272 (4.34), 340 (4.36). UV $\lambda_{max}^{EtOH-EtONa}$ mμ (log ε): 271 (4.28), 401 (4.62). *Anal.* Calcd. for $C_{21}H_{19}O_9$-(OCH_3)·2.5 H_2O: C, 53.78; H, 5.50; OCH_3, 6.31; H_2O, 9.2. Found: C, 53.42; H, 5.21; OCH_3, 6.10; H_2O, 8.8.

On refluxing with HI after the procedure of Iseda,[5] I gave apigenin, mp 340—341° (decomp.), which was identified by mixed melting point determination and the comparison of its IR spectrum with that of authentic specimen.

Ferric chloride oxidation of I was carried out after the procedure of Hay, *et al.*[6] to afford glucose and arabinose, which were identified on paper chromatogram (BuOH–pyridine–H_2O (3: 2: 1), double ascending method).

Penta-O-acetylswertisin (II)——Acetylation of I with Ac_2O and pyridine in the usual manner yielded II as colorless needles, mp 191—192° (from MeOH), which gave a reddish brown color with $FeCl_3$. The same treatment of authentic swertisin gave colorless needles, mp 186—187°. Mixed melting point determination showed the identity of two specimens. UV λ_{max}^{EtOH} mμ (log ε): 252 (4.38), 273 (4.61), 317 (4.26). NMR ($CDCl_3$, δ): 7.82 (2H, d, J=9 cps) (2′, 6′–H), 7.22 (2H, d, J=9 cps) (3′, 5′–H), 6.57 (H, s) (8–H), 6.42 (H, s) (3–H), 3.92 (3H) (OCH_3), 2.34 (3H) (4′–OAc), 2.06 (6H) (3″, 4″–OAc), 2.01 (3H) (6″–OAc), 1.77 (3H) (2″–OAc). *Anal.* Calcd. for $C_{32}H_{32}O_{15}$·½ H_2O: C, 57.74; H, 4.96; H_2O, 1.4. Found: C, 57.63; H, 5.01; H_2O, 1.0.

Di-O-methylswertisin (III)——To a solution of I (0.5 g) in MeOH (30 ml) was added an etheral solution of CH_2N_2 prepared from 3 g of nitrosomethylurea. The reaction mixture was allowed to stand overnight and the product separated out as colorless crystals was collected by filtration, washed with MeOH, and recrystallized from dioxane–H_2O to yield III as colorless needles, mp 304—305° (decomp.), undepressed on admixture with authentic di-O-methylswertisin.[9] Its IR and UV spectra were also identical with those of an authentic specimen. UV λ_{max}^{EtOH} mμ (log ε): 264 (4.34), 322 (4.39). *Anal.* Calcd. for $C_{21}H_{17}O_7$ $(OCH_3)_3$: C, 60.75; H, 5.52; OCH_3, 19.62. Found: C, 60.30; H, 5.58; OCH_3, 19.44.

Di-O-methylswertisin Tetraacetate (IV)——Acetylation of III with Ac_2O and pyridine in the usual manner yielded IV as colorless needles, mp 127—129° (from MeOH) (reported[4] mp 150—155° (from $CHCl_3$–hexane)). Its IR and NMR spectra were identical with those of authentic di-O-methylswertisin tetraacetate. NMR ($CDCl_3$, δ): 7.75 (2H, d, J=9 cps) (2′, 6′–H), 6.93 (2H, d, J=9 cps) (3′, 5′–H), 6.71 (H, s) (8–H), 6.52 (H, s) (3–H), 3.99, 3.92, 3.88 (9H)(OCH_3), 2.06, 2.04, 2.02 (9H) (3″, 4″, 6″–OAc), 1.75 (3H) (2″–OAc).

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9) Mixed melting point determination was kindly carried out by Dr. T. Tomimori.

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The Oxidation of *p*-Toluidine with Potassium Ferricyanide in Liquid Ammonia

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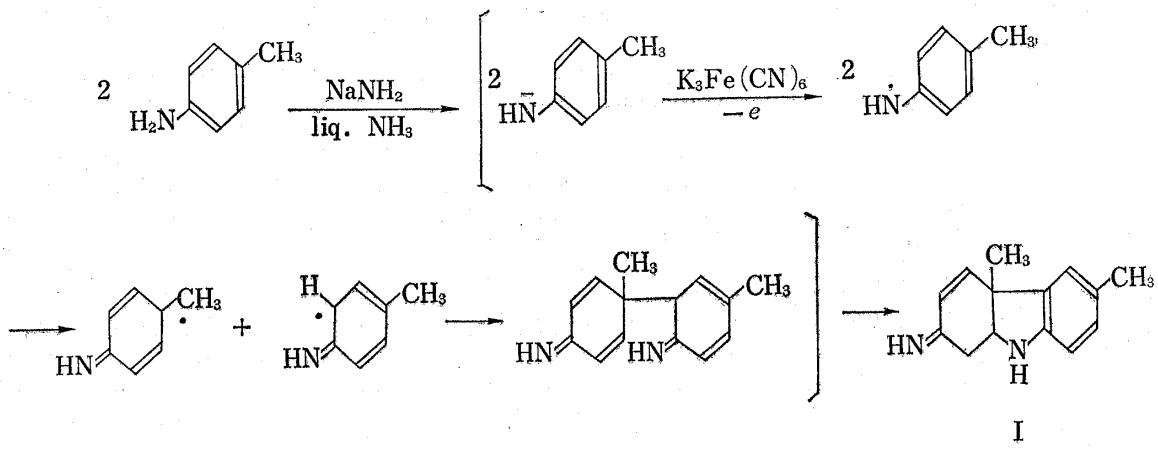
In a previous paper,[2] it was shown that oxidation of *p*-cresol with potassium ferricyanide in liquid ammonia in the presence of sodium amide afforded the Pummerer's ketone in better yield than that of Haynes' method.[3] In order to continue our investigation regarding the

1) Location: *No. 85, Kita-4-bancho, Sendai.*
2) T. Kametani and K. Ogasawara, *Chem. Pharm. Bull.* (Tokyo), **16**, 1138 (1968).
3) C.G. Haynes, A.H. Turner, and W.A. Waters, *J. Chem. Soc.*, **1956**, 2823.

oxidation in liquid ammonia, we used *p*–toluidine as a starting material and expected to isolate the carbazole derivative (I) through the same oxidation mechanism as that of *p*–cresol.

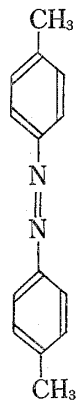


I

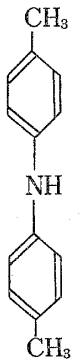
Chart 1

The oxidation similar to the procedure in case of *p*–cresol was carried out, but, instead of our expected carbazole derivative (I), three unexpected oxidized products were isolated, an orange neutral compound (II), a colorless basic compound (III) and a reddish quinoid–type compound (IV) being obtained. Among them, the compounds, II and III, were easily assigned as 4,4′–dimethylazobenzene and 4,4′–dimethyldiphenylamine, respectively. The compound (IV) was revealed to have the molecular weight as 315 and empirical formula of $C_{21}H_{21}N_3$ by its mass spectrometry and elementary analysis. The nuclear magnetic resonance (NMR) spectrum showed three methyl protons, one of which was shown as doublet with coupling constant of $J=2$ cps, ten aromatic protons (1H, singlet; 1H, multiplet; two pairs of AB–type quartets (8H) with $J=10$ cps), and two amino–protons (disappeared with D_2O).

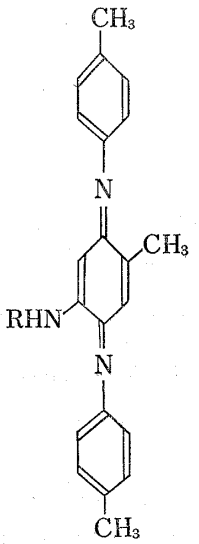
These facts suggest that this compound (IV) should be 4–amino–2,5–toluquinone di–*p*–tolylimine formed by the oxidative trimerization of three *p*–toluidine molecules. The structure (IV) seems to be very interesting from the point of anti–tumor activity,[4] because



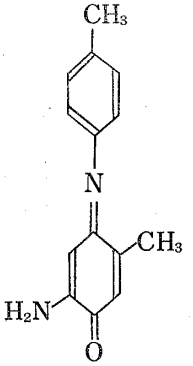
II



III



IV : R = H
V : R = *p*–$CH_3C_6H_5$–



VI

Chart 2

4) L.D. Hamilton, W. Fuller, and E. Reich, *Nature*, **198**, 538 (1963).

the effective anti-tumor antibiotics, such as streptonigrin, mitomycin C, actinomycin and porfiromycin have the same aminoquinone unit as IV in their structures.

With regards to the compound (IV), Perkin[5] reported previously the formation of IV, by oxidation of *p*-toluidine with potassium dichromate. Later, Saunders and Mann[6] also obtained this compound (IV), together with II, III, V and VI, from the oxidation of *p*-toluidine by hydrogen peroxide at pH 4.5, catalyzed by the enzyme peroxidase derived from horse-radish or from turnips.

Our results were similar to those of Saunders and Mann,[6] but both compounds, V and VI, had never been obtained. Furthermore, the formation ratio of the above products was very different from Saunders' data. This difference seems to indicate that the mechanism of potassium ferricyanide oxidation in liquid ammonia was not identical with that of the oxidation catalyzed by enzyme with hydrogen peroxide. It would suggest the compound (II) to be the precursor for V that the compound (III) was formed as a minor product in our case but was obtained as a main product in case of enzymatic oxidation. Furthermore, since Saunders and Mann[6] had shown the compound (IV) to be converted into VI by treatment with hydrochloric acid at 25°, the compound (VI) would not be obtained from *p*-toluidine as the result of the direct oxidation, but formed in isolation step in case of enzymatic oxidation.

Experimental

NMR spectra were determined on a Hitachi H-60 spectrometer with $CDCl_3$ as solvent and tetramethylsilane as an internal reference. The mass spectrum was obtained on a Hitachi RMU-6D mass spectrometer, using an all-glass inlet system heated to 250°. The ionizing energy was maintained at 70 eV and the ionizing current at 80 μA.

Oxidation of *p*-Toluidine——To a stirred suspension of $NaNH_2$ (prepared from 1.3 g of metallic Na and an excess of liq. NH_3) in liq. NH_3 was added 10 g of *p*-toluidine. After 5 min, 20 g of $K_3Fe(CN)_6$ were added to the above solution and the stirring was continued for 3 hr, to the mixture of which was then added 0.6 g of NH_4Cl. After the excess of NH_3 had been removed by evaporation, the resulting residue was extracted with benzene. The extract was washed with water, dried on K_2CO_3 and evaporated to leave 7.5 g of a dark brown oil, which solidified on standing. The thin-layer chromatograph (TLC) (silica gel; benzene–EtOH=20:1) showed four spots in this stage. Therefore, this was extracted with hexane and the extract was evaporated to leave a reddish brown crystalline residue, whose recrystallization from EtOH afforded 2 g of the compound (IV) as reddish fine prisms, mp 240° (lit.,[6] mp 236°). Mass spectrum, *m/e*: 315 (M^+). NMR ($CDCl_3$) τ: 7.88 (3H, doublet, J=2 cps, quinoid $-CH_3$), 7.65 (6H, singlet, aromatic CH_3), 5.39 (2H, broad singlet, disappeared with D_2O, NH_2), 4.21 (1H, singlet, quinoid proton adjacent to NH_2), 3.43 (1H, multiplet, quinoid proton adjacent to CH_3), 3.35—2.73 (8H, two pairs of AB-type quartets, J=10 cps). $IR_{max}^{CHCl_3}$ cm^{-1}: 3450 and 3350 (NH_2), 1640 (quinone imine). The hexane extract was evaporated to leave a reddish brown crystalline substance, which was chromatographed on Al_2O_3 using benzene as solvent. Evaporation of the first eluate gave 2 g of an orange crystals, whose recrystallization from hexane afforded the compound (II) as orange needles, mp 143—144° (lit.,[6] mp 145°). NMR (in $CDCl_3$) τ: 7.62 (6H, singlet, aromatic CH_3), 2.72 and 2.22 (4H, AB-type quartet, J=9 cps, aromatic protons). Removal of the second benzene eluate by distillation afforded 0.1 g of a crystalline substance, whose recrystallization from hexane gave the compound (III) as colorless needles, mp 82—83° (lit.,[6] mp 79°). NMR (in $CDCl_3$) τ: 7.60 (6H, singlet, aromatic CH_3), 4.81 (1H, broad singlet, NH), 3.11 and 3.05 (4H, AB-type quartet, J=9 cps, aromatic protons). $IR_{max}^{CHCl_3}$ cm^{-1}: 3350 (NH). The third $CHCl_3$ eluate afforded 1 g of *p*-toluidine.

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5) W.H. Perkin, *J. Chem. Soc.*, **37**, 546 (1880).
6) B.C. Saunders and P.G.J. Mann, *J. Chem. Soc.*, **1940**, 769.