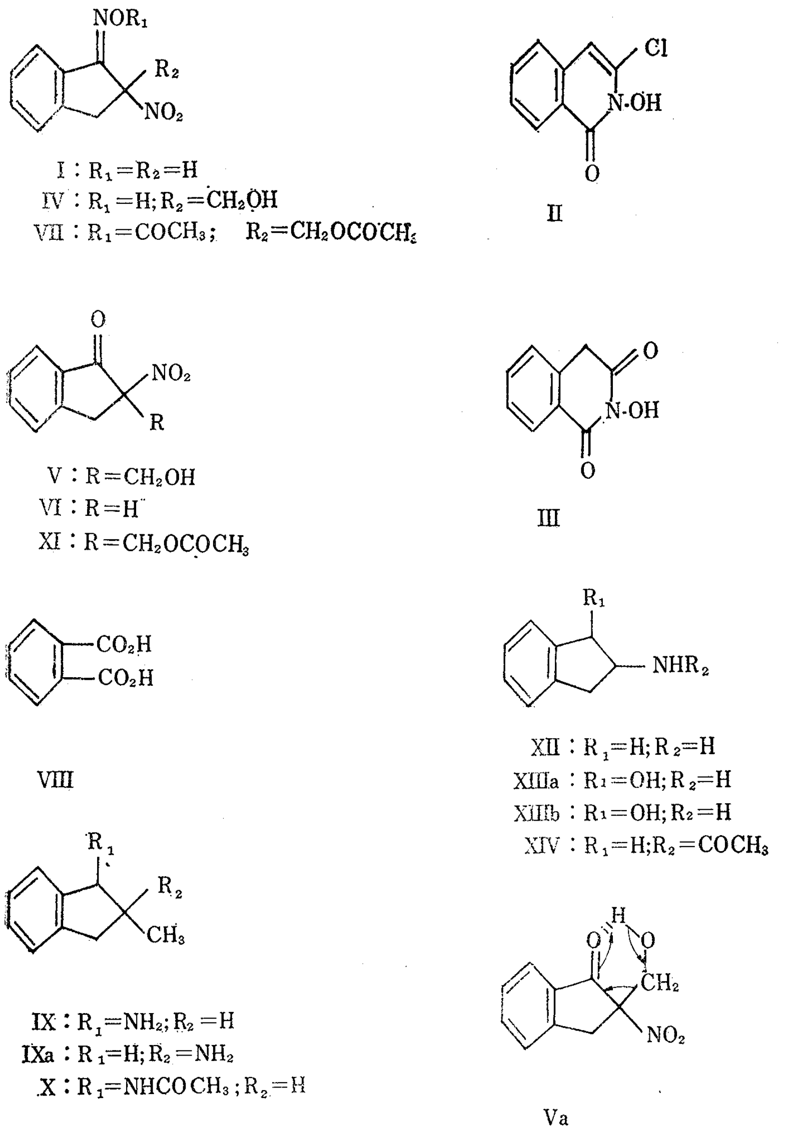

Chart 1.

of one molar amount of concentrated hydrochloric acid gave a mixture of diastereoisomers, m.p. 206~208° (decomp.) and 174~175° (decomp.), which were separated by recrystallization from ethanol-ether. The IR spectra of both specimens, XIIIa and XIIIb, showed maxima at 3250*4 and 3050 cm^{-1} (OH and NH_2) and were completely identical. Furthermore, Lebin, *et al*[6] reported the existence of two diasteroisomers of 2-amino-1-indanol[7] having m.p. 172° and m.p. 206°, in agreement with our specimens. Aceytlation of 2-indanamine (XII) gave the acetyl derivative (XIV), m.p. 126~127°, which agreed with an authentic sample[8] and had the correct analysis.

In this reaction the temperature and time seem critical. For instance, two hours' heating at 40~50° gave compounds (IV and V) as the main products, but four hours' heating at the same temperature afforded compounds (V and VI) as the main products. In case of five hours' heating at 50~60° the compound (IV) was scarcely obtained, but compound (VI) was formed as the main product. Almost the same amount of V and VI was obtained after five hours' heating at 70~80°. The reaction of IV with formalin under the same conditions as above at 40~50° for two hours gave no compound (V), and starting material was recovered. On the other hand, treatment of IV under these conditions at 50~60° for five hours gave a mixture of IV, V, and VI. Furthermore, the same treatment of the above compound (V) afforded a mixture of V and VI.

Perhaps the simplest mechanism to explain the formation of the compounds IV, V, and VI would initially involve addition of formalin to I and formation of IV in acid media to yield the compound (V). Elimination of the hydroxymethyl group would lead to VI *via* Va. This elimination mechanism of V to VI appears similar to the removal

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*4 In case of 2-indanamine (XII) the absorption band at 3250 cm^{-1}(in KBr) was not observed.

[6] N. Lebin, B.E. Grahem, H.G. Kolloff: J. Org. Chem., **9**, 380 (1944).

[7] German Pat., 598,142 (1934).

[8] J. Kenner, A.M. Mathews: J. Chem. Soc., **105**, 747 (1914).

reaction of a hydroxyethyl group from β-2-(2-oxo-3,5-dimethylcyclohexyl)-2-hydroxyethylglutarimide according to Kornfeld, *et al.*[9]

Experimental

IR and NMR spectra were measured on Type EPI-3 Hitachi recording spectrophotometer and a Varian A-60 spectrophotometer with deuterochloroform or trifluoroacetic acid as solvent and tetramethylsilane as internal reference. Melting points were not corrected.

The Reaction of 2-Nitro-1-indanone Oxime (I) with Formalin and Hydrochloric Acid——a) A mixture of 6.5 g. of 2-nitro-1-indanone oxime (I), 32 ml. of 37% CH_2O, 16 ml. of conc. HCl, and 16 ml. of acetone was heated at 40~50° for 2 hr. under stirring to give a clear solution. After the reaction, the solvent was removed under reduced pressure and the resultant residue was poured into ice and water, an oil being separated and extracted with ether. The solvent was washed with water, dried on Na_2SO_4, and distilled to give 6.5 g. of an oil, to which a small amount of benzene was added. On standing in a refrigerator, 3.2 g. of compound (IV) was separated as colorless crystals. The benzene layer was removed from the mother liquor by distillation. After a solution of the resultant residue in ether had been admixed with 10% Na_2CO_3 solution, a precipitate which separated after a few minutes was removed by filtration. The ethereal filtrate was washed with water, dried on Na_2SO_4, and distilled to give 2.5 g. of an oil (V). A suspension of the above precipitate in water was acidified with 10% HCl solution and extracted with ether. The solvent was washed with water, dried on Na_2SO_4, and removed by distillation, to give 0.4 g. of the compoud (VI) as pale yellowish brown crystals.

Recrystallization of IV from iso-PrOH gave 2-hydroxymethyl-2-nitro-1-indanone oxime as colorless prisms, m.p. 164°(decomp.). *Anal.* Calcd. for $C_{10}H_{10}O_4N$: C, 54.05; N, 4.54; N, 12.61. Found : C, 53.89; H, 4.10; N, 12.53. IR cm^{-1}(KBr) : ν_{max} 3300 (OH), 1650 (C=N), 1550, 1350 (NO_2), and 950 (N-O). UV mμ (log ε) : λ_{max}^{EtOH} 257.5 (4.11), 286 (3.59), 295 (3.68), and 305.5 (3.59), $\lambda_{max}^{0.1N\ NaOH\text{-}EtOH}$ 249 (4.08), 308 (4.00), and 318 (3.97). Recrystallization of VI from iso-PrOH gave 2-nitro-1-indanone as pale yellowish brown scales, m.p. 80~81.5°. *Anal.* Calcd. for $C_9H_7O_3N$: C, 61.01; H, 3.98; N, 7.91. Found : C, 61.01; H, 4.07; N, 7.88. IR cm^{-1} (KBr) : ν_{max} 1725 (C=O) and 1545, 1360 (NO_2). UV mμ (log ε) : $\lambda_{max}^{1N\ NaOH\text{-}EtOH}$ 263 (3.78) and 371 (4.37).

Distillation of the above yellowish brown viscous oil (V) failed because of decomposition. Therefore, after the oil (V) had been acetylated, distillation of the acetyl derivative (XI) gave an oil whose nature will be described later. Hydrolysis of 0.5 g. of the above oil with 5 ml. of 10% aq. HCl and 5 ml. of EtOH under reflux on a water bath for 0.5 hr. and treatment as usual gave 0.25 g. of an oil, which was moreover purified by alumina chromatography to give V as a yellow oil. IR cm^{-1}(liquid) : ν_{max} 3350 (OH), 1705 (C=O), and 1535, 1360 (NO_2).

b) After a mixture of 25 g. of the above oxime (I), 125 ml. of 37% CH_2O, 62.5 ml. of conc. HCl and 62.5 ml. of acetone had been heated at 50~60° for 5 hr. with stirring, the reaction mixture was treated as usual according to method (a), both compounds, 7.0 g. of V and 9.6 g. of VI being obtained. In this case the compound (IV) was scarcely obtained.

Furthermore, the same treatment of 5 g. of the oxime (I) with the corresponding reagents at 70~80° for 5 hr. afforded a mixture of 1.6 g. of V and 1.7 g. of VI.

The Reaction of the Compound (IV) with Formalin and Hydrochloric Acid——A mixture of 5 g. of IV, 25 ml. of 37% CH_2O, 12.5 ml. of conc. HCl, and 12.5 ml. of acetone was heated at 50~60° for 5 hr. The same treatment of the reaction mixture according to method (a) gave 2.0 g. of an oily substance (V) and 1.5 g. of VI in addition to 1.1 g. of the starting material (IV).

The Reaction of the Compound (V) with Formalin and Hydrochloric Acid——A mixture of 2.0 g. of V, 10 ml. of 37% CH_2O, 5 ml. of conc. HCl, and 5 ml. of acetone was heated at 40~60° for 4 hr. and treated as usual, 0.4 g. of the compound (VI) and 1.2 g. of an oily substance thus being obtained.

Acetylation of IV——To a suspension of 0.5 g. of IV in 2 ml. of Ac_2O was added dropwise 2 ml. of Ac_2O containing a few drops of conc. H_2SO_4, the crystals of IV being dissolved to give a clear solution with a heat formation. After being stirred for an additional 1 hr., the reaction mixture was poured into ice and water, and 0.6 g. of the crude crystals obtained were collected by filtration. Recrystallization from EtOH afforded 1-acetoxyimino-2-acetoxymethyl-2-nitroindane (VII) as colorless prisms, m.p. 150~151°. *Anal.* Calcd. for $C_{14}H_{14}O_6N_2$: C, 54.90; H, 4.61; N, 9.15. Found : C, 54.51; H, 4.83; N, 9.13. IR cm^{-1}(KBr) : ν_{max} 1785, 1745 (C=O) and 1565, 1360 (NO_2). UV mμ (log ε) : λ_{max}^{EtOH} 259.5 (4.15), 297.6 (3.67), and 302 (3.65). NMR (τ) (in $CDCl_3$) : 6.01, 6.56 (doublet, $J_{AB} = -18$ c.p.s.) and 4.84, 5.42 (doublet, $J_{AB} = -12$ c.p.s.).

Oxidation of IV——To a heated solution of 1 g. of IV in 20 ml. of 5% aq. KOH was added dropwise a saturated aqueous solution of 5 g. of $KMnO_4$ with stirring. After the decoloration had ceased, the reaction mixture was stirred and heated for an additional 0.5 hr., and an excess of $KMnO_4$ was decomposed with methanol. The resultant mixture was then filtered while warm and the filtrate was concentrated on a water

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[9] E. C. Kornfeld, R. G. Jones, T. V. Parke : J. Am. Chem. Soc., **71**, 150 (1949).

bath under reduced pressure. The residue was acidified with 10% HCl solution and extracted with ether. The extract was dried on Na_2SO_4 and removal of the solvent gave 0.8 g. of the crude crystals, which were recrystallized from water to give phthalic acid (VIII) as colorless prisms, m.p. 203° (decomp.). Sublimation of this acid gave phthalic anhydride, m.p. 133°, which was identical with an authentic sample by mixed melting point test and IR spectrum.

Catalytic Hydrogenation of IV——A solution of 1.1 g. of the above compound (IV) in 50 ml. of MeOH was hydrogenated with H_2 at room temperature in the presence of 0.5 g. of 30% Pd-C and 2 ml. of conc. HCl, a calculated amount of H_2 being absorbed within 17 hr. After the catalyst had been removed by filtration, removal of the solvent gave 0.4 g. of a colorless solid, which was extracted with iso-PrOH. In this case NH_4Cl remained as an insoluble substance, which was positive against Nessler's reagent and $AgNO_3$. Filtration, removal of the solvent, and recrystallization of the resultant residue from iso-PrOH afforded HCl salt of 2-methy-1-indanamine (IX) as colorless needles, m.p. 300° (decomp.). *Anal.* Calcd. for $C_{10}H_{13}N \cdot HCl$: C, 65.40; H, 7.63; N, 7.63. Found: C, 65.03; H, 7.65; N, 7.72. IR cm^{-1} (KBr): ν_{max} 2959 (C-Me), UV mμ (log ε): λ_{max}^{EtOH} 261 (2.56), 166.5 (2.71), and 273 (2.63). Recrystallization of the picrate from EtOH-water yielded yellow needles, m.p. 184~185° (decomp.). *Anal.* Calcd. for $C_{10}H_{13}N \cdot C_6H_3O_7N_3$: C, 51.06; H, 4.29; N, 14.89. Found: C, 51.41; H, 4.52; N, 14.46.

1-Acetamino-2-methylindane X——A solution of the above HCl salt of 0.3 g. of IX in a small amount of water was basified with 10% NH_4OH solution and extracted with ether. The extract was washed with water, dried on Na_2SO_4, and filtered. The ethereal filtrate was immediately admixed with 2 ml. of Ac_2O and then the solvent was removed by distillation. The resultant residue was heated under reflux in an oil-bath for 2 hr. After the reaction mixture had been poured into ice and water, 0.2 g. of crystals separated were collected by filtration. Recrystallization from EtOH-water gave 1-acetamino-2-methylindane (X) as colorless needles, m.p. 145~146°. *Anal.* Calcd. for $C_{12}H_{15}ON$: C, 76.19; H, 7.95; N, 7.41. Found: C, 76.07; H, 7.79; N, 7.50. IR cm^{-1} (KBr): ν_{max} 3300 (amide NH) and 1640 (amino C=O).

Acetylation of V——To a stirred solution of 1.0 g. of an oily substance (V) in 5 ml. of Ac_2O was added drop by drop 2 ml. of Ac_2O containing a few drops of conc. H_2SO_4 within 1 hr. on cooling, and the reaction mixture became a pale brown solution, which was poured into ice and water. An oil separated was extracted with ether. The extract was washed with saturated $NaHCO_3$ solution and water, and dried on Na_2SO_4. Removal of the solvent gave a yellowish brown viscous oil, whose distillation *in vacuo* afforded 0.3 g. of 2-acetoxymethyl-2-nitro-1-indanone (XI) as a yellow viscous oil, b.p$_{0.04}$ 138~142°. IR cm^{-1} (liquid): ν_{max} 1745 (ester C=O), 1725 (C=O), and 1550, 1370 (NO_2). UV mμ (log ε): λ_{max}^{EtOH} 257 (4.23), 297 (3.66), and 304 (3.64).

Catalytic Hydrogenation of VI——a) A solution of 1.5 g. of VI in 100 ml. of EtOH was hydrogenated with H_2 in the presence of 0.3 g. of 10% Pd-C and 1 mole of conc. HCl at room temperature, a calculated amount of 525 ml. (4 moles) of H_2 being taken up within 4 hr. Filtration of the catalyst and distillation of the solvent gave 1.5 g. of the solid as the hydrochloride, whose recrystallization from EtOH-ether afforded 0.5 g. of the HCl salt of 2-amino-1-indanol (XIIIa) as colorless needles. Recrystallization from EtOH gave colorless needles, m.p. 206~208° (decomp.). *Anal.* Calcd. for $C_9H_{11}ON \cdot HCl$: C, 58.22; H, 6.47; N, 7.54. Found: C, 58.25; H, 6.66; N, 7.58. IR cm^{-1} (KBr): ν_{max} 3250 (OH) and 3050 (NH). UV mμ (los ε): λ_{max}^{EtOH} 261 (2.66), 266 (2.80), and 272.5 (2.70). The ethanol-ethereal mother liquor afforded an additional crop of 0.5 g. of crystals after addition of an excess of ether. Recrystallization from EtOH-ether gave the other compound (XIIIb) as colorless needles, m.p. 174~175° (decomp.), whose IR spectrum was superimposable on that of the above sample (XIIIa) in KBr. *Anal.* Calcd. for $C_9H_{11}ON \cdot HCl$: C, 58.22; H, 6.47; N, 7.54. Found: C, 58.44; H, 6.69; N, 7.57. TLC [Wakogel B-O; ethanol as solvent; 1% aqueous potassium permanganate as spray]: Rf (XIIIa) 0.41, Rf (XIIIb) 0.31.

b) A mixture of 1 g. of VI, 100 ml. of EtOH, 0.5 g. of 10% Pd-C, and 5 ml. of conc. HCl was hydrogenated with H_2 as usual, a calculated amount of 635 ml. (5 moles) of H_2 being absorbed. Filtration and removal of the solvent gave 1.3 g. of the solid, whose recrystallization from EtOH-ether afforded 0.7 g. of the HCl salt of 2-indanamine (XII) as colorless needles, m.p. 235~238° (decomp.). The IR spectrum of this compound was superimposable on that of an authentic sample²⁾ in KBr.

2-Acetaminoindane XIV——A solution of 0.3 g. of the above hydrochloride of XII in a small amount of water was basified with 10% NH_4OH solution and extracted with ether. After the ethereal extract had been dried on Na_2SO_4, 2 ml. of acetone was added to the above solvent layer, and the mixture was heated on a water bath for 2 hr. Removal of the solvent gave an oily substance which was decomposed with water, basified with 10% NaOH solution, and extracted with $CHCl_3$. The extract was dried on Na_2SO_4 and removal of the solvent afforded 0.4 g. of a reddish brown oil, which was purified by alumina chromatography using benzene as solvent to give 2-acetaminoindane (XIV). Recrystallization from ether-ligroin yielded colorless needles, m.p. 126~127° (lit.,⁸⁾ 126~127°). *Anal.* Calcd. for $C_{11}H_{13}NO$: C, 75.40; H, 7.48; N, 7.99. Found: C, 75.39; H, 7.54; N, 8.10. IR cm^{-1} (KBr): ν_{max} 3300 (NH) and 1645 (C=O).

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Summary

Attempted deoximation of 2-nitro-1-indanone oxime (I) with formalin and hydrochloric acid in acetone gave unexpected compounds, namely, 2-hydroxymethyl-2-nitro-1-indanone oxime (Ⅳ), 2-hydroxymethyl-2-nitro-1-indanone (Ⅴ), and 2-nitro-1-indanone (Ⅵ).

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UDC 543.422.25[541.121]: 546.11.02

192. Yutaka Kawazoe and Masako Ohnishi: Studies on Hydrogen Exchange. Ⅲ.[*1] Deuterium Exchange of Carbonyl Compounds in Alkaline Media.[*2]

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Almost all of hydrogens contained in organic compounds can be considered to be acidic since the most atoms bonding to hydrogens are electrically more negative than hydrogen itself. They tend, therefore, to be abstracted away as protons in presence of bases or appropriate catalysts. Namely, any type of hydrogens can be regarded as the so-called active hydrogens under an appropriate circumstance. Therefore, when the reaction medium contains ordinary active hydrogens such as -OH, -NH, etc., intermolecular hydrogen exchange may occur between solute and solvent molecules. It can be expected, as a result, that any types of hydrogens are to be, in principle, deuterated selectively and successively by using deuterium-containing solvent if an appropriate reaction condition could be chosen. It turns out, therefore, that systematic studies on hydrogen-deuterium exchange must be important not only for synthetic purposes of deuterium (or tritium)-containing compounds but also for studies on various types of reactions such as oxidations, reductions, rearrangements, isomerizations, substitutions which are closely related to the exchange reactivity of hydrogens. From the above standpoint we have attempted to classify hydrogens depending on their reactivities toward intermolecular hydrogen exchange. The classification is tentatively made from two different standpoints; one, according to the reaction condition under which the exchange occurs and the other, according to the exchange rate at which it proceeds under a certain given reaction condition. The latter classification can be conveniently done by nuclear magnetic resonance (NMR) technique, all types of hydrogens being classified into three groups, as follows:

Group 1——Those in which chemical exchange proceeds rapidly enough to give only a singlet signal for all species of active hydrogens in the solution. (Theoretical condideration tells us that when two species of hydrogens, whose chemical shift-difference is δ, are under chemical exchange to give a singlet signal for both species of hydrogens,

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[*1] Part Ⅱ: This Bulletin, **13**, 1103 (1965).

[*2] A preliminary communication of this work appeared in This Bulletin, **12**, 846 (1964). This paper constitutes Part Ⅺ of a series entitled by "Nuclear Magnetar Resonance Studies" by T. Okamoto and Y. Kawazoe. Part Ⅹ: This Bulletin, **12**, 1384 (1964).

[*3] Tsukiji, Chuoku, Tokyo (川添　豊, 大西柾子).