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1-[3-(프로필티오)부티릴]-2, 6, 6-트리메틸시클로헥센의 합성

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Synthesis of 1-[3-(Propylthio)butyryl]-2, 6, 6-trimethylcyclohexene

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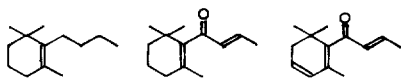
요 약. 2, 6, 6-trimethylcyclohex-1-en-1-yllithium (9)과 3-propylthiobutyraldehyde (16)의 반응으로 부터 1-[3-(propylthio)butyryl]-2, 6, 6-trimethylcyclohexene (18)을 합성하였다. 이 방법을 이용하여 강력한 향료로 알려진 1-[3-(methylthio)butyryl]-2, 6, 6-trimethylcyclohexene (1)을 합성할 것이다.

ABSTRACTS. 1-[3-(Propylthio)butyryl]-2, 6, 6-trimethylcyclohexene (18) was synthesized from the reaction of 2, 6, 6-trimethylcyclohex-1-en-1-yllithium (9) with 3-propylthiobutyraldehyde (16). This method will be employed to prepare 1-[3-(methylthio)butyryl]-2, 6, 6-trimethylcyclohexene (1) which is known as one of the powerful flavors and fragrances.

INTRODUCTION

The natural products with a carbon skeleton of megastigma-5-ene such as β-damascone and β-damascenone are the major constituents of plant oil and have fragrant odor.

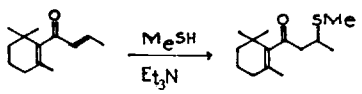
The synthetic chemistry of these natural flavoring compounds has been studied by many workers and reviewed by Torii.[1]



megastigma-5-ene β-damascone β-damascenone

The compounds with alkylmercapto substituted at the side chain of megastigma-5-ene such as 1-[3-(methylthio)butyryl]-2, 6, 6-trimethylcyclohexene (1) and its 1, 3-cyclohexadiene analog are useful as flavoring substances and fragrances for food, chewing gum, tooth paste, medicines, perfumes, tobacco, cologne water, and tobacco substitutes.

Wilson[2] synthesized 1 and its 1, 3-cyclohexadiene analog from methanethiol and β-damascone and β-damascenone, respectively, by using triethylamine as catalyst.



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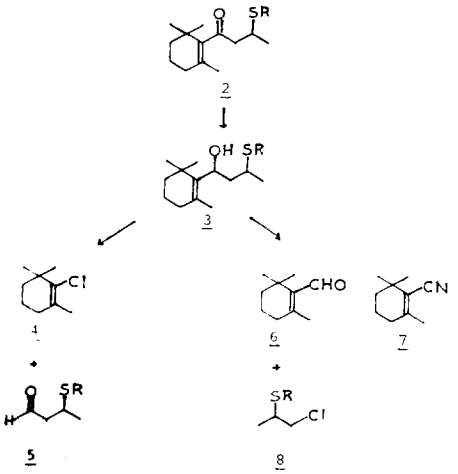
The experimental details for the synthesis of 1 and its analog were not reported. Due to the potentiality as flavor and fragrance, a study on

the new synthetic method of 1 and 1-[3-(alkylthio)butyryl]-2, 6, 6-trimethylcyclohexene (2) was undertaken.

The strategy for the synthesis of 2 was to combine two parts, *i.e.*, a cyclohexene ring and a side chain with an alkylthio group. 1-Chloro-2, 6, 6-trimethylcyclohexene (4) seems to be an appropriate model compound for the cyclohexene moiety and is known to give 1-lithio-2, 6, 6-trimethylcyclohexene. (9)[3], which is expected to react with 3-alkylthiobutanal (5) to give 3. On the other hands, either, β-cyclocitral (6) or β-cyclogeranonitrile (7) is expected to react with organometallics of 2-alkylthio-1-chloropropane (8) to give 3 and 2, respectively. *Scheme* 1 shows our approach to 2.



Scheme 1.

RESULTS AND DISCUSSION

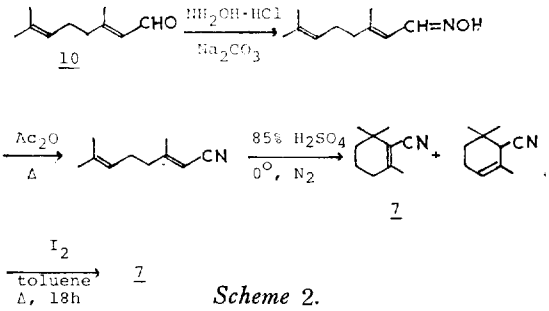
Preparation of β-Cyclocitral (6). Preparation of 6 was tried at the same conditions as in the reported methods[4] such as the treatment of citral pyrrolidine enamine or citral anil with sulfuric acid. When pyrrolidine enamine was treated with sulfuric acid by the Cainelli's method[4(e)], the product was black oil. By the Shibasaki's method[4(a)], the reaction mixture was hydrolyzed at pH 3~4 to give α-cyclocitral in a 6.5% yield. The pH of the acidic solution was important in hydrolyzing the enamine reaction mixture. At more acidic solution than pH 3~4, the product was only black oil. Therefore, attempts to obtain 6 in better yield were made employing different acid concentration, temperature, or pH. The results are summarized in *Table* 1.

Table 1. The results of cyclization reaction of citral

Enamines	H_2SO_4 (%)	Temp. (°C)	pH (Hydrolysis)	Cyclocitral (α : β)	Yield (α+β)
Pyrrolidine	90	0	3~4	10 : 1	6.5
Pyrrolidine	90	−20	1		0
Aniline	90	0	1	2 : 1	16
Aniline	95	−15	1	2 : 1	16

Citral anil method gave more 6 than pyrrolidine enamine method, and the mixture of α- and β-cyclocitral was treated with methanolic KOH at 0°C to give 6. The results of cyclization reaction of citral anil were independent of the reaction temperature and the concentration of sulfuric acid.

Preparation of β-Cyclogeranonitrile (7). Citral (10) was converted to 7, 1-cyano-2, 6, 6-trimethylcyclohexene, as shown in *Scheme* 2.



Scheme 2.

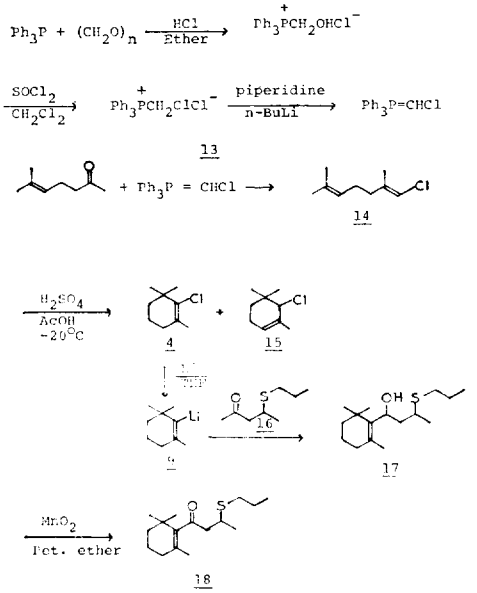
Among the several methods known for the conversion of aldehydes or their derivatives into nitriles[5], Olah's method[6] recently reported was applied to the conversion of 10 into 7. However, refluxing of 10 and hydroxylamine hydrochloride

in the presence of formic acid afforded unidentified products. The proposed mechanism of the nitrile formation from aldehyde shows an oxime and an aldoxime formate as intermediates, which then loses formic acid to give nitrile. We prepared citral oxime, which then was refluxed in the presence of formic acid. Only unidentified products were obtained. Refluxing of citral oxime with 95% sulfuric acid also gave black oil which could not be identified.

Attempted Preparation of 1-Chloro-2-(propylthio)propane (11). It has been known that reactions of 2-alkyl- and arylthio-1-propanol with hydrochloric acid or thionyl chloride give exclusively the rearranged product, 2-chloro-n-propyl alkyl and aryl sulfide rather than 2-alkyl- and arylthio-1-chloropropane.[7] We prepared 2-n-propylthio-1-propanol (12) in a 45% yield from the reaction of allyl alcohol with n-propanethiol in the presence of sulfur catalyst according to the literature.[7] The reaction with phosphorus trichloride, however, gave the rearranged product, 2-chloropropyl n-propyl sulfide, which was identified by ^{1}H NMR data. The alcohol, 12, was tried to convert tosylate by employing the standard method. However, only the rearranged product, 2-chloropropyl propyl sulfide was obtained. These results indicate that sulfides with a halogen or a tosyl group at β position undergo mainly rearrangement via sulfonium salt intermediate.[7]

Preparation of 1-Chloro-2, 6, 6-trimethylcyclohexene (4). Compound 4 was prepared and lithiated to 2, 6, 6-trimethylcyclohex-1-en-1-yllithium (9) as shown in *Scheme* 3.

To a mixture of triphenylphosphine and paraformaldehyde in ether hydrogen chloride gas was bubbled and the precipitate formed was collected, which was immediately treated with thionyl chloride to give chloromethyltriphenylphosphonium chloride (13). The overall yield



Scheme 3.

was a 63%. Compound 13 was treated with n-BuLi in the presence of piperidine to give ylide, which reacted with 6-methyl-5-hepten-2-one to give 1-chloro-2, 6-dimethyl-1, 5-heptadiene (14) in a 50% yield. Compound 14 was treated with sulfuric acid-glacial acetic acid mixture at −20°C under nitrogen atmosphere for 20 h to give 4 and 6-chloro-1, 5, 5-trimethylcyclohexene (15). Compound 14 was not formed at the condition in which triphenylphosphine, methylene chloride, 6-methyl-5-hepten-2-one, and *n*-BuLi were used as in the known procedure.[8] Treatment of methylene chloride with *n*-BuLi in the presence of triphenylphosphine gave the unreacted triphenylphosphine. Compound 15 can be eliminated as a phosphonium salt from the mixture by the treatment with triphenylphosphine since 15 has an allylic chloride but 4 not. Reaction of the mixture of 4 and 15 with silver nitrate proceeded smoothly but was a complicated reaction of which products were unable to be separated by column chromatography or fractional distillation.

Lithiation of 4 was performed in THF accor-

ding to the Köbrich's method.[9]

Preparation of 3-(Alkylthio)butyraldehyde (5). The title compound was prepared from crotonaldehyde and thiols using piperidine as a catalyst according to the literature.[10] Boiling point, 160~180° C at 2 mmHg,[11] of 3-(ethylthio) butyraldehyde appears to be incorrect in view of the observed value, 53°C at 7 mmHg.

Reaction of 3-(Propylthio)butyraldehyde (16) with *n*-BuLi. In order to see whether C-S bond cleavage of alkylthiobutyraldehyde occurs or not when the compound was treated with an organometallic reagent, *n*-BuLi was added to 16. From this reaction was obtained 2-(propylthio)-4-octanol in a 70% yield. This result suggests the preferential attack of an organolithium to the carbonyl group of 5.

Reaction of 16 with 9. The reaction of 9 and 16 was performed at −78°C under nitrogen atmosphere in THF. Yellow oil formed was analyzed by ^{1}H NMR and IR spectra. ^{1}H NMR spectrum shows no triplet signal centered at 9.77 ppm. This is strongly indicative of the absence of a CHO group. IR spectrum shows a strong OH absorption band at 3400 cm^{-1} and no carbonyl absorption band, which is indicative of the presence of an OH group and the absence of CHO group. Since 9 has no hydrogen at C-1 and C-2 and the product shows the absence of a carbonyl stretching vibration concomitant with no NMR peaks near 5 ppm due to methylene protons α to carbonyl group the possible involvements of reduction and enolization in this reaction are ruled out. Furthermore, it was demonstrated that C-S bonds of the aldehyde (16) were not attacked by *n*-BuLi at −78°C. oxidation reaction of 17 with MnO_2 proceeded smoothly to give 18 in a 61% yield.

EXPERIMENTAL

Unless otherwise stated the followings are implied. The 60-MHz nuclear magnetic resonance spectra were recorded on a Varian EM 360A NMR spectrometer. All signals were expressed by the ppm down field from tetramethylsilane used as an internal reference. Integrated area, signal multiplicity and interpretation are indicated in parenthesis. Infrared spectra were recorded on a Perkin-Elmer model 710B spectrophotometer. Silica gel (70~230 mesh) supplied by Merk was used for column chromatography.

The petroleum ether used was of boiling range 30~60°C. Dry ethyl ether (Ether) and tetrahydrofuran (THF) were obtained by distillation from sodium. Methylene chloride was dried by distillation from phosphorus pentoxide. n-Butyllithium (in *n*-hexene) was obtained from Aldrich Chemical Company, Inc. Citral, crotonaldehyde, and 6-methyl-5-hepten-2-one and thiols were obtained from Aldrich Chemical Company, Inc., and distilled before use.

Preparation of β-Cyclocitral (6).

(A) Pyrrolidine Enamine Method[4a] : A solution of citral (7.6 g, 50 mmol) and pyrrolidine (7.1 g, 100 mmol) in dry benzene (50 m*l*) in the presence of 5 g of molecular sieve (4Å) was refluxed for one hour under nitrogen atmosphere. The molecular sieve was then filtered off and the filtrate was evaporated in vacuo to give pyrrolidine enamine as a brown oil in quantitative yield.

This product was added dropwise to 90% H_2SO_4 (30 m*l*) at −20°C under nitrogen atmosphere. The mixture was stirred for 3 hours in an ice bath. Then a dark brown viscous oil formed was poured into a stirred ice-water (50 m*l*) with external ice-cooling. The pH of the acidic solution was adjusted to 3~4 with 10% NaOH solution, and the aqueous solution was extracted with chloroform several times. The combined extract was dried ($MgSO_4$) and concentrated and the residue was purified with cc-

lumn chromatography to give pure α-cyclocitral (0.5 g, 6.5%). ^{1}H NMR (CCl_4) δ 0.90, 0.98 (6H, two *s*, $C(CH_3)_2$), 1.50 (3H, *s*, CH_3), 1.30~1.70 (2H, *m*, CH_2), 1.90~2.30 (3H, *m*, allylic CH_2, C**H**−CHO), 5.60 (1H, broad *s*, =C**H**−CH_3), 9.30 (1H, *d*, CHO); IR (neat) 1720 (C=O) cm^{-1}.

(B) Aniline Method[4b~d]: The mixture of aniline (9.3 g, 100 mmol), citral (15.2 g, 100 mmol) and magnesium sulphate (10 g) was stirred for 3 hours under nitrogen atmosphere. Filtration of magnesium sulphate gave citral anil as a pale yellow oil in quantitative yield.

^{1}H NMR (CCl_4): δ 1.60, 1.70 (6H, two *s*, $C(CH_3)_2$), 1.98, 2.00 (3H, two *s*, CH_3), 2.10~2.40 (4H, *m*, CH_2CH_2), 5.10 (1H, broad *s*, =C**H**−CH_2), 6.10 (1H, *d*, =C**H**−CH=N), 7.10 (5H, *m*, phenyl), 8.20 (1H, two *d*, CH=N); IR (neat) 1620 (C=N) cm^{-1}.

Citral anil was gradually added to a mixture of 95% H_2SO_4 (50 m*l*) and H_2O (5 m*l*) with stirring at 0°C. The mixture was stirred for one hour in an ice bath. Then a dark brown viscous oil formed was poured into a stirred ice-water (400 m*l*) and extracted with chloroform. The extract was dried ($MgSO_4$) and distilled to give 2.5 g of α and β-cyclocitral (16%), bp 95~96°C at 8 mmHg.

The distillate was treated with potassium hydroxide (3 g) in methanol (15 m*l*) at 0°C for a few min. The mixture was diluted with water (40 m*l*), saturated with sodium chloride, and extracted with ether. Distillation of the extract gave 1.75 g of 6 as a colorless liquid in a 70% yield, bp 95~96°C at 8 mmHg.

^{1}H NMR (CCl_4): δ 1.20 (6H, *s*, $C(CH_3)_2$), 1.50 (4H, *m*, CH_2CH_2), 2.10 (3H, *s*, CH_3), 2.20 (2H, m, CH_2−C=), 10.00 (1H, *s*, CHO); IR (neat) 1680 (C=O, α,β-unsaturated) cm^{-1}.

β-Cyclogeranonitrile (7)

(A) Citral Oxime: To a solution of hydroxylamine hydrochloride (3.5 g, 50 mmol) and citral (6.1 g, 40 mmol) in water (60m*l*), a solution of sodium carbonate (2.8 g) in 50 m*l* of water was added gradually with stirring, and the mixture was stirred for further one hour. Organic layer was separated and the aqueous layer was extracted with ether and added to organic layer The organic layer was dried ($MgSO_4$) and evaporated. Citral oxime 6.1 g (90%) was obtained.

^{1}H NMR (CCl_4): δ 1.65, 1.75 (6H, two *s*, $C(CH_3)_2$), 1.90 (3H, *s*, CH_3), 2.23 (4H, *m*, CH_2 CH_2), 5.10 (1H, broad *s*, =C**H**−CH_2), 5.90, 6.50 (1H, two *d*, =C**H**−CH=N), 7.30−8.00 (1H, two *d*, C**H**=N−OH), 9.55 (1H, broad *s*, OH); IR (neat) 3250 (OH), 1625 (C=N) cm^{-1}.

(B) Geranonitrile: Citral oxime (6.1 g, 37 mmol) in acetic anhydride (25 m*l*) was refluxed for one hour. After cooling to room temperature, the red solution was added to powdered ice (150 g) and extracted with ether.

The combined ether extract was washed with water several times, and dried ($MgSO_4$). Distillation gave geranonitrile (4.0 g, 74%). bp 95~96°C at 10 mmHg. ^{1}H NMR (CCl_4): δ 1.70 (6H, two s, $C(CH_3)_2$) 1.80~2.50 (4H, *m*, CH_2CH_2), 2.00 (3H, *s*, CH_3), 5.05 (2H, broad *s*, vinyl); IR (neat) 2220 (C≡N), 1620 (C=C) cm^{-1}.

(C) β-Cyclogeranonitrile (7)[12]: To a mixture of 95% H_2SO_4 (30 m*l*) and H_2O (6 m*l*) was added an ethereal solution of geranonitrile (4.0 g, 27 mmol) dropwise at 0°C under nitrogen atmosphere. The mixture was stirred for 90 min., poured into a stirred ice-water (350 m*l*) and extracted with chloroform. Distillation gave α- and β-cyclogeranonitrile as a colorless liquid (2.0 g, 50%), bp 92~95°C at 8 mmHg. The product and iodine in toluene (20 m*l*) was refluxed for 18 hours. After cooling to room tempeature, the solution was washed with sodium thiosulfate solution, followed by water. The solution was dried and distilled to give 1.8 g

(90%) of 7 in a 28% total yield, bp 92~95°C at 8 mmHg.

^{1}H NMR (CCl_4): δ 1.10 (6H, *s*, $C(CH_3)_2$), 1.30~2.30 (6H, *m*, $CH_2CH_2CH_2$), 2.00 (3H, *s*, CH_3); IR (neat) 2180 (C≡N) cm^{-1}.[8]

(Hydroxymethyl) triphenylphosphonium Chloride[8,13]

Hydrogen chloride gas was bubbled through the solution of 262 g (1 mol) of triphenylphosphine and 30 g (1 mol) of paraformaldehyde in 500 m*l* of anhydrous ether, untill the formation of precipitates had stopped. Filtration and washing with ether afforded the crude product as white solids, which were immediately used for the next chlorination.

(Chloromethyltriphenyl) phosphonium Chloride[8,13]

The solution of 179 g (1.5 mol) of thionyl chloride and (hydroxymethyl) triphenylphosphonium chloride in 500 m*l* of methylene chloride was refluxed for 30 min. The methylene chloride and the excess thionyl chloride were distilled off. The residue was stored in a refrigerator to solidify and the yellow solid was washed with ether to give white solid of (chloromethyl) triphenylphosphonium chloride (13) in a 63% total yield (220 g). mp 260°C[13] ^{1}H NMR ($CDCl_3$): δ 6.26 (2H, ld, CH_2Cl), 7.50~8.20 (15 H, m, Ph_3P).

1-Chloro-2, 6-dimethyl-1, 5-heptadiene (14)[3,14]

To a mixture of 69.2 g (200 mmol) of 13, 17.2 g (200 mmol) of piperidine, and 250 m*l* of ether was added a solution of n-butyllithium in n-hexane dropwise at room temperature under nitrogen atmosphere over a period of one hour. The mixture was stirred for one hour and a solution of 25.2 g (200 mmol) of 6-methyl-5-hepten-2-one in ether (30 m*l*) was added over a period of two hours, and stirred overnight. The crystalline precipitate was collected by filtration and washed with ether. The ether and piperidine were removed from the filtrate by distillation. Low boiling petroleum ether (34~60°C) was added to the residue, and the triphenylphosphine oxide, which precipitated after a few hours in a refrigerator, was removed. Chromatography on aluminium oxide followed by distillation gave 16 g (50%) of 14 as a colorless liquid, bp 50~51°C at 6 mmHg.

^{1}H NMR (CCl_4): δ 1.60, 1.68 (6H, two *s*, $C(CH_3)_2$), 1.73 (3H, *s*, $\mathbf{CH_3}C=CHCl$), 1.90~2.30 (4H, *m*, CH_2CH_2), 4.67~5.30 (1H, broad *s*, $(CH_3)_2C=\mathbf{CH}$), 5.60~5.80 (1H, broad s, $=\mathbf{CH}Cl$); IR (neat) 1675 (*w*) and 1640 (*m*) (C=C) cm^{-1}

1-Chloro-2, 6, 6-trimethyl-2-cyclohexene (15) and 1-Chloro-2, 6, 6-trimethyl-1-cyclohexene (4)[3]

To a well stirred mixture of 35 g of glacial acetic acid and 100 g of 95% sulfuric acid 16 g (100mmol) of 1-chloro-2, 6, 6-trimethyl-1, 5-heptadiene (14) was added slowly at −20°C under nitrogen atmosphere. After stirring for 20 hours at −20°C, the red solution was poured onto a 300 g of powdered ice and extracted with ether. The ether extract was washed with sodium bicarbonate solution and water, and dried over anhydrous calcium chloride. After filtration and removal of the solvent the residue was distilled under reduced pressure to give 12 g of a mixture of 4 and 15 in an 80% yield, bp 50~51°C at 6 mmHg.

^{1}H NMR (CCl_4): δ 0.91, 0.97 (6H, two *s*, $C(CH_3)_2$ of 15), 1.05 (6H, *s*, $C(CH_3)_2$ of 4), 1.76 (6H, *s*, CH_3 of 4 and 15), 1.30~2.30 (10H, *m*, CH_2 of 4 and 15), 4.27 (1H, broad *s*, CH−Cl), 5.23 (1H, broad *s*, $=\mathbf{CH}-CH_3$); IR (neat) 1652 (C=C), 1385, 1380, 1170, and 1140 ($C(CH_3)_2$) cm^{-1}.

Isolation of 4

The solution of 12 g of 4 and 15 and 10 g

(40 mmol) of triphenylphosphine in toluene was refluxed for 5 days. After cooling and filtration of phosphonium salt of 15, the filtrate was chromatographed on aluminium oxide to remove the unreacted triphenylphosphine, 0.5 g (3.2 mmol) of 4 was obtained (4%).

^{1}H NMR (CCl_4) : δ 1.05 (6H, *s*, $C(CH_3)_2$), 1.76 (3H, *s*, $=C-CH_3$), 1.30~2.30 (6H, *m*, $CH_2CH_2CH_2$); IR (neat) 1652 (C=C), 1385, 1380, 1170, and 1140 ($C(CH_3)_2$) cm^{-1}.

3-(Ethylthio) butyraldehyde[9]

One drop of piperidine was added to a cooled mixture of 7.0 g (100 mmol) of crotonaldehyde and 6.2 g (100 mmol) of ethanethiol. The mixture was stirred at 5°C for one hour and at room temperature for two hours. Then the mixture was heated for one hour on the water bath. Ether (20 m*l*) was added, and after washing with dilute hydrochloric acid and water, the solution was dried over anhydrous magnesium sulfate. The ether was removed, and the residue was distilled under reduced pressure togive 7.2 g of the title compound in a 53% yield, bp 53°C at 7 mmHg (*Lit.*[11] 160~180°C at 2 mmHg).

^{1}H NMR (CCl_4) : δ 1.27 (3H, *t*, $\mathbf{CH_3}CH_2S$), 1.30 (3H, d, $\mathbf{CH_3}CHS$ 2.36~2.73 (4H, *m* $2CH_2$), 3.00~3.50 (1H, *m*, $CH_3\mathbf{CH}S$), 9.67 (1H, *t*, CHO); IR (neat) 1740 (C=O) cm^{-1}.

3-(Propylthio) butyraldehyde (16)

This compound was prepared by the synthetic procedure of 3-(ethylthio) butyraldehyde in a 70% yield. bp 62~63°C at 5 mmHg.

^{1}H NMR (CCl_4) : δ 1.00 (3H, *t*, $CH_2\mathbf{CH_3}$), 1.34 (3H, d, $SCH\mathbf{CH_3}$), 1.10~2.10 (2H, *m*, $SCH_2\mathbf{CH_2}CH_3$), 2.52 (4H, two *t*, $\mathbf{CH_2}CHO$ and $S\mathbf{CH_2}CH_2$), 2.80~3.50 (1H, *m*, $\mathbf{CH}SCH_2CH_2CH_3$), 9.77 (1H, t, CHO); IR (neat) 1740 (C=O) cm^{-1}.

Reaction of 16

(A) Reaction of 16 with *n*-BuLi: *n*-Butyllithium (13 mmol, 2.6*M* solution in *n*-hexane) and ether (5 m*l*) were syringed into a flask at −78°C, followed by the addition of 1.7 g (12 mmol) of 16 in ether (5 m*l*) dropwise at −78°C.

After addition, the reaction was allowed to warm to room temperature and stirred for one hour. Aqueous solution of NH_4Cl was added and the organic layer was dried ($MgSO_4$) and distilled to give 1.7 g of 2-(propylthio)-4-octanol in a 70% yield, bp 110~120°C at 3 mmHg.

^{1}H NMR ($CDCl_3$): δ 0.90~2.00 (19H, *m*, $\mathbf{CH_3}\mathbf{CH_2}CH_2SCHCH_3$, $SCH\mathbf{CH_2}CHOH\mathbf{CH_2}\mathbf{CH_2}\mathbf{CH_2}\mathbf{CH_3}$), 2.15 (1H, broad *s*, OH), 2.50 (2H, *t*, SCH_2), 2.85 (1H, *m*, CHS), 4.6 (1H, *m*, $\mathbf{CH}OH$); IR (neat) 3400 (OH) cm^{-1}.

(B) Reaction of 16 with 9: To a stirred suspension of 1 g (140 mmol) of lithium in THF (10 m*l*) was added half a solution of 0.5 g (32 mmol) of 4 in THF (8 m*l*) and the mixture was refluxed for for 10 min. under nitrogen atmosphere. After cooling to 5°C, remainder of 2 was added and the mixture was stirred for additional 90 min. at the same temperature. The resulting 2,6,6-trimethylcyclohex-1- yllithium (9) solution was syringed into another flask at −78°C under nitrogen atmosphere and 16 (0.4 g, 2.7 mmol) in THF (5 m*l*) was added dropwise. The mixture was stirred for two hours at this reaction condition, and at room temperature for one hour. The mixture was washed with saturated NH_4Cl solution and extracted with ether. Ether extract was dried and concentrated to yield a yellow liquid (0.7 g) of 17;

^{1}H NMR (CCl_4) : δ 0.90~1.30 (8H, *m*, $SCH_2\mathbf{CH_2}\mathbf{CH_3}$, $SCH\mathbf{CH_3}$), 1.05 (6H, *s*, $C(CH_3)_2$), 1.76 (3H, *s*, $=CCH_3$), 1.30~2.30 (8H, *m*, ring $\mathbf{CH_2}\mathbf{CH_2}\mathbf{CH_2}$, and $HOCH\mathbf{CH_2}CHS$), 3.00 (1H, *m*, CHS), 3.60 (1H, *t*, $\mathbf{CH}OH$), 2.45 (2H, *t*, SCH_2); IR (neat) 3400 (OH), 1652 (C=C), 1450 and 750 (CH_2) cm^{-1}.

(C) 1-[3-(*n*-Propylthio) butyryl]-2,6,6-trime-

thylcyclohexene (18): A solution of 0.5 g (1.8 mmol) of 17 in 40 m*l* of petroleum ether was shaken with 1 g of the active MnO_2 for 1 hour in a stoppered flask. The reaction mixture was worked up as usual to give 0.3 g (1.1 mmol) of 18; ^{1}H NMR (CCl_4): δ 0.93~1.34 (8H, *m*, $SCH_2CH_2CH_3$, $SCHCH_3$), 1.06 (6H, *s*, $=C(CH_3)_2$), 1.61 (3H, *s*, $=CCH_3$), 1.30~2.41 (8H, *m*, ring $CH_2CH_2CH_2$, and $COCH_2$), 3.02 (1H, *m*, CH_3), 2.46 (2H, *t*, SCH_2); IR (neat) 1645, 1685 (C=C-C=O) cm^{-1}.

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