Syntheses of Isoprenoids by Telomerizations. IX.[1] Stereoselectivity of Telomers and the Effect of Telogens in Anionic Telomerizations Using Secondary Amines

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The stereoselectivity of the telomers and the effect of the telogens in the anionic telomerizations of isoprene with secondary amines were investigated. Dimethyl-, diethyl-, di-*n*-propy-l, diisopropyl-, and methylphenyl-amines, pyrrolidine, morpholine, and piperidine were used as the telogens. The ratio of *N,N*-dialkyl(3,7-dimethyl-2,6-octadienyl)amine(**2A**) to *N,N*-dialkyl(2-isopropenyl-5-methyl-4-hexenyl)amine(**2B**), which were obtained in these reactions, was varied with the sort of secondary amines, the yield of the telomers was found to be dependent on the acidity of the secondary amines. Moreover, **2A**, which was the main component of the $n=2$ telomers, was confirmed to have a *cis*-configuration—that is, *N,N*-dialkylnerylamine. However, the $n=1$ telomer of myrcene with secondary amine was *N,N*-dialkylgeranylamine. These results were interpreted in terms of the stability of the cyclic intermediate of the carbanions.

In the preceding paper,[1] it was reported that the anionic telomerizations of isoprene with secondary amines gave mainly *N,N*-dialkyl(3,7-dimethyl-2,6-octadienyl)amine(**2A**) and *N,N*-dialkyl(2-isopropenyl-5-methyl-4-hexenyl)amine (**2B**) as the $n=2$ telomers.

In this paper, the stereoselectivity of the telomers and the effect of the telogens in the telomerizations using several secondary amines will be discussed, and the intermediate carbanions will be presumed on the basis of these results.

Results and Discussion

Stereoselectivity of the Telomers. *N,N*-Diethyl(3,7-dimethyl-2,6-octadienyl)amine (**2A**) has two stereoisomers, *cis* and *trans*—that is, *N,N*-diethylnerylamine and *N,N*-diethylgeranylamine. The structure of the telomer (**2A**) was identified as *N,N*-diethylnerylamine from IR, mass,[2] NMR,[3] and glc analyses.[4]

On the other hand, *N,N*-diethylgeranylamine was obtained quantitatively by the anionic telomerization of myrcene (3-methylene-7-methyl-1,6-octadiene) with diethylamine.

These anionic telomerizations can be formulated by the equations shown in Figs. 1 and 2. The stereoselectivity of the telomers can be interpreted in terms of the intramolecular solvation[5,6] (coordinate metal-nitrogen bond[7]), as with **1a'** and **1Ms'** (the stability

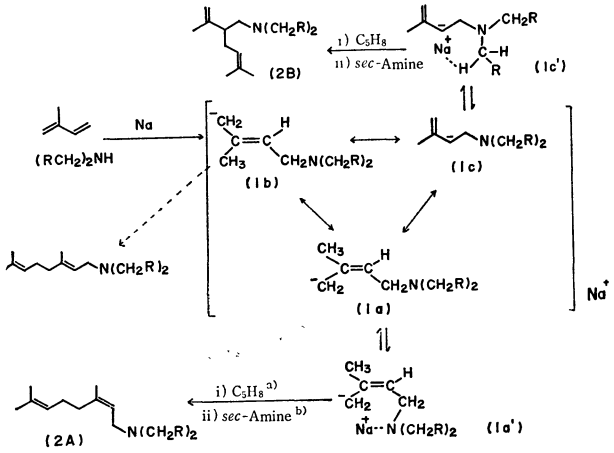

Fig. 1. Telomerization scheme of isoprene.
a) Propagation, b) Transmetalation

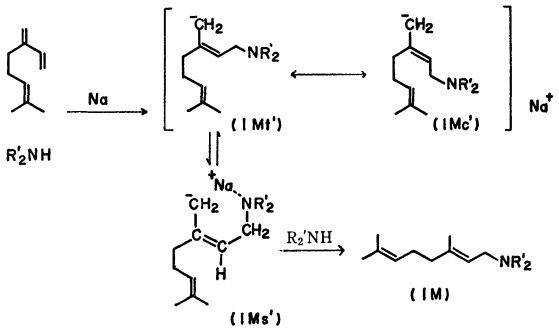

Fig. 2. Telomerization scheme of myrcene

of the carbanions: **1a'**>**1a**, **1b**, and **1Ms'**>**1Mt'**,**1Mc'**). Thus, it seems that the more stable carbanions (**1a'** and **1Ms'**) react with isoprene and the telomers (**2A** and **1M**) are formed stereoselectively.

The Effect of the Telogens. Dimethyl-, diethyl-, di-*n*-propyl-, and methylphenyl-amines were used as the telogens. The effects of these secondary amines on the yields and the compositions of the telomers are shown in Tables 1 and 2. The yields of the telomers varied with the sort of the secondary amines, they were in the following order: $Me_2NH>Et_2NH\approx(n\text{-propyl})_2NH>(isopropyl)_2NH>C_6H_5NH(CH_3)$. It is possible

1) Part VIII of this series: K. Takabe, T. Katagiri, and J. Tanaka, This Bulletin, **46**, 218 (1973).

2) The data of the IR and mass spectra of **2A** agreed very closely with those of authentic *N,N*-diethylgeranylamine, which was synthesized from geranyl chloride and diethylamine.

3) Slight difference between the NMR spectrum of **2A** and that of *N,N*-diethylgeranylamine were observed in the shapes of the signals of τ 7.90—8.10(=CH-C**H**$_2$-C**H**$_2$-C=) and 8.25—8.46 (C**H**$_3$-C=).

4) The retention times of **2A** and *N,N*-diethylgeranylamine were 10.8 and 11.7 min respectively under the same glc conditions (15% Apiezon grease L/Celite 545, 2.5 m, 150°C, H_2: 50 ml/min).

5) S. Bank, *J. Amer. Chem. Soc.*, **87**, 3245 (1965).

6) Such a concept of a cyclic intermediate has also been reported in the case of *cis*-1,4-polymerization of isoprene [A. V. Tobolsky, and C. E. Rogers, *J. Polym. Sci.*, **40**, 73 (1959)].

7) D. W. Slocum and P. L. Gierer, *Chem. Commun.*, **1971**, 305.

Table 1. Effect of *sec*-amines on compositions of telomers (I)[a]

sec-Amine	Yield (g)	Composition of telomer (%)						2A/2B
		1A[b]	1B[c]	2A	2B	2H[c]	$n\geq 3$	
Me_2NH	10.2	t	2	7	23	1	66	0.3
Et_2NH	5.5	38	18	21	14	1	6	1.5
$(n\text{-Propyl})_2NH$	6.3	70	7	10	5	1	2	3.0
$(Isopropyl)_2NH$	2.8	92	—	t	t	6	—	—
$C_6H_5NH(CH_3)$	—							

a) Reaction condition; isoprene 13.6 g, isoprene/*sec*-amine=5(molar ratio), Na 0.1 g, reaction temperature 40°C, reaction time 3 hr.
b) *N,N*-Dialkyl(3-methyl-2-butenyl)amine.
c) *N,N*-Dialkyl(2-methyl-2-butenyl)amine.
d) Myrcene.

Table 2. Effect of *sec*-amines on compositions of telomers (II)[a]

sec-Amine	Yield (g)	Composition of telomer (%)						2A/2B
		1A	1B	2A	2B	2H	$n=3$	
Me_2NH[b]	8.5	2	13	6.5	39	1	37	0.2
Et_2NH	5.2	70	13	8.6	6.3	1	1	1.4
$(n\text{-Propyl})_2NH$	5.5	85	9	4.1	1.7	t	t	2.4
$(Isopropyl)_2NH$	3.8	93	—	—	—	3	t	—
$C_6H_5NH(CH_3)$	—							

a) Reaction condition; isoprene 10.2 g, isoprene/*sec*-amine=3(molar ratio), Na 0.1 g, reaction temperature 40°C, reaction time 3 hr.
b) Na 0.08 g.

Table 3. Effect of cyclic *sec*-amines on compositions of telomers

sec-Amine	Yield (g)	Composition of telomer (%)						2A/2B
		1A	1B	2A	2B	2H	$n=3$	
Pyrrolidine[b]	6.5	34	15	19	11	1.5	16	1.7
Piperidine[c]	6.3	46	19	8.0	4.5	1	19	1.8
Morpholine[d]	5.2	55	26	4.5	2.5	2	9	1.8

a) Reaction condition; isoprene 10.9 g, isoprene/*sec*-amine=4(molar ratio), benzene 15 ml, reaction temperature 50°C.
b) Na 0.2 g, reaction time 1.5 hr.
c) Na 0.1 g, reaction time 3.5 hr.
d) Na 0.1 g,reaction time 6 hr.

to explain these results by considering the acidity of the secondary amines[8] in the step of the transmetalation.

The ratios of **2A/2B**, which were obtained in these reactions, varied with the sort of the secondary amines as is shown in Tables 1 and 2. These ratios seems to correspond to the yields of the telomers. In the case of the cyclic secondary amines (pyrrolidine, piperidine, and morpholine), however, the ratios of **2A/2B** were nearly constant, as is shown in Table 3. This phenomenon may be interpreted by presuming the presence of the cyclic intermediate (**1c'**)[9] as is shown in Fig. 1.

The difference in the **2A/2B** ratio among these secondary amines—that is, the facility of the formation of **1c'**—seems to be dependent on the steric factor of the R group in **1c'**. For example, the formation of **1c'** may become more difficult in the case of di-*n*-propylamine than in the case of dimethylamine. The very preferential formation of **2B** over **2A** (**2A/2B**= 0.2) in the reaction using dimethylamine may be interpreted by considering the effect of the hyperconjugation of the methyl group. The result in the case of the cyclic secondary amines seems to be due to the lack of any steric difference in the formation of **1c'** among them.

Thus, the ratios of **2A/2B** are considered to be dependent on the degree of the formation of the stable carbanions, **1a'** and **1c'**.

Experimental

Materials. The secondary amines were commercial products of the purest grade, they were distilled and checked by glc. The isoprene and myrcene were dried over anhydrous sodium sulfate and distilled in the presence of hydroquinone. The inorganic compounds were also commercial materials.

Reaction Procedure. In a typical reaction, a mixture of isoprene (8.2 g) and morpholine (3.0 g) was allowed to

8) This has been reported in detail by Asahara *et al.* in relation to the acidity of the amines and reactivity in anionic telomerizations: T. Asahara, M. Senō, and S. Tanaka, *Seisan Kenkyu*, **23**, 304, 353, 356 (1971).

9) If so, the secondary carbanion (**1c**) should convert into a more stable carbanion (**1c'**), and **2B** should increase.

TABLE 4. CHARACTERIZATION OF TELOMERS DIALKYLAMINES

Telogen	Telomer	IR (cm^{-1})	NMR (τ)
Et_2NH	**2A**	1200, 1165, 1050(C–N), 1660, 830 (trisubstituted double bond).	4.65—5.18 (2H, m,–Ċ=C**H**–), 7.09 (2H,d, J=6.6 Hz, =CH–**CH_2**–N〈), 7.62(4H, q, J=7.0 Hz, 〉N–**CH_2**–CH_3), 7.89—8.09(4H, m, =CH–**CH_2CH_2**–C=), 8.24—8.47(6H, m, **CH_3**–Ċ=), 9.04(6H, t, J=7.0Hz, **CH_3CH_2**–).
	2B	1200, 1165, 1065(C–N), 1645, 890 (end methylene group), 1670, 835 (trisubstituted double bond).	4.76—5.16(1H, m, –Ċ=C**H**–), 5.39(2H, bs, –Ċ=**CH_2**), 7.31—8.17(5H,m, =C–**CH_2**–,=Ċ–Ċ**H**–), 7.57(4H, q, J=6.9 Hz, 〉N–**CH_2CH_3**), 8.26—8.48(9H, bs, **CH_3**–Ċ=), 9.08(6H, t, J=7.0 Hz, **CH_3CH_2**–).
$(n\text{-}C_3H_7)_2$ NH	**1A**	1028, 1065, 1160, 1180(C–N), 1675, 830 (trisubstituted double bond).	4.88 (1H, t, J=6.0 Hz, –Ċ=C**H**–), 7.14 (2H, d, J=6.0 Hz, =CH–**CH_2**–N〈), 7.74(4H, t, J=6.8 Hz, 〉N–**CH_2**–CH_2–), 8.30 (3H, s, **CH_3**–Ċ=), 8.40(3H, s, **CH_3**–Ċ=), 8.40—8.90(4H, m, –**CH_2**–), 9.15(6H, t, **CH_3CH_2**–).
	1B	1025, 1065, 1160, 1183(C–N), 1670, 820 (trisubstituted double bond).	4.53—5.03 (1H, m, –Ċ=C**H**–), 7.20(2H, s, =C–**CH_2**–N〈), 7.75 (4H, t, J=6.9Hz,〉N–**CH_2**–CH_2–), 8.23—8.90(10H, m, **CH_3**–Ċ=, –**CH_2**–), 9.16(6H, t, J=7.1 Hz, **CH_3CH_2**–).
	2A	1030, 1065, 1090, 1165, 1185(C–N), 1670, 828 (trisubstituted double bond).	4.63—5.20 (2H, m, –Ċ=C**H**–), 7.06 (2H, d, J=6.8Hz, =CH–**CH_2**–N〈), 7.74 (4H, t, J=7.1 Hz, 〉N–**CH_2CH_2**–), 7.80—8.11(4H, m, =CH–**CH_2CH_2**–C=), 8.23—8.90 (13H, m, **CH_3**–Ċ=, –**CH_2**–), 9.15(6H, t, J=7.0 Hz, **CH_3**–CH_2–).
	2B	1020, 1075, 1190 (C–N), 1650, 885 (end methylene group), 1670, 840 (trisubstituted double bond).	4.90—5.14 (1H, m, –Ċ=C**H**–), 5.34 (2H, bs, –Ċ=**CH_2**), 7.74 (4H, t, J=7.0 Hz, 〉N–**CH_2**–CH_2–), 7.50—8.20 (9H, m, –**CH_2**–N〈, =C–**CH_2**–, =C–Ċ**H**–), 8.30—8.83(13H, m, **CH_3**–C=, –**CH_2**–), 9.14(6H, t, J=7.0 Hz, **CH_3**–CH_2–).
(*iso*-$C_3H_7)_2NH$	**1A**	1113, 1137, 1170, 1200(C–N), 1670, 830(trisubstituted double bond).	4.95 (1H, t, J=6.0 Hz, –Ċ=C**H**–), 6.80—7.37 (4H, m, =C–**CH_2**–N, –CH–N), 8.33(3H, s, **CH_3**–Ċ=), 8.40(3H, s, **CH_3**–C=), 9.09 (12H, d, J=6.3Hz, **CH_3**–ĊH–).

TABLE 5. CHARACTERIZATION OF TELOMERS (CYCLIC *sec*-AMINES)

Telogen	Telomer	IR (cm^{-1})	NMR (τ)
Pyrrolidine	**1A**	2770, 1200, 1140, 1030 (), 1665, 830 (trisubstituted double bond).	4.84(1H,t,J=6.1Hz,–Ċ=C**H**–), 7.09(2H, d, J=6.1 Hz, =CH–**CH_2**–N), 7.45—8.00(4H, m, –N–**CH_2**–), 8.16—8.65 (10H, m, **CH_3**–Ċ=, –**CH_2**–).
	1B	2780, 1198, 1138, 1082 (), 1670, 820 (trisubstituted double bond).	4.55—5.01(1H, m, –Ċ=C**H**–), 7.17(2H, s, =C–**CH_2**–N), 7.45—7.98 (4H, m, –N–**CH_2**–), 8.17—8.65 (10H, m, **CH_3**–Ċ=, –**CH_2**–).
	2A	2775, 1140, 1125, 1070, 1035, (), 1665, 830 (trisubstituted double bond).	4.65—5.10 (2H, m, –Ċ=C**H**–), 7.14 (2H, d, J=6.8 Hz, =CH–**CH_2**–N), 7.45—7.90 (4H, m, –N–**CH_2**–), 7.95—8.13 (4H, m, =CH–**CH_2**–**CH_2**–C=), 8.25—8.63(13H, m, **CH_3**–Ċ=, –**CH_2**–).
	2B	2780, 1150, 1130, 1070, 1035 (), 1650, 887(end methylene group), 1665, 838(trisubstituted double bond).	4.79—5.13 (1H, m, –Ċ=C**H**–), 5.38 (2H, bs, –Ċ=**CH_2**), 7.26—8.16 (9H, m, =C–**CH_2**–, =C–C**H**–, –N–**CH_2**–), 8.20—8.60 (13H, m, **CH_3**–C=, –**CH_2**–).
Piperidine	**1A**	2800, 2750, 1150, 1115, 1110, 1035, 990(), 1675, 840 (trisubstituted double bond).	4.88(1H, t, J=6.6 Hz, –Ċ=C**H**–), 7.26(2H, d, J=6.6 Hz, =CH–**CH_2**–N), 7.61—8.00 (4H, m, –N–**CH_2**–), 8.32(3H, s, **CH_3**–Ċ=), 8.43(3H, s, **CH_3**–Ċ=), 8.38—8.85(6H, m, –**CH_2**–).
	1B	2800, 2750, 1150, 1118, 1080, 1035, 990(), 1670, 828(trisubstituted double bond).	4.50—5.02(1H, m, –Ċ=C**H**–), 7.32(2H, s, =C–**CH_2**–N), 7.60—7.98 (4H, m, –N–**CH_2**–), 8.28—8.85 (12H, m, **CH_3**–Ċ=, –**CH_2**–).
	2A	2800, 2750, 1150, 1115, 1105, 1035, 990(), 1660, 830(trisubsti-	4.65—5.13 (2H, m, –Ċ=C**H**–), 7.24 (2H, d, J=6.6 Hz, =CH–**CH_2**–N), 7.50—7.95(4H, m, –N–**CH_2**–), 7.95—8.15

		tuted double bond).	(4H, m, =CH-CH_2-CH_2-C=), 8.20—8.80(15H, m, CH_3-Ċ=, -CH_2-).
	2B	2800, 2750, 1155, 1120, 1040, 990 (◯N-R), 1640, 887(end methylene group), 1660, 835 (trisubstituted double bond).	4.80—5.20(1H, m, -Ċ=C**H**-), 5.40(2H, bs, -Ċ=C**H**$_2$), 7.40—8.20(9H, m, =C-CH_2-, =C-C**H**-, -N-CH_2-), 8.25—8.80 (15H, m, CH_3-Ċ=), -CH_2-).
Morpholine	**1A**	2851, 2800, 1118, 1070, 1031, 1002, 868(O◯N-R), 1675, 842 (trisubstituted double bond).	4.87 (1H, t, J=7–1 Hz, -Ċ=C**H**-), 6.32—6.60 (4H, m, -CH_2-O), 7.19(2H, d, J=7.1 Hz, =CH-CH_2-N), 7.57—7.87 (4H, m, -CH_2-N), 8.30(3H, s, CH_3-Ċ=), 8.38(3H, s, CH_3-Ċ=).
	1B	2851, 2800, 1118, 1070, 1031, 1002, 868(O◯N-R), 1670, 832 (trisubstituted double bond).	4.53—5.01(1H, m, -Ċ=C**H**-), 6.60(4H, m, -CH_2-O), 7.28 (2H, s, =C-CH_2-N), 7.55—7.86(4H, m, -CH_2-N), 8.25—8.53(6H, m, CH_3-Ċ=).
	2A	2850, 2800, 1118, 1070, 1034, 1005, 868(O◯N-R), 1660, 830 (trisubstituted double bond).	4.60—5.12(2H, m, -Ċ=C**H**-), 6.33—6.60(4H, m, -CH_2-O), 7.18(2H, d, J=7.0 Hz, =CH-CH_2-N), 7.55—7.83 (4H, m, -CH_2-N), 7.85—8.12 (4H, m, =CH-CH_2-CH_2-C=), 8.22—8.47(9H, m, CH_3-Ċ=).
	2B	2850, 2800, 1140, 1118, 1070, 1034, 1010, 865(O◯N-R), 1640, 887 (end methylene group), 1660,830 (trisubstituted double bond).	4.80—5.15(1H, m, 5.15(1H, m, -Ċ=C**H**-), 5.24—5.47(2H, m, -Ċ=C**H**$_2$), 6.35—6.61(4H, m, -CH_2-O), 7.49—8.24 (9H, m, =C-CH_2-, =C-C**H**-, -CH_2-N), 8.37 (6H, s, CH_3-Ċ=), 8.42(3H, s, CH_3-Ċ=).

react in the presence of sodium (0.1 g) at 40°C for 3 hr while being stirred in a pressure bottle by the method described in the preceding paper.[1] The reaction products (5.9 g) included the n=1 telomer (bp 62.5—64.0°C/6 mmHg, 1.4 g), the n=2 telomer (bp 91.0—97.5°C/1.5 mmHg, 1.7 g), and the $n\geq 3$ telomer (residue, 2.6 g).

Reaction of Myrcene with Diethylamine. A mixture of myrcene (9.9 g) and diethylamine (3.6 g) was allowed to react in the presence of sodium (0.1 g) at 40°C for 3 hr, as has been described in the preceding paper.[1] The reaction products (8.0 g) included the n=1 telomer (bp 85—87°C/2 mmHg, 7.7 g) and the $n\geq 2$ telomers (residue, 0.2 g). The n=1 telomer was found by glc analyses to consist 90% of the compound **1M** (*N,N*-diethylgeranylamine).

Synthesis of N,N-*Diethylgeranylamine.* *N,N*-Diethylgeranylamine was prepared from geranyl chloride by a modification of Sandler's method.[10] Mass (*m/e*); 209(M^+), IR(cm^{-1}, liquid film); 1200, 1165, 1050(C-N), 1660, 830 (trisubstituted double bond). NMR (τ, CCl_4); 9.04 (6H, t, J=7.0 Hz, CH_3-CH_2-), 8.25—8.46 (9H, m, CH_3-C=), 7.89—8.09 (4H, m, =CH-CH_2-CH_2-C=), 7.62 (4H, q, J=7.0 Hz, CH_3-CH_2-N-), 7.09 (2H, d, J=6.6 Hz, =CH-CH_2-N◯), 4.69—5.18 (2H, m, -Ċ=C**H**-).

Identification of the Telomers. Glc (15% Apiezon grease L/Celite 545, 2.5 m, H_2) was used for the determination of the compositions of the telomers. The IR, NMR, and mass spectra were measured by the use of Perkin Elmer Model 337, Hitachi-Perkin Elmer Model R-20 (60 MHz), and Hitachi RMU-7L spectrometers respectively. The characterizations of the telomers which were obtained using secondary amines are shown in Tables 4 and 5.

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10) S. R. Sandler and W. Karo, "Organic Functional Group Preparations," Academic Press, New York and London (1968), p. 324.