[Chem. Pharm. Bull.
16(7)1324—1329(1968)]

UDC 546.265.1.04 : 547.362.3.04

Studies on Organo Sulfur Compounds. II.[1] The Reaction of *sec*- and *tert*-*a*-Acetylenic Alcohols and Carbon Disulfide

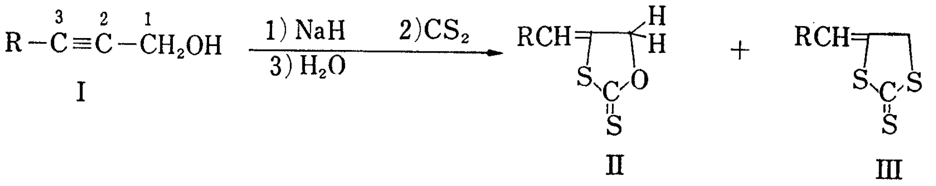
Kazuo Tomita and Mitsuo Nagano

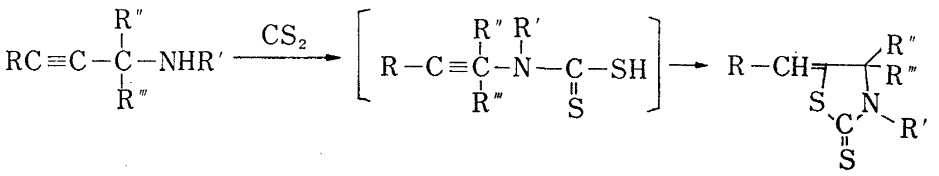
Agricultural Chemicals Research Laboratories, Sankyo Co., Ltd.[2]

(Received October 4, 1967)

The reaction of sodium alcoholates of *sec*– or *tert*– *a*–acetylenic alcohole having no ethynyl group with carbon disulfide in an aprotic solvent gave 4–alkylidene–1,3–oxathiolane–2–thiones, but from alcohols having ethynyl group 4–methylidene–1,3–dithiolane–2–thiones, or their rearranged isomers were mainly isolated, and in the case of 1–hexyn–3–ol (VI) or 1–ethynylcyclohexano l(XV) 4–methylidene–1,3–oxathiolane–2–ones were also isolated.

In the preceding paper,[1] authors reported that sodium alcoholates of primary *a*–acetylenic alcohols (I) from 4–alkylidene–1,3–oxathiolane–2–thiones (II) by the reaction with carbon disulfide. In this reaction, 4–alkylidene–1,3–dithiolane–2–thiones (III) are also formed as byproducts, but no six–membered cyclic compounds are isolated. Intramolecular cyclization of compounds having both a carbon–carbon triple bond and a nucleophilic radical would be influenced by their structural and steric effects. It has been reported that 3–amino–1–butyne[3] or 3–monoalkylamino–1–butyne[4] reacts with carbon disulfide to give 4–methyl–5–methylidenethiazolidine–2–thiones in the presence of aqueous sodium hydroxide, but more hindered 3–*tert*–octylamino–1–butyne[5] does not add to carbon disulfide under similar condition.

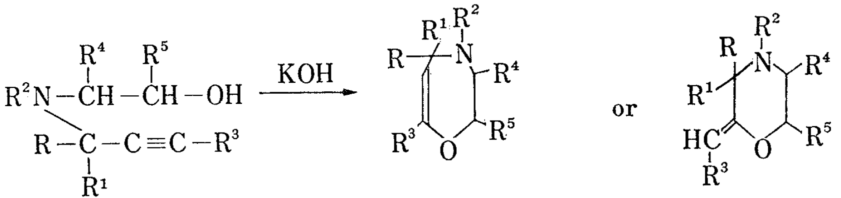




Dillard and Easton[6] have reported that the influence of substitution on the acetylenic group of N–(*β*–hydroxyethyl)–1,1–dialkyl–2–propynylamines to intramolecular alkoxide ion addition is apparent, when 3–substituent of 2–propynylamines is alkyl or methoxymethyl, they cyclize to 2,3,4,5–tetrahydro–1,4–oxazepines, whereas chloro, phenyl or methlthio derivative gives the corresponding 2–propynylalkylidene morphorine, and these observations relate only to the inductive effect of the substitution.

---

1) Part I: *Chem. Pharm. Bull.* (Tokyo), **16**, 914 (1968).
2) Location: *Hiromachi, Shinagawa-ku, Tokyo.*
3) Y. Yura, *Chem. Pharm. Bull.* (Tokyo), **10**, 1087 (1962).
4) W. Batty and B.C.L. Weedon, *J. Chem. Soc.*, **1949**, 786.
5) P.N. Shacht and J.J. Bagnell, *J. Org. Chem.*, **28**, 991 (1963).
6) Robert D. Dillard and Nelson R. Easton, *J. Org. Chem.*, **31**, 122 (1966).



R^3=alkyl, methoxy, methyl R^3=chloro, phenyl, methylthio, hydrogen

Expecting the same results as the case of primary α–acetylenic alcohols, this cyclization reaction was extended to secondary and tertiary α–acetylenic alcohols in this paper. Furthermore, authors intended to clarify the influence of the structure of α–acetylenic alcohols to the intramolecular addition reaction.

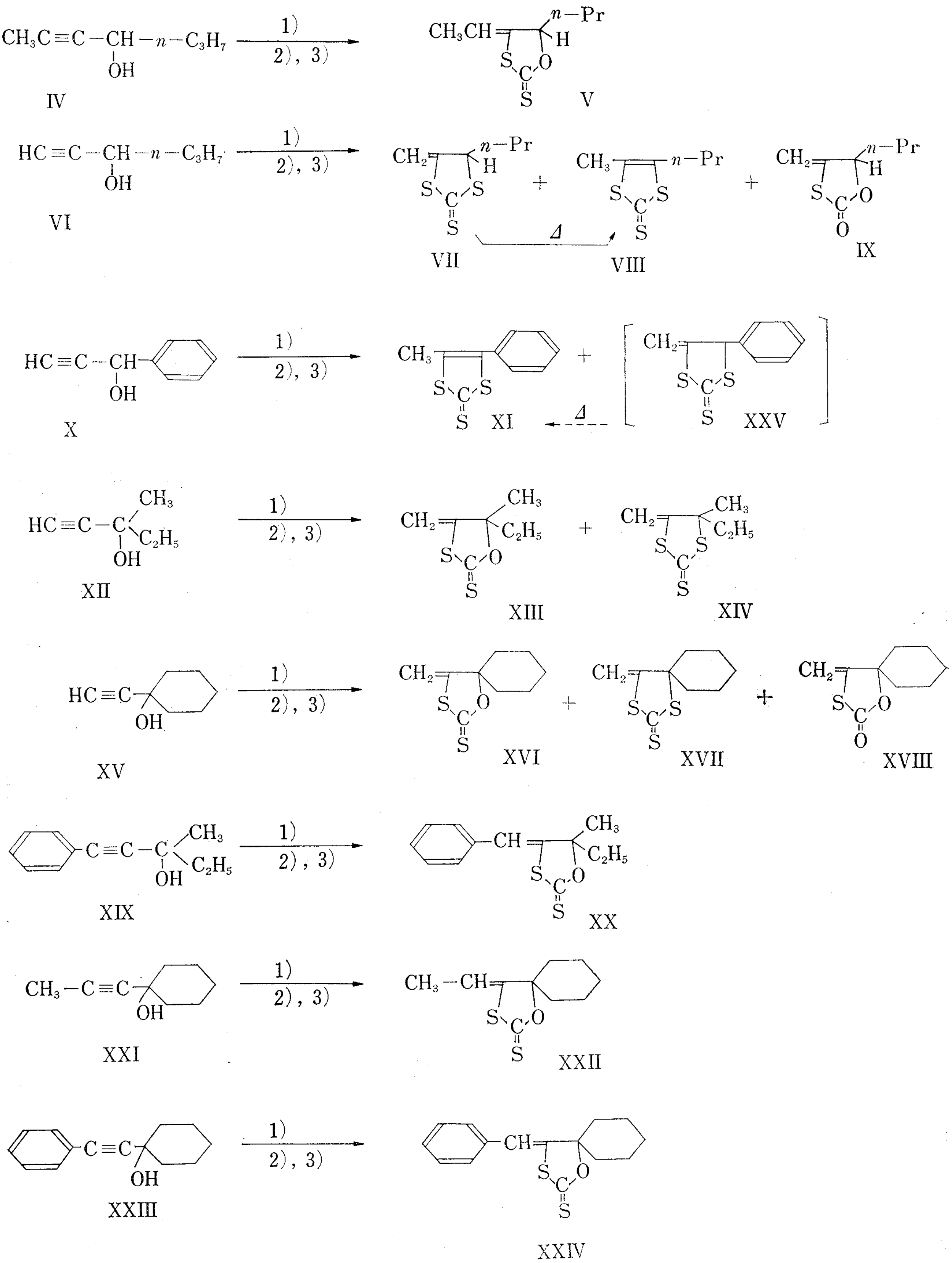
The alcoholate prepared from sodium sand and small excess of 2–heptyn–4–ol (IV) was treated with carbon disulfide in dry benzene and then the reaction mixture was hydrolyzed to afford 4–ethylidene–5–*n*–propyl–1,3–oxathiolane–2–thione (V), the structure of which was determined on the basis of analytical and spectral data (see Table I, II and III).

In place of 2–heptyn–4–ol, 1–hexyn–3–ol (VI) was treated with carbon disulfide in the same manner to give three main products after silica–gel chromatography. Two of them were identified as 4–methylidene–5–*n*–propyl–1,3–dithiolane–2–thione (VII) and 4–methyl–5–*n*–propyl–1,3–dithiole–2–thione (VIII), respectively (see Table I, II and III); the former was easily rearranged into the latter by vacuum distillation. The other was identified as 4–methylidene–5–*n*–propyl–1,3–oxathiolane–2–one (IX) on the basis of elemental and spectral analyses. Characteristic infrared absorption bands were observed at 1633 (C=C), 1085 (–S–CO–S–) and 872 cm^{-1} (CH_2=), but no characteristic band to carbon–carbon triple bond and hydroxy group were observed. Further confirmation of the structure was obtained from its nuclear magnetic resonance (NMR) spectrum, which showed a multiplet ($J=7.0$, $J_{AC}=J_{AB}=1.5$ cps) at 4.8 ppm for one proton, and two triplets at 5.3 and 5.45 ppm for two unequivalent protons of methylidene with coupling constant of 1.5 cps.

The reaction product obtained from 1–phenyl–2–propyn–1–ol (X) showed two main yellow spots on thin–layer chromatogram. Attempts upon separation of them by silica gel column were failed. The difficulty of separations probably is due to thermodynamical instability of a compound which is rearranged into the more stable isomer by silica–gel chromatography or post–treatment. When the reaction product was distilled under reduced pressure only 4–methyl–5–phenyl–1,3–dithiole–2–thione (XI) was obtained as yellow crystals. It was considered that the compound XI having a styrene component was thermodynamically more stable than 4–methylidene–5–phenyl–1,3–dithiolane–2–thione (XXV) having a allylbenzene component, so an yellow oil obtained from reaction mixture was a mixture of XI and XXIV, and the latter would be thermally rearranged into the former on distillation.

In the case of 3–methyl–1–pentyn–3–ol (XII), two five–membered cyclic compounds (XIII and XIV) were isolated, and from 1–ethynylcyclohexanol (XV) three five–membered cyclic compounds (XVI, XVII and XVIII) were obtained. From other tertiary α–acetylenic alcohols (XIX, XXI and XXIII) only the corresponding five–membered dithiocarbonates (XX, XXII and XXIV) were isolated. Their structures were determined on the basis of analytical and spectral data shown in Table I, II and III.

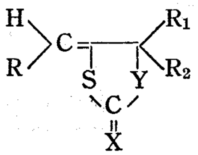
Every α–acetylenic alcohols used in this investigation gave five–membered heterocyclic compounds, and six–membered ones which should be formed by intramolecular addition to β–position of the triple bond could not be isolated. Whether 3–substituent influenced the formation of five–membered heterocyclic compounds was questionable, but total amounts of isolated cyclic compounds from a series of acetylenic alcohols each having a different 3–substituent decreased in the order Ph>H>Me, which might suggest that inductive effects of the substituents affect more or less in formation of the five–membered rings.



1): Na sand in benzene
2): CS_2
3): H_2O

Chart 1

Table II. Nuclear Magnetic Resonance Spectra of 4-Alkylidene-1,3-dithiolane-2-thiones, -1,3-Oxathiolane-2-thiones and 1,3-Oxathiolane-2-ones



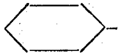
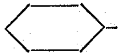
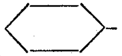
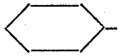
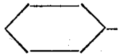
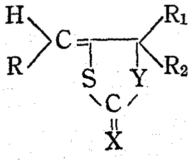
Comp. No.	Substituent					δ=ppm, J=cps				
	R	R_1	R_2	X	Y	A $\underline{H}$>C= R	B H>C= $\underline{R}$	C -CH-O-	D -CH-S-	Another
VII	H	H	n-Pr	S	S	$\delta=5.3$ (d.d.) $J_{AB}=1.2$ (d.) $J_{AD}=1.5$ (d.)	$\delta=5.45$ (d.d.) $J_{AB}=1.2$ (d.) $J_{BD}=1.5$ (d.)		$\delta=4.8$ (t.q.) $J=7.0$ (t.) $J_{AD}=1.5$ (d.) $J_{BD}=1.5$ (d.)	$\delta=1.0$ (3H, t.) $\delta=1.18$—2.36 (4H, m.) } n-Pr
XVII	H			S	S	$\delta=5.77$ (d.) $J_{AB}=1.4$	$\delta=5.9$ (d.) $J_{AB}=1.4$			$\delta=1.05$—2.5 (10H, m.) } 
XIV	H	Me	Et	S	S	$\delta=5.25$ (s.) $J_{AB}=0$	$\delta=5.25$ (s.) $J_{AB}=0$			$\delta=1.76$ (3H, s.)— Me $\delta=1.11$ (3H, t.) $\delta=1.98$ (2H, q.) } Et
XIII	H	Me	Et	S	O	$\delta=ca.$ 5.15 (d.) $J_{AB}=3.0$	$\delta=ca.$ 5.2 (d.) $J_{AB}=3.0$			$\delta=1.66$ (3H, s.)— Me $\delta=1.02$ (3H, t.) $\delta=1.88$ (2H, q.) } Et
XVI	H			S	O	$\delta=ca.$ 5.14 (d.) $J_{AB}=2.5$	$\delta=ca.$ 5.18 (d.) $J_{AB}=2.5$			$\delta=1.05$—2.46 (10H, m.) } 
IX	H	H	n-Pr	O	O	$\delta=5.27$ (d.) $J_{AB}=0$ $J_{AC}=1.9$	$\delta=5.27$ (d.) $J_{AB}=0$ $J_{BC}=1.9$	$\delta=5.2$ (d.) $J=7.0$ $J_{AB(C)}=1.9$		$\delta=0.71$—2.12 (7H, m.) } n-Pr
XVIII	H			O	O	$\delta=ca.$ 5.15 (d.) $J_{AB}=2.8$	$\delta=ca.$ 5.21 (d.) $J_{AB}=2.8$			$\delta=1.15$—1.46 (10H, m.) } 
V	Me	H	n-Pr	S	O	$\delta=5.5$ (q.d.) $J_{AB}=7.0$ (q.) $J_{AC}=2.0$ (d.)	$\delta=1.73$ (d.d.) $J_{AB}=7.0$ (d.) $J_{BC}=2.0$ (d.)	$\delta=5.6$ (m.)		$\delta=1.03$ (3H, t.) $\delta=1.28$—2.19 (4H, m.) } n-Pr
XXII	Me			S	O	$\delta=5.43$ (q.) $J_{AB}=7.0$	$\delta=1.68$ (d.) $J_{AB}=7.0$			$\delta=1.17$—2.39 (10H, m.) } 
XX	Ph	Me	Et	S	O	$\delta=6.29$ (s.)	$\delta=ca.$ 7.3 (m.)			$\delta=1.76$ (3H, s.)— Me $\delta=1.07$ (3H, t.) $\delta=1.95$ (2H, q.) } Et
XXIV	Ph			S	O	$\delta=6.51$ (s.)	$\delta=ca.$ 7.35 (m.)			$\delta=1.32$—2.35 (10H, m.) } 

Table I. Ultraviolet and Infrared Spectra of 4-Alkylidene-1,3-dithiolane-2-thiones, -1,3-Oxathiolane-2-thiones and -1,3-Oxathiolane-2-ones



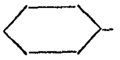
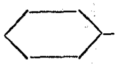
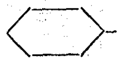
Comp. No.	Substituents					UV: λ_{max}^{EtOH} = mμ (ε×10⁻³)			IR cm⁻¹				
	R	R₁	R₂	X	Y	Low wave length	High wave length	Another	-C=C-	$H_2C=$	-S-C(=S)-S-	-S-C(=S)-O-	-S-C(=O)-O-
VII	H	H	*n*-Pr	S	S	235 (5.55)	324 (12.40)		1615	879	1072		
XVII	H			S	S	236 (6.90)	328 (17.50)		1613	877	1070		
XIV	H	Me	Et	S	S	273 (5.00)	327 (14.40)	308 (14.10)	1610	883	1070		
XIII	H	Me	Et	S	O	230.5 (4.40)	292.5 (8.70)		1626	877		1260 1137	
XVI	H			S	O	240 (4.30)	273 (8.00)		1626	877		1226 1136	
IX	H	H	*n*-Pr	O	O				1633	872			1750 1085
XVIII	H			O	O				1625	865			1748 1173
V	Me	H	*n*-Pr	S	O	245.5 (4.50)	298 (7.60)		1665				
XXII	Me			S	O	246 (5.80)	299 (10.00)		1655			1222 1060	
XX	Ph	Me	Et	S	O	251 (9.50)	307 (13.80)		1660			1250 1122	
XXIV	Ph			S	O	260 (8.30)	312 (9.30)		1635			1230 1068	

Table III. Yields and Analytical Data of 4-Alkylidene-1,3-dithiolane-2-thiones, -1,3-Dithiolane-2-thiones and -1,3-Oxathiolane-2-ones

Starting alcohol	Product	mp (°C) or bp (°C)/mmHg	Yield (%)	Formula	Analysis (%) Calcd.			Found		
					C	H	S	C	H	S
IV	V	95/0.25	18.4	$C_8H_{12}OS_2$	51.25	6.38	34.00	51.18	6.38	32.81
VI[a]	VII	—[b]	22.4	$C_7H_{10}S_3$	44.16	5.29	50.53	44.20	5.33	49.67
	IX	65/2	6.3	$C_7H_{10}O_2S$	53.13	6.37	20.26	53.38	6.53	19.91
XII	XIII	120/0.05	32.8	$C_7H_{10}OS_2$	48.27	5.79	36.79	48.67	5.69	36.24
	XIV	130—135/0.35	16.0	$C_7H_{10}S_3$	44.16	5.29	50.53	44.61	5.31	49.92
XV	XVI	52	29.0	$C_9H_{12}OS_2$	53.94	6.04	32.02	54.03	5.89	31.99
	XVII	85—89/0.1	7.2	$C_9H_{12}S_3$	49.95	5.58	44.45	49.61	5.44	44.40
	XVIII	75—76	8.0	$C_9H_{12}O_2S$	58.64	6.56	17.38	58.79	6.47	17.24
XIX	XX	83—84	42.0	$C_{13}H_{14}OS_2$	62.36	5.63	25.61	62.72	5.92	24.96
XXI	XXII	75—76	22.0	$C_{10}H_4OS_2$	56.03	6.58	29.91	55.91	6.60	29.27
XXIII	XXIV	83—84	35.0	$C_{15}H_{16}OS_2$	65.25	5.84	23.10	65.13	5.84	23.02

[a] Besides VII and IX, 4-methyl-1,3-dithiole-2-thione (VIII) was obtained (7.2%).

[b] Under vacuum distillation, VII was rearranged to VIII.

Cyclic trithiocarbonates were isolated only from the alcohols (VI, X, XII and XV) having ethynyl group (HC≡C–) and in the cases of VI and XV considerable amounts of cyclic thiolcarbonates (IX and XVIII, respectively) could be also isolated, which would be a clue for the investigation of mechanism of producing cyclic trithiocarbonates, and the study on this mechanism is in progress.

Each cyclic compound having 4–benzylidene or 4–ethylidene group has a pair of stereoisomers, but only one of which could be isolated in every case and their configuration remains to be solved.

Experimental[7]

Preparation and Purification of Starting Alcohols——2–Heptyn–4–ol (bp 54° (2 mmHg)),[8] 1–propynylcyclohexanol (bp 88—90° (10 mmHg)),[9] 3–methyl–1–phenyl–1–pentyn–3–ol ($bp_{0.3-0.4}$ 109°)[10] and 1–phenylethynylcyclohexanol (bp 138—140° (2 mmHg))[11] were prepared from corresponding acetylenes and aldehydes or ketones. These alcohols were confirmed on the basis of spectral data.

Commercially available 1–phenyl–2–propyn–1–ol (bp 92—95° (4 mmHg)), 1–hexyn–3–ol (bp 75° (45 mmHg)), 1–ethynylcyclohexanol (bp 73° (12 mmHg)) and 3–methyl–1–pentyn–3–ol (bp 121.5°) were purified by distillation.

General Method for Reaction of *sec*- and *tert*-*α*-Acetylenic Alcohols with Carbon Disulfide——To a suspension of powdered sodium (0.5 mole) in anhydrous benzene, *sec*– or *tert*–*α*–acetylenic alcohol (0.55 mole) was added at room temp. under stirring, and the solution was refluxed until a grain of sodium disappeared. To the alcoholate solution carbon disulfide (0.6 mole) was added under cooling, and the reaction mixture was stirred for 3 hr at room temp. and then was poured into ice–water. Benzene layer was separated, aqueous layer was extracted with ether. Combined organic extracts were washed with water and dried over anhyd. Na_2SO_4. After removal of the solvent by evaporation the residue was chromatographed by silica gel column, and the isolated compounds were refined by distillation or recrystallization.

Thermal Rearrangement of 4-Methylidene-1,3-dithiolane-2-thione (VII) to 4-Methyl-1,3-dithiole-2-thione (VIII)——Compound VII (0.5 g) was distilled at 100° under 0.05 mmHg to afford compound VIII as a yellow oil in a good yield (80%). *Anal.* Calcd. for $C_7H_{10}S_3$ (VIII): C, 44.16; H, 5.33; S, 49.93. Found: C, 44.20; H, 5.33; S, 49.62. IR ν_{max}^{Liquid} (cm^{-1}): 1624 (–C=C–), 1021 (–S–CS–S–). UV λ_{max}^{EtOH} mμ (log ε): 239 (3.77), 307.5 (3.93). NMR (in CCl_4) τ (J=cps): 7.8 (3H, s.), 9.02 (3H, t., J=7.0), 8.38—7.44 (4H, m.).

Reaction of 1-Phenyl-2-propyn-1-ol (X) with Carbon Disulfide——1–Phenyl–2–propyn–1–ol (X) (7.03 g) was reacted in dry benzene (200 ml) with Na sand (1.15 g) and carbon disulfide (5.0 g). After removal of the solvent by evaporation a yellow oily residue was obtained which showed two main yellow spots on TLC. Separation of them by using a silica gel column (hexane–benzene) gave many fractions showing two yellow spots on TLC but no fraction showing one spot. Solvents were evaporated under reduced pressure from the combined fractions, and an oily residue was distilled *in vacuo* (bp 120° (0.05 mmHg)) to afford a yellow solid, which was recrystallized from a mixture of *n*–hexane and benzene (1:1) to give 2.4 g (44%) of 4–methyl–1,3–dithiole–2–thione (XI) (mp 64—65°) as yellow crystals. *Anal.* Calcd. for $C_{10}H_8S_3$ (XI): C, 53.53; H, 3.59; S, 42.89. Found: C, 53.96; H, 3.64; S, 42.22. IR ν_{max}^{Nujol} (cm^{-1}): 1580 (–C=C–), 1055 (–S–CS–S–). UV λ_{max}^{EtOH} mμ (log ε): 224 (4.08), 378 (4.19). NMR (in $CDCl_3$) τ (ppm): 7.78 (3H, s.), 2.63 (5H, s.).

Acknowledgement We are grateful to Dr. K. Takahashi, manager of this laboratories, and Dr. I. Iwai, assistant manager of Central Research Laboratories, this company. We are also indebted to the members of the Section of Physical Chemistry for the elemental analyses and determination of absorption spectra.

---

7) All boiling points were uncorrected. The NMR spectra were recorded on Varian A-60 in deuteriochloroform or tetrachloromethane containing tetramethyl silane as internal standard. The spectral data of the 4–alkylidene–1,3–oxathiolane–2–thiones, –1,3–dithiolane–2–thiones and –1,3–oxathiolane–2–ones were summarized in Table I, II, III.

8) Melvin S. Newman and John H. Wotiz, *J. Am. Chem. Soc.*, 71, 1292 (1942).

9) B. Raymond Fleck and James E. Kmiecik, *J. Org. Chem.*, 22, 90 (1957).

10) A.F. Thompson and C. Margnetti, *J. Am. Chem. Soc.*, 64, 573 (1942).

11) E.D. Venns–Danilova and M.V. Goreeik, *Zh. Obshch. Khim.*, 23, 1139 (1953).