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SYNTHESIS OF 10-SUBSTITUTED 9-PHENYLTHIOXANTHENIUM SALTS AND THEIR REACTIONS WITH BASES[1)]

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Each of 10-(p-methoxyphenyl)- and 10-(n-propyl)-9-phenylthioxanthenium perchlorates (Ia and Ii) was separated into two geometrical isomers. Their conformations were discussed in some detail. The reactions of 10-substituted 9-phenylthioxanthenium salts with bases were investigated using Ia as a typical substrate. The main product thus obtained was 9-(p-methoxyphenyl)-9-phenylthioxanthene (II). The reaction pathway via intramolecular Stevens-type 1,4-rearrangement is postulated.

Recently, we reported on the scope and the limitation of various synthetic methods of cyclic sulfonium salts.[2)]

In this paper, we wish to report on the isolation and the structures of two isomers of 10-substituted 9-phenylthioxanthenium salts (I), and on the new Stevens-type 1,4-rearrangement of the salts caused by bases.

The Separation and the Structures of Two Isomers of 10-Substituted 9-phenylthioxanthenium Salts

When 9-Phenylthioxanthene 10-oxide was allowed to condence with anisole in the presence of conc. H_2SO_4 and then treated with 70% $HClO_4$, a mixture of two isomers, Ia-A and Ia-B, of 10-(p-methoxyphenyl)-9-phenylthioxanthenium perchlorate (Ia) in the production ratio of ca. 3 : 1 was obtained. The isomers were confirmed by the measurement of NMR spectrum.

Slow recrystallization of the mixtures from 1-butanol afforded two types of crystals, plates (Ia-A) and prisms (Ia-B), which could be separated mechanically with the aid of a microscope, although the separation of two isomers of tricyclic sulfonium salts has not been successful so far. Elemental analysis of the isomers gave an empirical formula $C_{26}H_{21}O_5SCl$. Their IR spectra were also approximately the same except for the regions of 1400 cm^{-1} and 700-800 cm^{-1}. Ia-A showed mp 210-211°C and NMR bands (CF_3COOH) at δ 7.20-7.80 (15H, m, aromatic H), 6.90-7.20 (2H, m,

aromatic H), 5.80 (1H, s, C_9-H), and 5.93 (3H, s, OCH_3). Ia-B showed mp 154°C and was converted into Ia-A on heating above the melting point and melted again at 210°C. Ia-B showed NMR bands (CF_3COOH) at δ 7.70-8.30 (8H, m, aromatic H), 6.50-7.20 (9H, m, aromatic H), 5.80 (1H, s, C_9-H), and 3.87 (3H, s, OCH_3). The band of methoxyl group appeared in a magnetic field higher than that of Ia-A. The band of C_9-H appeared at the same position as that of Ia-A, but in a magnetic field higher than that of Ia-A in $CDCl_3$ solution (Ia-A: δ 5.82, Ia-B: δ 5.75).

The pure Ia-A was converted into an equilibrium mixture with Ia-B, upon heating at 72°C for ca. 10 min in an NMR tube (CF_3COOH solution). The relative strength of proton signals of the methoxyl groups of Ia-A and Ia-B in the NMR spectrum showed that the existence ratio of the isomers was ca. 2:1. The Ia-B also gave the equilibrium mixture when kept at the same temperature for 30 min. The composition of the equilibrium mixture indicates that Ia-A is the more stable. It was recognized that this equilibrium was affected by the solvent as shown in Table 1.

There are four possible conformers of I, A, B, C, and D as shown in Fig. 1. Interconversion[3] by the ring inversion takes place between A and B and between C and D. Interconversion by pyramidal inversion[4] of sulfonium salts takes place between A and D and between B and C. It seems reasonable to assume that the order of the relative stability of the above four conformers is A > B ≫ C > D in view of the NMR studies of the structures of dihydroanthracenes,[5] dihydroacridines,[6] xanthenes,[7] thioxanthenes,[8] and 9,10-diphenylanthracene.[9]

From the discussion mentioned above, it is suggested that Ia-A and Ia-B prefer conformer A and B, respectively, and that they are interconverted on heating by the ring inversion. The same interpretation is applicable to the isomers of Ib∼e. Ib∼e were also obtained as the mixtures of two isomers, A and B, by the same synthetic methods as Ia. In these cases, only one of the isomers was obtained in a pure form on recrystallization from MeOH. NMR studies indicated that these were preferred isomers, Ib∼e-A corresponding to Ia-A.

The studies by NMR spectra indicated that two isomers exist in 10-alkyl-9-phenylthioxanthenium salts (Ig∼i) synthesized by the reaction of 9-phenylthioxanthene and alkyl halides in the presence of $AgBF_4$ or $AgClO_4$, as in the case of 10-aryl derivatives (Table 2). The interconversion between the isomers of 10-alkyl derivatives was not observed under the conditions given to 10-aryl derivatives. Ii was successfully separated into two isomers, Ii-A and Ii-B, by recrystallization from MeOH. The isomers Ig-A and Ih-A were obtained on recrystallization of Ig and

Ih from MeOH, respectively. However, the corresponding isomers Ig-B and Ih-B were not isolated by recrystallization.

Table 1. 10-Aryl-9-phenylthioxanthenium Perchlorates

Compounds	R (Aryl)	Yield (%)	Ratio of two isomers in an equilibrium state A : B		mp(°C) of preferred isomer (A)
Ia	4-$CH_3OC_6H_4$	74	2.5 : 1	a)	211
Ib	4-$C_2H_5OC_6H_4$	75.3	3 : 1	a)	229
Ic	2,4-$(CH_3O)_2C_6H_3$	82.9	3 : 1	a)	236
Id	2,5-$(CH_3)_2C_6H_3$	50.3	4.5 : 1	b)	273 (decomp.)
Ie	C_6H_5	2.6	———	c)	266 (decomp.)
If	2,4,6-$(CH_3)_3C_6H_2$	45.6	———	d)	224

a) in DMSO-d_6 at 100°C. b) in CF_3COOH at 72°C. c) The proton at 9-position of the two isomers of Ie showed the same absorption in the NMR band. Therefore, the existence ratio of the two isomers could not be determined by the NMR spectra. d) No isomers are known.

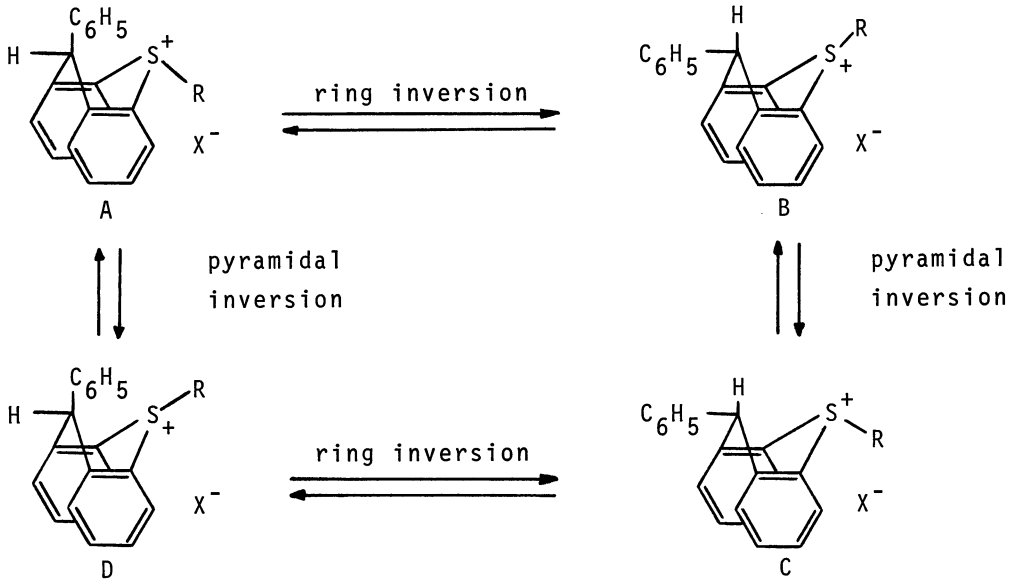

Fig. 1

Table 2. 10-Alkyl-9-phenylthioxanthenium Salts

Compounds	R (Alkyl)	X	Yield (%)	mp(°C) of preferred isomer
Ig	CH_3	BF_4	83.6	158
Ih	C_2H_5	BF_4	82.7	170
Ii	n-C_3H_7	ClO_4 a)	37.2	165 b)

a) In the presence of $AgBF_4$ in the place of $AgClO_4$, tetrafluoroborate corresponding to Ii was not synthesized. b) The melting point of one of the isomers was 161-162°C.

Rearrangement of 10-Aryl- and Alkyl-9-phenylthioxanthenium Salts (I) with Various Bases

In the course of a study on the synthesis of thiaänthracenes, a new Stevens-type 1,4-rearrangement was found to occur in the reaction of I with bases.

The reaction of Ia with 5 eq. $NaCH_2SOCH_3$ in DMSO under N_2 stream at room temperature gave 9-(p-methoxyphenyl)-9-phenylthioxanthene (II) in 95% yield after 5 hr: mp 218°C, NMR ($CDCl_3$) δ: 6.58-7.52 (17H, m, aromatic H), 3.78 (3H, s, OCH_3). II was also obtained from the reaction of Ia with NaH in THF, $NaOCH_3$ in MeOH, and phenylmagnesium bromide in benzene in 91%, 87%, and 74% yield, respectively. However, the reaction of Ia with phenyllithium under N_2 stream for 6 hr gave II in 60% yield, and also 9,9-diphenylthioxanthene (III) in 39% yield as a by-product, which was identified with an authentic sample by the comparison of IR and NMR spectra. The reaction of Ia with methyllithium not only gave II in 45% yield, but also 9-methyl-9-phenylthioxanthene, IV (mp 138°C) and 9-phenylthioxanthene, V (mp 98°C) in 16% and 23% yield, respectively. In this case, the production of norcarane was confirmed when the reaction was carried out in the presence of cyclohexene.

The results described above strongly support the view that organolithiums nucleophilically attack trivalent sulfur atoms and cause initial ligand exchange by the S_N2 mechanism[10] but that other bases abstract a proton at 9-position at first.

It was proved that this rearrangement was different from the Pummerer-type reaction which is an intermolecular reaction, since a crossover reaction of a mixture of Ia and 10-(p-ethoxyphenyl)-9-phenyl(-d_5)thioxanthenium perchlorate with $NaOCH_3$ in MeOH gave no crossed products.[11] Moreover, when 10-(n-propyl)-9-phenylthioxanthenium perchlorate (Ii) was allowed to react with bases, no rearranged

products having isopropyl group at 9-position, isomerized from n-propyl group of Ii during the reaction, were not obtained.

Thus, it is concluded that the new rearrangement in the title reaction proceeds by the intramolecular Stevens-type 1,4-rearrangement. Any ESR and CIDNP spectra were not observed during these reactions.

All the experimental data described in this report indicate that the mechanism of the new rearrangement of 10-substituted 9-phenylthioxanthenium salts to 9,9-disubstituted thioxanthenes by the reaction with bases is as shown in Chart 1.

Studies are now in progress on the structures of the two isomers of Ia by X-ray analysis.

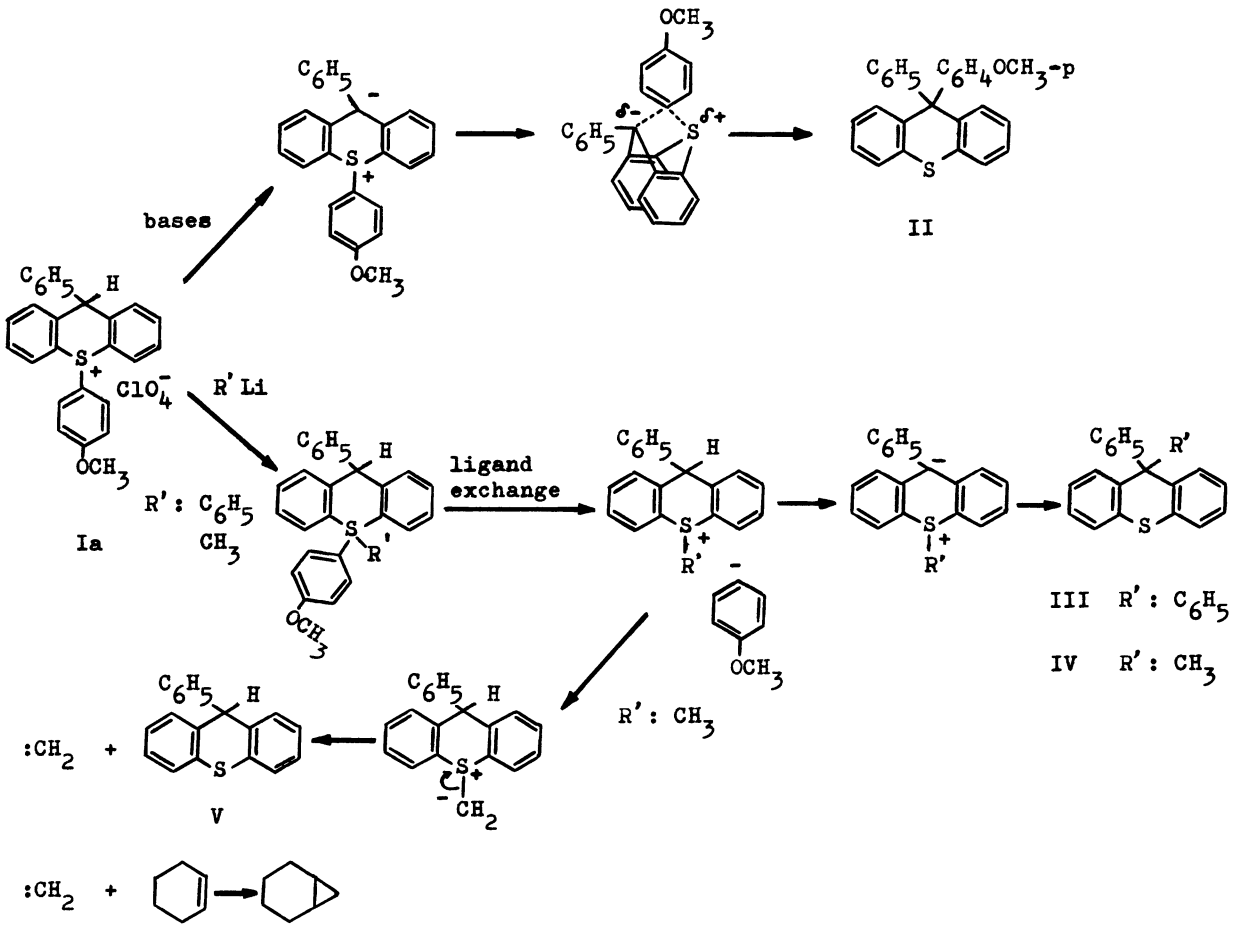

Chart 1

REFERENCES AND NOTES

1) This work was presented at the 6th Congress of Heterocyclic Chemistry, Nagoya, November 1-2, 1973, Abstracts p. 79.

2) M. Hori, T. Kataoka, H. Shimizu, and M. Miyagaki, Yakugaku Zasshi, 93, 476 (1973).

3) Recently, we obtained cis- and trans-isomer of 9-phenylthioxanthene 10-oxide in a pure form. Both the pure cis- and trans-isomers gave Ia by the reaction with anisole in the presence of conc. H_2SO_4. The ratio of the amount of Ia-A to that of Ia-B was ca. 3:1 in both cases. This result suggested the interconversion between Ia-A and Ia-B.

4) Andersen and his co-workers reported on the pyramidal inversion of 9,9-dimethyl-10-phenylthioxanthenium perchlorate. However, they did not succeed in the separation of the sulfonium salts into the two isomers. [K. K. Andersen, M. Cinquini, and N. E. Papanikolaou, J. Org. Chem., 35, 706 (1970).]

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11) A crossover experiment was carried out as follows; To a stirred solution of sodium metal (25 mmol) in dry MeOH (150 ml), a solution of Ia (2.1 mmol) and 10-(p-ethoxyphenyl)-9-phenyl(-d_5)thioxanthenium perchlorate (2.1 mmol) in dry MeOH (100 ml) was added under N_2 stream. The mixture was stirred at room temperature for 5 hr and then refluxed for 3.5 hr. The reaction mixtures were poured into ice water and extracted with CH_2Cl_2. The organic layer was washed with water and dried over anhydrous K_2CO_3. The solvent was evaporated in vacuo to give 1.4 g of a mixture of several crude products. Mass spectrum of the mixture showed the molecular ion peak of 9-(p-ethoxyphenyl)-9-phenyl(-d_5)-thioxanthene at m/e 399.5 and that of II at m/e 380.5. However, there were no peaks at m/e 394.5 and 385.5, which are attributable to the molecular ion peaks of crossed products. The separation of the mixtures by the preparative TLC on silica gel with hexane-benzene (5:3) as the eluent gave II in a quantitative yield and 9-(p-ethoxyphenyl)-9-phenyl(-d_5)thioxanthene as colorless prisms in a quantitative yield, mp 174°C, IR (KBr) ν : 2240 cm^{-1} (C-D), NMR ($CDCl_3$) δ : 6.72-7.52 (12H, m, aromatic H), 4.05 (2H, q, J=7 Hz, CH_2CH_3), 1.40 (3H, t, J= 7 Hz, CH_2CH_3), Mass: m/e 399.5 (M^+).

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