alternative spraying of 0.2% caustic alkali solution and umbelliferone solution was desirable. It was readily obtained by the ultraviolet ray of 2537 Å, by attaching Kaken 2537 Å filter on the disinfection light tube (Mazda GL-15), by which detection of spots on paper was more sensitive than that by the commercial black light tube of 3650 Å.

10% $CHCl_3$ solution of $SbCl_5$: All phthalates of terpene alcohols turned yellowish brown to orange yellow.

Color reagents for borate buffer electrolyte for terpene alcohol: The same reagents are available as for alcohol hydrogen phthalates mentioned above.

(2) **Aldehydes, Ketones, and Lactones**—Miscellaneous color reagents were used for revealing spots of aldehydes, ketones, and lactones on filter paper, including ultraviolet ray (Table X), which is one of the most sensitive detection as was pointed out by Feigl with coumarin and its derivatives. In general, 2,4-dinitrophenylhydrazine, *m*- and *p*-phenylenediamine, *m*-dinitrobenzene, and sodium nitroprusside showed some coloration with aldehydes and ketones, but none was observed for coumarin, umbelliferone, and related compounds.

Summary

Extensive studies were made for the detection of terpene alcohols, aldehydes, ketones, and lactones by paper electrophoresis. The method is generally available for a rapid test of perfume products and it could be accomplished more rapidly than chromatography on paper by using a current of 500~8,000 V, reported previously. The higher the voltage, the sooner the results are obtained in electrophoresis, while a constant time was required in chromatography owing to the constant capillarity of the filter paper itself. One of many electrolytes applied, mercuric chloride, has shown the most satisfactory result and a formation of conjugated carbonyl groups with mercuric ion was presumed.

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89. **Kiichi Arakawa and Masachika Irie**: Bromination of Cyclic 1,3-Diketone Monoenolates with N-Bromosuccinimide. I.

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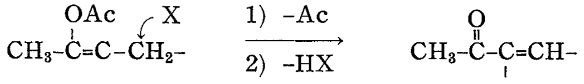
Several results have been reported on the bromination of an alkyl or acyl enolate and these could be divided into two groups from the type of their reaction. Thus, 3α,12α,20-triacetoxypregn-17-ene and 3β,20-diacetoxyallopregn-17-ene were reacted with N-bromosuccinimide (NBS) in the presence of peroxide and respectively gave 3α,12α-diacetoxypregn-16-en-20-one and 3β-acetoxyallopregn-16-en-20-one.[1]

In these reactions allyl bromination with NBS at C-16 was followed by deacetylation and dehydrobromination with simultaneous rearrangement of the double bond to give the final product. The general type of these reactions could be represented by (A).

(A)



$$CH_3\text{-}\overset{\overset{OAc}{|}}{C}\text{=}C\text{-}\overset{X}{CH_2}\text{-} \xrightarrow[2)\ -HX]{1)\ -Ac} CH_3\text{-}\overset{\overset{O}{\|}}{C}\text{-}\underset{|}{C}\text{=}CH\text{-}$$

Another type of the reaction is summarized as (B) in which 2-hepten-2-ol acetate, pregna-5,20-diene-3β,20-diol diacetate, and pregna-5,16,20-triene-3β,20-diol diacetate were reacted with NBS or N-iodosuccinimide (NIS) to furnish 3-bromoheptan-2-one, 3β-acetoxy-21-iodopregn-5-en-20-one, and 3β-acetoxy-21-iodopregena-5,16-dien-20-one

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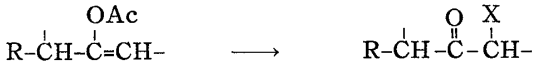
[1] C. Djerassi, C. R. Scholz: J. Org. Chem., **14**, 660(1949).

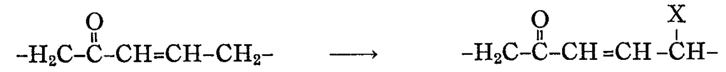
respectively.[2,3]

(B) 

$$R\text{-}\overset{|}{C}H\text{-}\overset{OAc}{\overset{|}{C}}\text{=}CH\text{-} \longrightarrow R\text{-}\overset{|}{C}H\text{-}\overset{O}{\overset{\|}{C}}\text{-}\overset{X}{\overset{|}{C}}H\text{-}$$

In the latter type of the reaction, bromination at the carbon atoms involved in the enolic double bond was followed by deacetylation to give the final product, α-haloketones.

Further, many works on bromination of α,β-unsaturated ketones with NBS so far reported show that in these cases the bromination generally occurs for allylic methylene preceding the vicinal methylene of the carbonyl groups (type C reaction),[4] although an exceptional reaction was reported by Karrer, *et al.*[5] that cholesta-3,5-dien-7-one gave 8-bromocholesta-3,5-dien-7-one with the same reagent (type C′ reaction).

(C) 

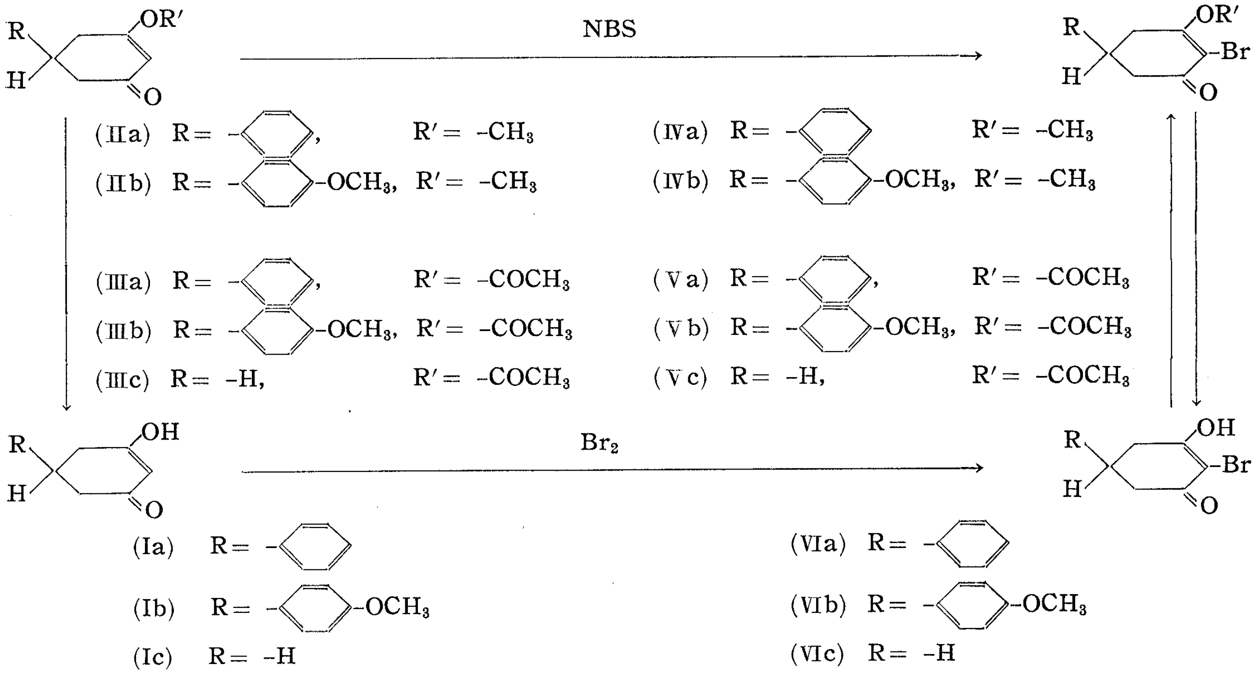
$$\text{-}H_2C\text{-}\overset{O}{\overset{\|}{C}}\text{-}CH\text{=}CH\text{-}CH_2\text{-} \longrightarrow \text{-}H_2C\text{-}\overset{O}{\overset{\|}{C}}\text{-}CH\text{=}CH\text{-}\overset{X}{\overset{|}{C}}H\text{-}$$

(C′) 

$$\text{-}H_2C\text{-}\overset{O}{\overset{\|}{C}}\text{-}CH\text{=}CH\text{-}CH_2\text{-} \longrightarrow \text{-}H\overset{X}{\overset{|}{C}}\text{-}\overset{O}{\overset{\|}{C}}\text{-}CH\text{=}CH\text{-}CH_2\text{-}$$

In spite of the above cited reports on the NBS bromination for enolates and unsaturated ketones, there are no available data on the mode of reaction for the bromination of 1,3-diketone monoenolates. This paper deals with several observations on the results of such reactions with cyclic 1,3-diketone monoenolates.

Monomethyl ethers, (IIa) and (IIb), and monoenol acetates, (IIIa) and (IIIb), of both 5-phenyl-1,3-cyclohexanedione (Ia) and 5-*p*-methoxyphenyl-1,3-cyclohexanedione (Ib) were brominated with NBS.



The monomethyl enolates, (IIa) and (IIb), smoothly reacted with equimolar amount of NBS in CCl_4, but in the case of acetylates (IIIa) and (IIIb), the reactions occurred only under irradiation of the reaction mixtures with ultraviolet ray.

The products, brominated enol diketones, (IV), and (V), were hydrolyzed to give

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2) C. Djerassi, C. T. Lenk : J. Am. Chem. Soc., **75**, 3483(1953).
3) *Idem.* : *Ibid.*, **76**, 1722(1954).
4) C. Djerassi : Chem. Revs., **43**, 271(1948).
5) P. Karrer, A. R. Naik : Helv. Chim. Acta, **32**, 2392(1949).

monobromo derivatives of 1,3-diketones which were identified with 2-bromo derivatives of the parent diketones (I), prepared according to the methods reported by Vorländer[6] and by Norris.[7]

Similar results were observed even for monoenols of simple 1,3-cyclohexanedione (Ic) which was expected to have no sterical hindrances at 4- or 6-position by an aryl substituent at the 5-position.

In order to remove the possibility of 4→2 or 6→2 migration of bromine during hydrolysis of (IV) and (V), an authentic 2-bromodiketones (VI) obtainable by Vorländer's procedure, were methylated. The products, 2-bromodiketone methyl enols (IV) thus prepared were identical with those obtained by NBS-bromination of (II).

Thus these monoenols of cyclic 1,3-diketone used this time were shown to be attacked by NBS at the carbon atom between enol and carbonyl groups.

It is of interest that the starting compounds which involve an overlapped system of an enol with α,β-unsaturated carbonyl system and which are expected to be brominated by both (B) and (C) types of reaction, were proved to give only the products resulting from the type (B) reaction for the simple enols without the removal of methyl or acetyl group.

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Experimental

5-Phenyl-1,3-cyclohexanedione (Ia), 5-(*p*-Methoxyphenyl)-1,3-cyclohexanedione (Ib), and 1,3-Cyclohexanedione (Ic)—These compounds were synthesized according to the method in the Organic Syntheses.[8]

3-Methoxy-5-(*p*-methoxyphenyl)-2-cyclohexen-1-one (IIb)—To a solution of 5 g. of (Ib) in 50 cc. of dehyd. MeOH, 0.25 cc. of conc. H_2SO_4 was added and the mixture was refluxed for 10 hrs. After cool, the reaction mixture was poured into NaOH solution containing pieces of ice and the alkaline solution was quickly extracted with Et_2O. After drying over Na_2SO_4, the solvent was removed from the ether solution and the brown residual liquid was distilled under diminished pressure to give 3.8 g. of colorless liquid, b.p$_2$ 198~200°. *Anal.* Calcd. for $C_{14}H_{16}O_3$: C, 72.40; H, 6.90. Found : C, 71.96; H, 6.54.

3-Methoxy-5-phenyl-2-cyclohexen-1-one (IIa)—This was synthesized by the method similar to that for (IIb). The product showed b.p$_4$ 168~170°.

3-Acetyl-5-phenyl-2-cyclohexen-1-one (IIIa)—5 g. of (Ia) and 30 cc. of glacial AcOH were mixed and refluxed for 10 hrs. After evaporation of the solvent under reduced pressure, the residual syrupy liquid was distilled under diminished pressure to give 4.1 g. of colorless liquid, b.p$_2$ 168~170°. The solidified oil was recrystallized from EtOH to give colorless crystals, m.p. 98~99°. Yield, 4.0 g. *Anal.* Calcd. for $C_{14}H_{14}O_3$: C, 73.02; H, 6.13. Found : C, 73.00; H, 5.91.

3-Acetyl-5-(*p*-methoxyphenyl)-2-cyclohexen-1-one (IIIb) and 3-Acetyl-2-cyclohexen-1-one (IIIc)—These were synthesized by the method similar to that for (IIIa). (IIIb), b.p$_3$ 190~195°, and m.p. 86~87°, as recrystallized from EtOH. (IIIc), b.p$_3$ 98~100°.

2-Bromo-3-methoxy-5-(*p*-methoxyphenyl)-2-cyclohexen-1-one (IVb)—To a solution of 7.6 g. of (IIb) dissolved in 100 cc. of dehyd. CCl_4, 5.9 g. of NBS was added and the mixture was refluxed for 10 mins. Upon cooling, the separated succinimide was removed by filtration, and the filtrate was concentrated under reduced pressure to about 30 cc. On cooling, colorless crystals separated out, which were collected by filtration and recrystallized from EtOH to colorless crystals, m.p. 148~149°. Yield, 2.3 g. *Anal.* Calcd. for $C_{14}H_{15}O_3Br$: C, 54.00; H, 4.83; Br, 25.72. Found : C, 53.66; H, 4.77; Br, 25.83.

2-Bromo-3-methoxy-5-phenyl-2-cyclohexen-1-one (IVa)—This was obtained by the method similar to that for (IVb). The product showed m.p. 163~164°.

NBS-Bromination of Diketone Enol Acetate (IIIa, IIIb, and IIIc)—To a solution of 1 part of enol acetate (IIIa), (IIIb), or (IIIc), dissolved in 20 parts of dry CCl_4, equimolar amount of NBS was

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6) D. Vorländer, M. Kohlmann : Ann., **322**, 239(1902).
7) G. P. Norris, J. F. Thorpe : J. Chem. Soc., **1921**, 1119.
8) Org. Syntheses, **15**, 15; **27**, 21.

added and the mixture was refluxed for 10～15 mins. under irradiation of ultraviolet ray. Removal of the solvent from the filtrate obtained after filtration of succinimide gave an oily residue. Because of unstability of the latter to liberate the acetyl group, these were directly hydrolyzed with dil. H_2SO_4 to obtain the desired brominated products. The brominated diketones thus obtained were identified by mixed fusions with 2-bromo derivatives which were synthesized by the following procedure.

2-Bromo-5-phenyl-1,3-cyclohexanedione (VIa)—a) To a solution of 0.37 g. of (Ia) dissolved in 8 cc. of glacial AcOH, 0.16 g. of Br_2 was added. The mixture was poured into cold water, the precipitate was collected by filtration, and washed with cold water. Recrystallization of the product from dil. EtOH gave colorless crystals, m.p. 187°; yield, 0.35 g. EtOH solution of the product colored reddish brown with $FeCl_3$. *Anal.* Calcd. for $C_{12}H_{11}O_2Br$: C, 53.93; H, 4.12; Br, 29.96. Found : C, 53.94; H, 4.28; Br, 29.54.

b) A mixture of 0.2 g. of (IVa) and 2 cc. of 50% H_2SO_4 was warmed on a steam bath for 5 mins. and poured into ice water. The precipitate was extracted with Et_2O, the ether solution was washed with 5% Na_2CO_3 solution, and dried over anhyd. Na_2SO_4. The solvent was removed and the residue, after repeated recrystallization from dil. EtOH, gave pure product with m.p. 187°; yield, 0.12 g., which showed no depression when mixed with the product obtained by the method (a).

c) To the suspension of 0.37 g. of (Ia) in 15 cc. of dehyd. CCl_4, 0.35 g. of NBS was added and the mixture was refluxed for 10 mins. After cool, the suspended product was collected by filtration, washed with warm 5% $NaHCO_3$ solution, and recrystallized from dil. EtOH to crystals melting at 187°. No depression of m.p. was observed on admixture of this compound with the sample obtained by the method (a).

2-Bromo-5-(*p*-methoxyphenyl)-1,3-cyclohexanedione (VIb)—This was synthesized as for (VIa). The product showed m.p. 182～183°(decomp.) and colored reddish brown with $FeCl_3$ in EtOH. *Anal.* Calcd. for $C_{13}H_{13}O_3Br$: C, 52.53; H, 4.26; Br, 26.94. Found; C, 52.34; H, 4.26; Br, 26.76.

2-Bromo-1,3-cyclohexanedione (VIc)—This was obtained by the method for the synthesis of (VIa). The product was recrystallized from EtOAc to colorless sandy crystals, m.p. 166°, which colored reddish orange with $FeCl_3$ in EtOH. *Anal.* Calcd. for $C_6H_7O_2Br$: C, 37.69; H, 3.66; Br, 41.88. Found : C, 37.61; H, 3.93; Br, 41.90.

Methylation of 2-Bromo-5-phenyl-1,3-cyclohexanedione—To a solution of 0.5 g. of (VIa) dissolved in 5 cc. of dehyd. MeOH, 0.2 cc. of conc. H_2SO_4 was added and the mixture was refluxed for 10 hrs. After cool, the reaction product was poured into a mixture of NaOH pellets and crushed ice and extracted with Et_2O quickly. The ether solution was dried over anhyd. Na_2SO_4, solvent evaporated, and the colorless sandy crystals obtained were recrystallized from EtOH to melt at 163～164°. On mixed fusion with (IVa), it showed no depression.

Summary

The position of bromine substituted by bromination of 1,3-cyclohexanedione monoenolate with N-bromosuccinimide was investigated. 1,3-Cyclohexanedione monoenolates, which have no or one aryl substituent in their 5-position, were found to be brominated with the N-bromosuccinimide at the 2-position.

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