

Short Communications

Chemistry of *gem*-Dihalocyclopropanes. XII. Preparation of *gem*-Dibromocyclopropyl Ketones and Alkyl *gem*-Dibromocyclopropanecarboxylates under Phase Transfer Conditions

LEIV KR. SYDNES

Department of Chemistry, University of Oslo, Blindern, Oslo 3, Norway

In connection with a study aiming to uncover some chemical properties of functionalized *gem*-dibromocyclopropanes it became of interest to react several α,β -unsaturated esters and ketones with bromoform under basic conditions. Such reactions have been carried out according to Seyferth's,¹ Doering-Hoffmann's² and Makosza's³ procedures. Using the phase transfer method Dehmow prepared several substituted 2,2-dichlorocyclopropanecarboxylic acid esters.⁴ We have treated α,β -unsaturated esters and ketones with bromoform using the same method in order to prepare the corresponding *gem*-dibromocyclopropane derivatives; the results of these reactions are reported here.⁵

At the time this work was initiated, the addition of dihalocarbenes to α,β -unsaturated ketones under two-phase conditions had not been reported; however, recently Barlet published the preparation of a number of alkyl-

substituted 2-acyl-1,1-dibromocyclopropanes in low to excellent yields.⁶

Most of the reactions were carried out with bromoform, but for comparison some substrates were also reacted with chloroform. Usually a 30–100 % excess of haloform, a five-fold excess of base, and a reaction time of 16 h were used; in all reactions triethylbenzylammonium chloride (TEBA) was employed as catalyst. The corresponding *gem*-dihalocyclopropane derivatives were formed in variable yields (Tables 1 and 2). The reactions of mesityl oxide, phorone, and methyl cinnamate with bromoform gave no identifiable products.

Despite the excess of haloform and base used, starting material was isolated unchanged in several of the experiments. The recovered materials of 3,4-dimethyl-3-penten-2-one (5) and 2,4,5-trimethyl-4-hexen-3-one (6), however, were contaminated, the former with small amounts of 3,4-dimethyl-4-penten-2-one (32) and the latter with some 2,4,5-trimethyl-5-hexen-3-one (33) as well as traces of 2-hydroxy-2,4,5-trimethyl-4-hexen-3-one (34).⁷

When carvone (4) and haloform were exposed to the phase transfer conditions a regioselective reaction took place. Thus, 7,7-dihalo-4-isopropenyl-1-methylbicyclo[4.1.0]heptan-2-one (10 or 11) was the only isolable product; no compound arising from addition to the exocyclic double bond was detected. However, from the available data no conclusion can be drawn with respect to the stereospecificity of the reaction.

Compound 11 was also the only product when a mixture of carvone and 2-methyl-2-

Table 1. Alkyl-substituted *gem*-dihalocyclopropyl ketones from α,β -unsaturated ketones and haloform under two-phase conditions.

α,β -Unsaturated ketone	Product	Yield (%)
3-Methyl-3-buten-2-one (1)	2-Acetyl-1,1-dibromo-2-methylecyclopropane (7)	79
<i>E</i> -3-Methyl-3-penten-2-one (2)	<i>E</i> -2-Acetyl-1,1-dibromo-2,3-dimethylcyclopropane (8)	61
1-Acetylcyclohexene (3)	1-Acetyl-7,7-dibromobicyclo[4.1.0]heptane (9)	35
Carvone (4)	7,7-Dichloro-4-isopropenyl-1-methylbicyclo[4.1.0]heptan-2-one (10)	67
	7,7-Dibromo-4-isopropenyl-1-methylbicyclo[4.1.0]heptan-2-one (11)	87
3,4-Dimethyl-3-penten-2-one (5)	2-Acetyl-1,1-dibromo-2,3,3-trimethylcyclopropane (12)	21
2,4,5-Trimethyl-4-hexen-3-one (6)	1,1-Dibromo-2-isobutyryl-2,3,3-trimethylcyclopropane (13)	30

Table 2. Alkyl *gem*-dihalocyclopropanecarboxylates and other products from the reactions of α,β -unsaturated esters with haloform (CHX_3) under two-phase conditions.

α,β -Unsaturated ester	X		Yield (%)	Other products (% yield)
	Notation	Yield (%)		
$\text{R}^1=\text{H}, \text{R}^2=\text{R}^3=\text{Me}$ (14)	Cl (20)	^a		2,2-Dichloro-1-methylcyclopropanecarboxylic acid (28) (60) Methacrylic acid (29) (35)
	Br (21)	45 ^b		2,2-Dibromo-1-methylcyclopropanecarboxylic acid (30) (42) 30 (5)
$\text{R}^1=\text{H}, \text{R}^2=\text{Me}, \text{R}^3=\text{Et}$ (15)	Br (22)	78 ^b		
$\text{R}^1=\text{H}, \text{R}^2=\text{Me}, \text{R}^3=\text{Bu}$ (16)	Br (23)	87		
$\text{R}^1=\text{H}, \text{R}^2=\text{Ph}, \text{R}^3=\text{Et}$ (17)	Cl (24)	95		
	Br (25)	93		
$\text{R}^1=\text{R}^2=\text{Me}, \text{R}^3=\text{Et}$ (18)	Br (26)	60		
$\text{R}^1=\text{Ph}, \text{R}^2=\text{Me}, \text{R}^3=\text{Et}$ (19)	Cl			<i>E</i> -2-Methyl-3-phenylpropenoic acid (31) (8)
	Br (27)	6		

^a When an excess of 14 was employed methyl 2,2-dichloro-1-methylcyclopropanecarboxylate (20) was formed in 8% yield. ^b Cf. Ref. 12.

butene reacted with bromoform in the usual way, a result that is in accordance with generation of tribromomethylide which subsequently attacks the α,β -unsaturated system prior to formation of dibromocarbene. The intermediate anion reacts further in a fast $\text{S}_{\text{N}}1$ reaction; consistent with this *E*-2-acetyl-1,1-dibromo-2,3-dimethylcyclopropane (8), ethyl *E*-2,2-dibromo-1,3-dimethylcyclopropanecarboxylate (26) and ethyl *E*-2,2-dibromo-1-methyl-3-phenylcyclopropanecarboxylate (27) were formed stereospecifically.

When α,β -unsaturated esters reacted with haloform under phase transfer conditions different types of products were formed (Table 2). In some cases (esters 14 and 19) the corresponding acids were isolated; this is not surprising since both 14 and 19 were hydrolyzed by

aqueous sodium hydroxide in the presence of TEBA (Table 3). However, these acids were not formed when chloroform was replaced by bromoform which indicate that the two-phase system is affected by the haloform.

Similar effects are also attributable to the esters employed. Reactions carried out with bromoform and different methacrylates (14–16) yielded variable amounts of 2,2-dibromo-1-methylcyclopropanecarboxylic acid (30) (Table 2). This acid could be a secondary product, formed by hydrolysis of the esters 21–23, or it could result from addition to initially formed sodium methacrylate. In the former case hydrolysis of these esters, using 50% aqueous sodium hydroxide as base and TEBA as catalyst, should give acid 30 which turned out to be the case (Table 4).

The latter reaction path is ruled out by experiments. Certainly the esters 14–16 were hydrolyzed under the strong basic conditions employed (Table 3), but sodium methacrylate did not give acid 30 when treated with bromoform under phase transfer conditions.

Experimental. General. The apparatus employed have been described elsewhere.⁸

α,β -Unsaturated ketones and esters used were either commercial samples or synthesized as described in the literature.^{9–11}

Reactions between haloform and α,β -unsaturated ketones and esters were carried out essentially as described by Dehmlow.⁷ The products isolated are recorded in Tables 1 and 2. Spectral data and elemental analyses agreed with the

Table 3. Unsaturated esters hydrolyzed by 50% aqueous sodium hydroxide in the presence of TEBA.

α,β -Unsaturated ester	Yield of corresponding acid (%)
$\text{R}^1=\text{H}, \text{R}^2=\text{R}^3=\text{Me}$ (14)	90
$\text{R}^1=\text{H}, \text{R}^2=\text{Me}, \text{R}^3=\text{Et}$ (15)	60
$\text{R}^1=\text{H}, \text{R}^2=\text{Me}, \text{R}^3=\text{Bu}$ (16)	20
$\text{R}^1=\text{Ph}, \text{R}^2=\text{Me}, \text{R}^3=\text{Et}$ (19)	20

Table 4. Preparation of 2,2-dibromo-1-methylcyclopropanecarboxylic acid (30) from alkyl esters of 30 by 50 % aqueous sodium hydroxide in the presence of TEBA.

Alkyl group	Yield of 30 (%)
Methyl	7
	2 ^a
	1 ^b
Ethyl	40
Butyl	2 ^b
	0

^a This experiment was carried out in the presence of chloroform. ^b This experiment was run in the presence of bromoform.

Table 5. Physical constants of gem-dibromocyclopropane derivatives.

Compound	B.p. (°C/mmHg)	M.p. (°C)
9	80/0.01	44
10	85/0.45	
11	94/0.01	
13	62/0.05	
23	75/0.13	
24	72/0.05	85
25		
26	56/0.10	

assigned structures. Physical constants of the compounds are compiled in Table 5. Ester 27 was isolated as an oil by CC.

Hydrolysis of esters under phase transfer conditions. A mixture of 25 mmol of ester, a 10 % excess of 50 % aqueous sodium hydroxide, 5–10 ml of CH₂Cl₂, and 0.1–0.3 g of TEBA was stirred vigorously for 12 h at 20 °C. The reaction mixture was acidified and worked up in the usual way.⁸

Reaction of sodium methacrylate with bromoform. A solution of sodium methacrylate was prepared by treating methacrylic acid with 60 % aqueous sodium hydroxide. The reaction was then carried out according to the general procedure.

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