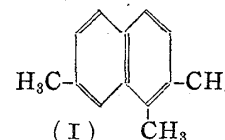


68. **Kazutaka Yamaguchi and Hatsue Shoji**: Studies on the Insecticidal Action of Japanese Plants. V.¹⁾ Insecticidal Constituents of Birch Tar Oil. (3). Dehydrogenation Product of Active Distillate.

(National Hygienic Laboratory, Tokyo*)

Ruzicka *et al.*²⁾ reported that 1,2,7-trimethylnaphthalene (sapotalin) is obtained when the neutral distillate, b.p.₁₂ 130~150°, of birch tar oil is dehydrogenated with selenium. They concluded that the dehydrogenation product must be identical with synthetic 1,2,7-trimethylnaphthalene (I), since no depression of melting point was shown on admixture of their picrate and trinitrobenzoate,^{2, 3, 4)} and that this same substance must be one of the dehydrogenation products of betulin.



Yamaguchi *et al.*⁵⁾ previously reported that a neutral distillate of birch tar oil (b.p.₅ 110~113°=b.p.₇₆₀ 260°, d^{20}_4 0.8951, n^{15}_D 1.5073, $[\alpha]^{20}_D$: +12.29°, iodine value 74.5), which was obtained by dry distillation of the bark of Japanese birch (*Betula platyphylla* Sukatchev var. *japonica* Hara) shows a remarkable insecticidal activity for the larvae of *Curex pipiens*. This substance was considered a sesquiterpenic hydrocarbon of C₁₅H₂₄ from its elementary composition and the result of molecular weight determination.

The present series of experiments, the dehydrogenation of the distillate mentioned above with selenium, was carried out in order to elucidate its chemical structure. It seemed highly probable that this dehydrogenation product obtained from active distillate would be sapotalin.

A light yellow oil, b.p.₇ 117°, n^{21}_D 1.5219, whose analytical data corresponded to the formula of C₁₃H₁₄ or C₁₃H₁₆, was obtained. However, inspite of expectations, this dehydrogenation product did not appear to be identical with synthetic 1,2,7-trimethylnaphthalene¹⁾ from the following results:

(1) The dehydrogenation product instantly decolorized a cold neutral potassium permanganate solution as well as bromine solution in acetic acid, while synthetic 1,2,7-trimethylnaphthalene gave negative results.

(2) The catalytic reduction of the dehydrogenation product proceeded smoothly up to a point where one mole of hydrogen had been absorbed. This reduction product still decolorized the potassium permanganate or bromine solution. It seems, therefore, that a second double bond is still present in the hydrogenation product.

(3) The ultraviolet absorption spectra of the dehydrogenation product and 1,2,7-trimethylnaphthalene are shown in Fig. 1.** There can be seen no similarity between these absorption curves, the dehydrogenation product having an absorption maximum at 275 mμ (log ε 3.4), whereas that of 1,2,7-trimethylnaphthalene is at 285 mμ (log ε 3.99). From these facts, it seems to be probable that the dehydrogenation product belongs to tetralene, indene, or fulvene derivative, but not to alkylnaphthalenes.

(4) As can be seen from Fig. 2, the infrared absorption spectrum of the dehydrogenation product shows absorption bands at 3.42 and 6.1 μ (double bond), at 12.03

* Yoga-machi, Setagaya-ku, Tokyo (山口一孝, 庄司初枝).

1) Part IV: J. Pharm. Soc. Japan, **74**, 20(1954).

2) Ruzicka, *et al.*: Helv. Chim. Acta, **27**, 185(1944).

3) Ruzicka, *et al.*: *Ibid.*, **17**, 426, 428(1934).

4) Ruzicka, *et al.*: *Ibid.*, **22**, 94, 1524(1939).

5) K. Yamaguchi, H. Shoji, and M. Suzuki: Bochu-Kagaku, **15**, 199(1950).

** The spectrophotometric measurement of 1,2,7-trimethylnaphthalene at ultraviolet range showed somewhat higher extinction at the maximum absorption compared to that in the earlier report (see Fig. 1).

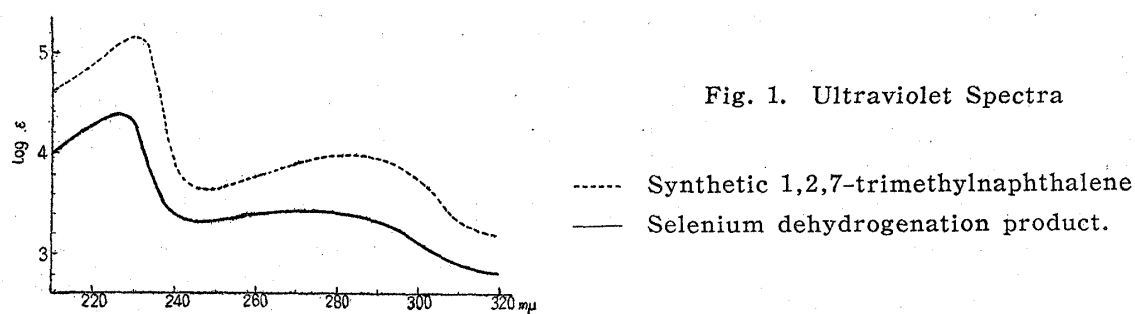


Fig. 1. Ultraviolet Spectra

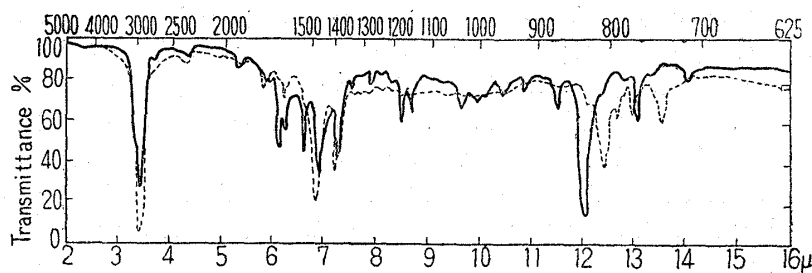


Fig. 2. Infrared Spectra

— Selenium dehydrogenation product
 ---- Synthetic 1,2,7-trimethylnaphthalene

and $12.8\ \mu$ (trisubstituted double bond),^{6, 10)} at 6.2 , 6.3 , and $6.57\ \mu$ (benzene or naphthalene ring), and at 6.9 and $7.25\ \mu$ (methyl or methylene). Further, it indicates that a vinyl group, especially vinylidene type, may be present (10.1 , 10.85 , $11.5\ \mu$).⁷⁻⁹⁾ The absorption band of isopropenyl group ($11.3\ \mu$) which appeared distinctly in the case of betulin (Fig. 3 a) was not observed. There is no similarity between the infrared absorption spectra of the dehydrogenation product and 1,2,7-trimethylnaphthalene as shown in

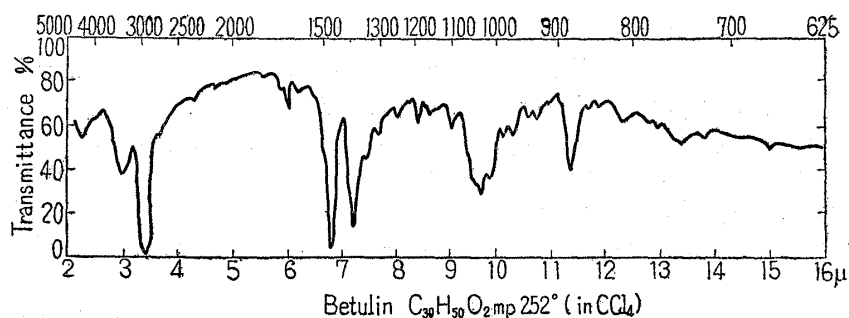


Fig. 3a Infrared Spectrum of Betulin

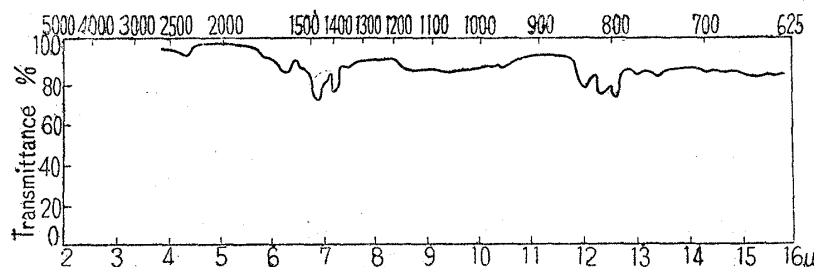


Fig. 3b. Infrared Spectrum of Catalytic Reduction Product of Dehydrogenated Substance

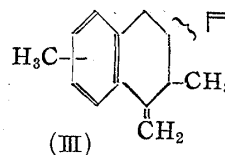
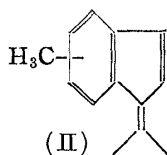
- 6) Ames, Beton, Bowers, Halsall, Jones: J. Chem. Soc., 1954, 1908.
- 7) Kamata, Nishino, Tanaka: Japan Analyst, 2, 337(1953); 3, 264(1954).
- 8) Spectrochimica Acta, 4, 373~395(1951).
- 9) "A. P. I. Curves," American Petroleum Institute.
- 10) K. Nakanishi: J. Japan. Chem., 7, 3(1953).

Fig. 2. Fig. 3b shows the infrared spectrum of the catalytic reduction product of the dehydrogenated substance.

(5) The picrate of the dehydrogenation product forms an orange red needle, m.p. 129°. On admixture with synthetic sapotalin picrate it showed a distinct depression of the melting point, but no depression with trinitrobenzene complex.

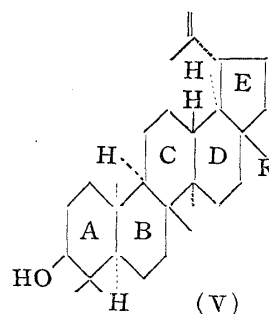
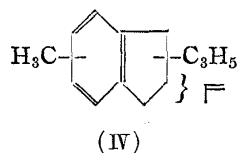
(6) On ozonization of the dehydrogenation product, formaldehyde, an oily neutral substance, and an acidic substance were obtained. This oily neutral substance turned into crystals after a few days, which as well as its mother liquor, showed a positive aldehyde reaction with ammoniacal silver nitrate or Schiff's reagent. Its recrystallization from petroleum ether yielded colorless plates of m.p. 53°. An addition product with sodium bisulfite and 2,4-dinitrophenylhydrazine of m.p. 165~167° were obtained from this substance. Analytical values of 2,4-dinitrophenylhydrazine corresponded to $C_{30}H_{24}O_{12}N_{12}$, which was calculated for trisubstituted hydrazone of $C_{12}H_{12}O_3$. The aldehyde was oxidized to a ketonic acid with ammoniacal silver nitrate. It seems highly probable, therefore, that the formation of an aldehyde on ozonization indicates the existence of a bond in the ring and the formation of formaldehyde shows the existence of a vinyl group in the molecule.

Neither of these facts can be ascribed to sapotalin or other naphthalene derivatives. Therefore, some other elucidation of the structure of the dehydrogenation product than those mentioned above must be found which would confirm the result of these experiments, although they might not be able to explain the whole problem. The assumption that it belongs to fulvene derivatives (II) must be excluded, because acetone was not obtained but formaldehyde on ozonization.



Accordingly, a tetralene derivative such as (III) should be considered. The infrared absorption spectrum shows the absorption bands due to a double bond, methyl, phenyl, and vinylidene or vinyl groups, but isopropenyl group (11.32μ), which appears distinctly in the case of betulin, was not observed. The results of reduction and ozonization could be also interpreted by this structure.

The next probable assumption is that it belongs to indene derivatives like (IV).



Ruzicka *et al.* identified the dehydrogenation products of betulin with selenium as a mixture of various polymethylbenzene and polymethylnaphthalene derivatives.^{3, 11, 12)} It was shown by Ruzicka *et al.* that most of birch tar oil must be a mixture of pyrolysed products of betulin,⁴⁾ which is present in over 40% in birch bark.

A new formula of betulin (V) had been proposed recently by Guide *et al.*¹³⁾ It is

11) Ruzicka, *et al.*: *Helv. Chim. Acta*, **15**, 1496(1932).

12) Ruzicka, *et al.*: *Ibid.*, **23**, 1317, 1338(1940).

13) Guide, *et al.*: *J. Chem. Soc.*, **1953**, 3024.

probable that a sesquiterpene hydrocarbon will be formed from the five-membered ring (E) of betulin, so that an indene derivative (IV) would be expected. However, the infrared absorption spectrum shows no absorption band of isopropenyl group (11.32μ).

If there are two double bonds, one of which was hydrogenated more easily than the other, it should be a vinyl group ($-\text{HC}=\text{CH}_2$), considering the ozonic decomposition as well as the infrared spectrum. The second double bond seems to exist in a cyclic structure. An attempt to obtain an adduct of benzaldehyde with an active methylene group gave negative result. These experimental results suggest that the possible structures which meet these requirements would belong to tetralene (III) or indene derivatives (IV).

A more definite consideration on the chemical structure of this substance is expected by further investigations.

The authors are grateful to Prof. Emeritus Dr. Asahina, Prof. Kariyone, and to Prof. Ochiai for their guidance and encouragement. They are also indebted to Dr. Kuratani, Dr. Okamoto, Mr. Maruyama, and Mr. Tabata for the absorption spectrum measurements, to Mr. Watanabe for the ozonizations, and to Mr. Sako and Mr. Masuda for microanalysis.

Experimental

Material—The neutral distillate of b.p.₅ 110–113° (260° under 760 mm. Hg) from birch tar oil, obtained by the dry distillation of the bark of *Betula platyphylla* Sukatchev var. *japonica* Hara was used as the starting material. This distillate indicates a remarkable insecticidal activity to the larvae of *Culex pipiens*; its physical constants are: d^{20}_4 0.8951, n^{15}_D 1.5073, iodine value 74.5, $[\alpha]^{20}_D$: +12.29°. This substance has the formula $\text{C}_{15}\text{H}_{24}$, from the results of elementary analysis and molecular weight determination.

Dehydrogenation with Selenium—In a 300-cc. acetylation flask equipped with a bleaching lime tube, 5 g. of the above distillate (b.p.₁₀ 130°, n^{22}_D 1.5100) and 5 g. of powdered Se were placed and the mixture was heated on a sand bath at 280–320° for 27 hrs. After cool, 100 cc. of ether was added and the ethereal layer was washed with 1% AgNO_3 solution in order to remove H_2Se , then washed with water, and dried over CaCl_2 . The ether was evaporated and 5 g. of an oily residue obtained was distilled *in vacuo*. The pale yellow oil, b.p.₇ 117°, n^{21}_D 1.5219, was obtained. The neutral KMnO_4 solution or Br_2 in AcOH was instantly decolorized by this substance at room temperature, while 1,2,7-trimethylnaphthalene gave negative reaction.

Picrate and Trinitrobenzene Complex—The dehydrogenation product was dissolved in EtOH , the same amount of picric acid or trinitrobenzene added, and the mixture was heated on a steam bath. After cooled, picrate or trinitrobenzene complex that separated was filtered and recrystallized from EtOH .

Picrate: Orange red needles, m.p. 129°. On admixture with the picrate of synthetic 1,2,7-trimethylnaphthalene (m.p. 129°) showed distinct depression (123–125°). *Anal.* Calcd. for $\text{C}_{12}\text{H}_{12} \cdot \text{C}_6\text{H}_3\text{O}_7\text{N}_3$: C, 56.09; H, 3.93; N, 10.90. Calcd. for $\text{C}_{13}\text{H}_{14} \cdot \text{C}_6\text{H}_3\text{O}_7\text{N}_3$: C, 57.13; H, 4.28; N, 10.52. Calcd. for $\text{C}_{13}\text{H}_{16} \cdot \text{C}_6\text{H}_3\text{O}_7\text{N}_3$: C, 56.83; H, 4.77; N, 10.46. Calcd. for $\text{C}_{14}\text{H}_{16} \cdot \text{C}_6\text{H}_3\text{O}_7\text{N}_3$: C, 58.11; H, 4.63; N, 10.17. Found: C, 57.77, 56.75, 57.06; H, 4.38, 4.07, 4.38; N, 10.39, 10.71.

Trinitrobenzene Complex: Yellow needles, m.p. 156–156.5°. Admixture with the trinitrobenzene complex of synthetic 1,2,7-trimethylnaphthalene (m.p. 149°) showed no depression (146–150°). *Anal.* Calcd. for $\text{C}_{12}\text{H}_{12} \cdot \text{C}_6\text{H}_3\text{O}_6\text{N}_3$: C, 58.53; H, 4.09; N, 10.37. Calcd. for $\text{C}_{13}\text{H}_{14} \cdot \text{C}_6\text{H}_3\text{O}_6\text{N}_3$: C, 59.25; H, 4.48; N, 10.96. Calcd. for $\text{C}_{13}\text{H}_{16} \cdot \text{C}_6\text{H}_3\text{O}_6\text{N}_3$: C, 59.19; H, 4.97; N, 10.90. Calcd. for $\text{C}_{14}\text{H}_{16} \cdot \text{C}_6\text{H}_3\text{O}_6\text{N}_3$: C, 60.45; H, 4.83; N, 10.59. Found: C, 59.62; H, 4.50; N, 10.50.

Ultraviolet and Infrared Spectra—The ultraviolet absorption spectra of the dehydrogenation product and synthetic 1,2,7-trimethylnaphthalene** are shown in Fig. 1 and their infrared absorption spectra in Fig. 2.

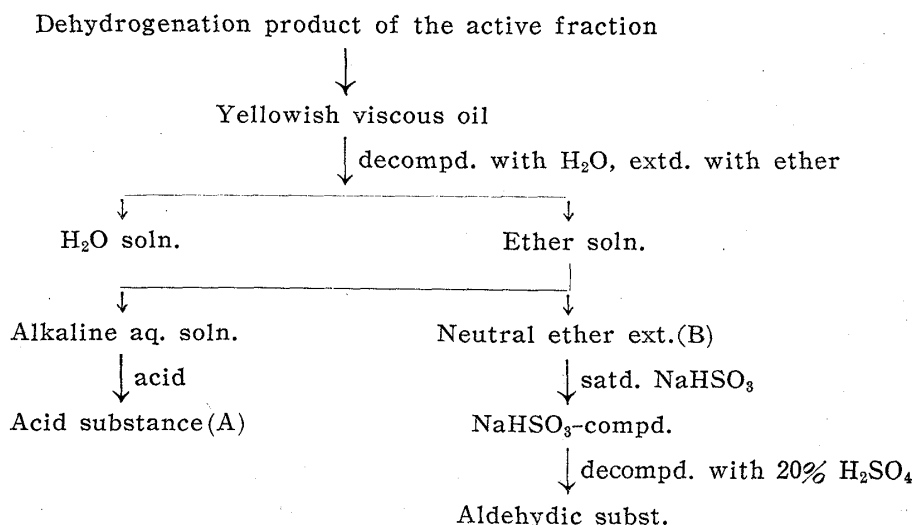
Catalytic Reduction—A solution of 0.552 g. of purified dehydrogenation product (b.p.₁₀ 135°, n^{23}_D 1.5150) in 50 cc. of pure AcOH , added with 1 g. Pd-C (2%) as a catalyst, was submitted to catalytic reduction which went on smoothly at room temperature (18°) until 72 cc. of H_2 had been absorbed, and then the absorption almost ceased (theoretical, 72.7 cc.). After the catalyst and the solvent had been removed, an yellowish oil, b.p.₃ 100°, n^{18}_D 1.5040, was obtained, when the residue was distilled *in vacuo*. This substance decolorized a solution of KMnO_4 and Br_2 , but slower than that by the dehydrogenation product.

Existence of Active Methylene Group¹⁴⁾—To a solution of 0.01 g. of the dehydrogenation product in 1 ml. of CHCl_3 , 0.1 ml. of 1% NaOH solution was added, and the mixture was heated on a steam bath. After cooled, the mixture was filtered and the filtrate was extracted with 1 ml. of CHCl_3 . The extract was dried over CaCl_2 and distilled *in vacuo*. This substance decolorized a solution of KMnO_4 and Br_2 , but slower than that by the dehydrogenation product.

14) Roman, Smith: Analyst, 78, 679(1953).

product in 10 cc. of toluene, 5 cc. of 20% abs. EtOH solution of benzaldehyde and 5 cc. of 5% EtOH-KOH solution were added, mixed well, and kept at room temperature for 0.5 hr. Then 10 cc. of 4% AcOH was added, but the solution did not develop the yellow color characteristic to active methylene group, while the solution of indene gave a positive reaction.

Ozonization—An ozonized air (ca 3%) was introduced into CHCl_3 solution of 8.5 g. of the dehydrogenation product, in a freezing mixture of -10° , for 16 hrs. A yellowish viscous substance, with a peculiar odor, was obtained. This substance was poured into 200 cc. of ice water with stirring and kept at room temperature for 24 hrs. The mixture was then heated on a water bath at 40° for 10 mins., CHCl_3 was evaporated *in vacuo*, and the oily residue and water layer were extracted with ether. The ethereal solution was evaporated and the residue was treated as follows:



Aqueous Solution—An intense reddish purple color appeared when chromotropic acid was added to it. A dimedone compound, m.p. 186° , obtained gave no depression of m.p. on admixture with formaldehyde dimedone (m.p. 187°). An indigo color reaction with *o*-nitrobenzaldehyde was negative. Evaporation of ether yielded 8 g. of light yellowish oil.

The ethereal solution was extracted with 5% NaHCO_3 solution to separate an acidic fraction (A) from a neutral one (B).

Acidic Substance (A)— NaHCO_3 solution was acidified with dil. HCl and extracted with ether. A yellow oil (5.0 g.) was obtained, when the ethereal solution was evaporated. This oil turned crystalline, when it was cooled to -20° to -30° , but it melted into an oil at room temperature.

Neutral Ethereal Solution (B)—Yellowish oil (5.1 g.) was obtained on evaporation. This substance gave a positive aldehyde reaction with $\text{AgNO}_3\text{-NH}_4\text{OH}$ or fuchsin-sulfite solution (Schiff's reagent). It forms an addition product with NaHSO_3 and a 2,4-dinitrophenylhydrazone of m.p. $165\sim 167^\circ$.

Crystals separated from this oil after standing for a week and recrystallization from petr. ether afforded colorless plates, m.p. $51\sim 53^\circ$. This substance gave a positive aldehyde reactions with the reagents mentioned above and formed a 2,4-dinitrophenylhydrazone of orange needles, m.p. $165\sim 167^\circ$ (from EtOH) (Anal. Calcd. for $\text{C}_{30}\text{H}_{24}\text{O}_{12}\text{N}_{12}$: N, 22.58. Found: N, 22.51.), and addition product with NaHSO_3 as white powder. Anal. Calcd. for $\text{C}_{12}\text{H}_{13}\text{O}_6\text{NaS}$: Na, 7.47. Found: Na, 7.39.

An oily substance separated from crystals also indicated a positive aldehyde reactions.

Oxidation of Aldehydic Substance with Ammoniacal AgNO_3 ¹⁵⁾—Ammoniacal AgNO_3 solution was prepared from 4 g. of AgNO_3 . The solution was heated on a steam bath and 0.5 g. of the aldehydic substance was added with agitation. Silver mirror appeared immediately on the wall of the beaker. After the formation of silver mirror was completed, precipitated silver was filtered off, the filtrate was acidified with 20% H_2SO_4 and extracted with ether. On evaporation of ether, a yellowish oil was obtained which was soluble in NaHCO_3 solution. Its 2,4-dinitrophenylhydrazone, m.p. $163\sim 163.5^\circ$, showed a depression (m.p. $160\sim 163^\circ$) on admixture with the hydrazone, m.p. $165\sim 167^\circ$ of the aldehydic substance.

Summary

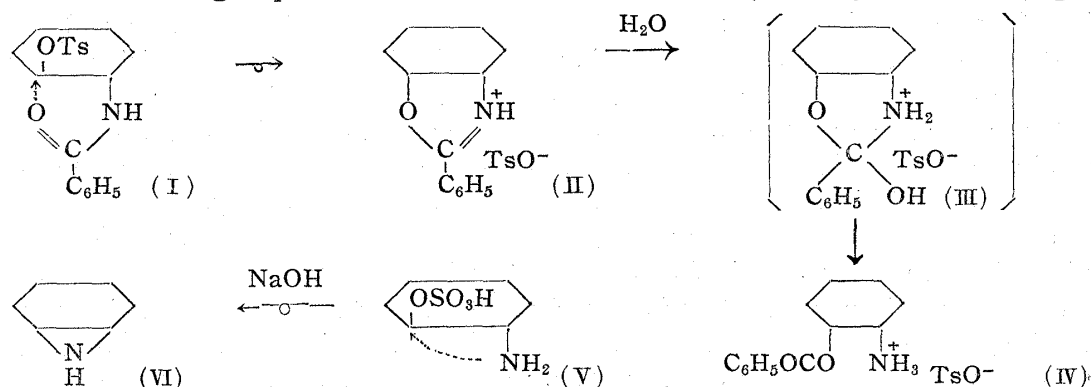
The dehydrogenation of the insecticidal distillate of birch tar oil with selenium was carried out in order to elucidate its chemical structure. The product obtained was a light yellow oil of b.p. 117°, n_D^{21} 1.5219, whose analytical data corresponded to the formula of $C_{13}H_{14}$ or $C_{13}H_{16}$. However, this substance was not identical with synthetic 1,2,7-trimethylnaphthalene from the present experimental results which suggest that the possible structures which meet the requirements would be tetralene or indene derivatives.

(Received June 9, 1955)

69. Tanezo Taguchi and Masaharu Kojima : Studies in Stereochemistry. VI.¹⁾
Solvolysis Reactions of *dl*-*cis*-2-Benzoylamino-cyclohexyl Tosylate.

(Pharmaceutical Institute, Medical Faculty, University of Kyushu*)

It has been reported by McCasland,²⁾ Winstein,³⁾ and Taguchi⁴⁾ separately that solvolysis of *dl*-*trans*-2-benzoylamino-cyclohexyl tosylate (I) in the presence of water or ethanol gave rise to *dl*-*cis*-2-benzoyloxycyclohexylamine tosylate (IV) in a good yield via *dl*-*cis*-2-phenyl-4,5-cyclohexano-oxazolinium tosylate (II). The formation of the *dl*-*cis*-oxazolinium salt (II) as an intermediate was proved by its isolation and due to the anchimeric property of the neighboring acyl group, suggesting a probable reaction mechanism for the solvolysis. It is properly supposed that the two geometrical isomers of 2-aminocyclohexanols, owing to the difference of the steric configuration, vary from each other in their chemical properties. In the *trans* isomer, the two functional groups, hydroxyl and amino, can interconvert between *aa* \rightleftharpoons *ee* conformations. Therefore, the amino group can easily approach the carbon atom with the hydroxyl group from behind. For example, treatment of *dl*-*trans*-2-aminocyclohexylsulfuric acid (V) with aqueous sodium hydroxide causes the formation of *meso*-*cis*-cyclohexenimine⁵⁾ (VI) by the anchimeric property of the neighboring amino group. In *dl*-*trans*-2-benzoylamino-cyclohexyl tosylate (I) the N-acyl group has a larger driving force due to its anchimeric property than a naked amino group, and therefore, treatment of (I) only with boiling dry



* Katakasu, Fukuoka (田口胤三, 小島正治).

1) Part V: J. Pharm. Soc. Japan, **75**, 666(1955).

2) G. E. McCasland, R. K. Clark, H. E. Carter: J. Am. Chem. Soc., **71**, 637(1949).

3) S. Winstein, R. Boschan: *Ibid.*, **72**, 4669(1950).

4) T. Taguchi, M. Nakayama: *Ibid.*, **73**, 5679(1951).

5) O. E. Paris, P. E. Fanta: *Ibid.*, **74**, 3007(1952).