Extraction of Acetals of Phenyl-Propargyl Aldehyde Using the Method of Liquid Column Chromotography

E K Aminova¹, V V Fomina¹, A N Krasnov²

¹Ufa State Petroleum Technological University, Salavat Branch, 22B, Gubkin street, Salavat, 453250, Russia
²Ufa State Petroleum Technological University, 1, Kosmonavtov street, Ufa, 450044, Russia

E-mail: ufa-znanie@mail.ru

Abstract. The interreaction of substrates containing cyclopropane fragment with initial allyl and butyl alcohol, the influence of bromide atom in a gem-dichlorocyclopropane ring on the direction of the reaction with alcohol. The reaction of O-alkyllation 2-bromide-2-phenyl-gem-dichlorocyclopropane with alcohol in dimethylformamide with solid sodium hydroxide and without a phase transfer catalyst occurs selectively and produces the corresponding acetals of phenyl-propargyl aldehyde. The optimal conditions were selected for the reaction. It was researched and established that gem-dichlorocyclopropanes with a bromide atom in the cycle can also participate in such transformations. Acetals of phenyl-propargyl aldehyde were extracted from the reaction mix using the method of liquid column chromatography

1. Introduction

The main transformations of substituted gem-dichlorocyclopropanes are associated either with the substitution of one or two atoms of halogens, or with the opening of the cyclopropane ring and obtainment of the corresponding olefins, dienes and allenes [1-10].

In order to identify the prospects of the synthesis of polygalogencyclopropanes, the interreaction of substrates with cyclopropane fragment and initial allyl and butyl alcohol was analysed.

The previous research showed only synthetic capabilities of polychloro- and polybromidecyclopropanes, while the influence of a bromide atom in the gem-dichlorocyclopropane ring on the direction of the reaction with alcohols has never been studied [11-13].

The obtained compounds were extracted using the method of column chromatography, as it is one of the most important methods to divide liquid mixes and solid organic substances on the preparative scale. The division was carried out in a column, or a glass tube filled with a sorbing agent (silicagel) that acts as a porous layer, with the moving phase going through it (eluting the mix of solvents, hexane:ethyl acetate at the ratio of 98:2). The eluent for the column chromatography was chosen using thin layer chromatography. The mix was chromatographed in several eluents and for the column chromatography was used the one with the largest distance between spots. The divided part was put into the upper part of the column where it was absorbed by the stationary phase and then the eluent was continually fed through the column. Every component of the mixture was transferred down the column by the moving phase (eluent) with the speed that depends on the affinity with the sorbing
agent (it can be assessed by the value Rf, TLC method). After the solvent was eliminated, pure substances were extracted from the corresponding collectors.

2. Results and discussions

The reaction of O-alkyllation 2-bromide-2-phenyl-gem-dichlorocyclopropane with alcohols in dimethylformamide with solid sodium hydroxide and without a phase transfer catalyst at 100 °C occurs selectively and produces the corresponding acetals of phenyl-propargyl aldehyde (Figure 1).

![Reaction scheme](image1.png)

**Figure 1.** Interreaction of 2-bromide-2-phenyl-gem-dichlorocyclopropane with alcohols.

The methodology of the interreaction of 2-bromide-2-phenyl-gem-dichlorocyclopropane with alcohols: put 0.012 moles of substituted alcohol (0.67 g allyl alcohol, 0.89 g butyl alcohol) into a four-neck vial with a mechanical mixer, thermometer, a backflow condenser and a dropfunnel; gradually add 0.001 moles (0.02 g) sodium metal. Add to the obtained sodium alcololate 0.005 moles (1.33 g) 2-bromide-2-phenyl-gem-dichlorocyclopropane in drops and then heat up to 100°C for 8 hours. The reaction mass is diluted with water, separated by chloroform, washed with water, the solvent was boiled out, the target products were extracted on the silica-gel using the method of liquid column chromatography. Hexane:ethyl acetate ratio in the eluent 9:1 correspondingly.

It was established that the interreaction of gem-dichlorocyclopropane with allyl and butyl alcohol leads to the opening of the cyclopropane ring and the formation of the corresponding acetylene acetals. The product output on the basis of butyl alcohol was 30%, and on the basis of allyl alcohol it was 70%

The formation of acetals of phenyl-propargyl aldehyde during the reaction of 2-bromide-2-phenyl-gem-dichlorocyclopropane with alcohols is supposedly associated with the elimination of hydrogen bromide and the formation of cyclopropene's derivatives that suffer the substitution of allyl chlorine atoms with alkoxy group and further cyclopropane fragment fission (Figure 2).
The opening of the cyclopropane ring of polysubstituted gem-dichlorocyclopropanes without a bromide atom in the reaction with alcohols accompanied by the formation of propargyl esters was described in the works of R.R. Kostikov and L.K. Sydnesch [14-18].

The research allowed to establish for the first time that gem-dichlorocyclopropanes with a bromide atom in the cycle can also participate in such transformations.

As a result of the research it was proved that the main factor influencing the direction of the reaction of alcohols and substituted gem-dichlorocyclopropanes is the nature and position of the substitute in the cyclopropane ring.

The structure of the obtained compounds was established on the basis of NMR spectral data $^1$H and $^{13}$C and confirmed by the mass spectrometric analysis method. The special feature of the NMR range $^{13}$C [3,3-bis(allyloxy)prop-1-in-1-il]benzol recorded in the C-H interreaction (IMOD) constant modulation regime is the characteristic signals of carbonic atoms with triple bond and quaternary carbon atom C(OR)$_2$-group, observed in case of the compounding happening in a weaker field at 85.8 ppm, 84.0 ppm and 91.0 ppm correspondingly.

Mass-spectral characteristics were obtained with the help of the electronic shock method developed and often used in research practice.

Acetal mass spectra are characterized by low stability of molecular ions that is lower than 0.1%.

3,3-bis(allyloxy)prop-1-in-1-il benzol is colourless fluid, 70% output, R$^0$30 (eluent - hexane:AcOEt, 98:2; SiO$_2$ 60-100 μ). NMR range $^1$H (CDCl$_3$; δ, ppm, J/Hz): 4.13-4.32 (m, 4H, O-CH$_2$), 5.21-5.39 (m, 4H, =CH$_2$), 5.56 (s, 1H, CH); 5.91-6.04 (m, 2H, =CH); 7.27-7.50 (m, 4H, Ph). NMR range $^{13}$C (CDCl$_3$; δ, ppm): 66.3 (CH$_2$O), 84 (C$_5$), 85.8 (C$_1$), 91.0 (CH), 117.5 (=CH$_2$), 121.8, 128.3, 132.0, 134.1 (Ph). Mass-spectre, m/z (I$_{rel}$ %): 228 [M]$^+$ (<0.1), 171 [M-OCH$_3$H$_2$]$^+$ (18), 142 (78), 128 (100), 115 (40), 102 (58), 91 (22), 77 (27), 63 (13), 51 (19).

3,3-Dibutoxiprop-1-in-1-il benzol is colourless fluid, 30% output, R$^0$27 (eluent - hexane:AcOEt, 98:2; SiO$_2$ 60-100 μ). NMR range $^1$H (CDCl$_3$; δ, ppm, J/Hz): 0.95-1.01 (m, 6H, CH$_3$), 1.38-1.49 (m, 4H, CH$_2$-CH$_3$), 1.72-1.81 (m, 4H, CH$_3$-CH$_2$O), 3.43-3.50 (m, 2H, CH$_2$O), 3.66-3.72 (m, 2H, CH$_2$O), 5.29 (s, 1H, CH), 7.25-7.48 (m, 5H, Ph). Mass-spectre, m/z (I$_{rel}$ %): 260 [M]$^+$ (<0.1), 203 [M-C$_6$H$_5$]$^+$, 187 (17), 159 (3), 147 (6), 131 (100), 102 (36), 91 (6), 77 (22), 57 (36).

3. Conclusions

Compounds of cyclopropane range have biological activity of broad spectrum of activity and are of interest in what concerns synthesis of important difficult to access carbon- and heterocycles. Substituted gem-dichlorocyclopropane play a special role in organic synthesis, that have both a cyclopropane ring and other functional groups. Galogen-, alkenyl-gem-dichlorocyclopropanes are such polyfunctional compounds that are used as valuable reagents in the synthesis of polysubstituted cyclopropanes, olefins, diens and allenes. Moreover, interphase catalyst for the generation of digalocarbens in the reactions of cycloaddition allows to obtain gem-dichlorocyclopropanes different in form and with high output [19-23].

Synthetic potential of substituted gem-dichlorocyclopropanes that have chloroalkyl groups, alkenyl groups and galogen atoms basically have never been studied. In this regard the research of synthetic capabilities of polychlor-, bromidecyclopropanes obtained on the basis of industrially accessible galogenolefins as well as the development of convenient methods for the synthesis of biologically active polyfunctional compounds is an important and pertinent task.
Alcohols with gem-dichlorocyclopropane and dimethylsulfoxide and solid alkali at 20°C do not interreact. It was experimentally established that the optimal temperature for this reaction is 100 °C.

Alcohols with gem-dichlorocyclopropane and dimethylsulfoxide and solid alkali at 20°C do not interreact. It was experimentally established that the optimal temperature for this reaction is 100 °C.

Thus the present research has shown that the interreaction of 2-bromide-2-phenyl-gem-dichlorocyclopropane with alcohols takes place with the opening of the cyclopropane ring and the formation of the corresponding acetals of phenyl-propargyl aldehyde.

References
[1] Zefirov N S, Kazimirchik I V, Lukin K A 1985 Cycloaddition of dichlorocarbene to olefines (Moscow: Nauka) 135 p
[2] Bogomazova A A, Mikhailova N N, Zlotsky S S 2011 Modern Chemistry of Cyclical Acetals Obtainment, reactions, properties (Saarbrücken: LAP LAMBERT Academic Publishing GmbH & Co. KG) 87 p
[3] Kopsov S V 2008 Some reactions of addition and reduction with tris (trimethylsilyl)silan Thesis in support of candidature for a chemistry degree (Ufa)
[4] Kukovinets O S, Nikolaeva S V, Kunakova R V 2006 Cyclopropanes (properties, synthesis, use) (Ufa) 152 p
[5] Hine J, Dowell A M 1954 Carbon dihalides as intermediates in the basic hydrolysis of haloforms Combination of carbon dichloride with halide ions J. Amer. Chem. Soc vol 76 pp 2688 - 2692
[6] Tobey S W, West R 1964 Hexachlorocyclopropane J. Amer. Chem. Soc. vol 86 pp 56 - 61
[7] Nefedov O M, Ioffe A I, Menchikov L G, Carben chemistry (Moscow: Khimia) pp 228-233
[8] Kirmse V 1966 Carben chemistry (Moscow: Mir) 324 p
[9] Shields T C, Gardner P D 1967 A study of nucleophilic additions to substituted cyclopropanes J. Am. Chem. Soc. vol 89 pp 5425 -5428
[10] Arct J, Migaj B 1981 Transformations of haloctylcyclopropanes VI: Reactions of 7,7-dichlorobicyclo[4.1.0]heptane with some organic anions in nonpolar media Tetrahedron vol 37 pp 953-956
[11] Hine J, Dowell A M 1954 Carbon dihalides as intermediates in the basic hydrolysis of haloforms Combination of carbon dichloride with halide ions J. Amer. Chem. Soc. vol 76 pp 2688 - 2692
[12] Tobey S W, West R 1964 Hexachlorocyclopropane J. Amer. Chem. Soc. vol 86 pp 56 - 61
[13] Kulinkovich O G, Tishchenko I G, Masalov N V 1984 Chemistry of Heterocyclic Compounds vol 20 12 pp 1319-1321
[14] Kostikov R R, Varakin G S, Molchanov A P, Ogoblin K A 1966 Interreaction of gem-dichlorocyclopropanes with nucleophile reagents: acetylen derivatives formation, reaction mechanism Organic Chemistry Journal vol 32 1 pp 39-43
[15] Sydnes L K, Bakstad E 1966 Formation of acetylenic acetals by ring opening of 1,1,2-trihalocyclopropanes under phase-transfer conditions Acta Chem. Scand. vol 50 pp 446-453
[16] Bakstad E, Olsen A S, Sandberg M, Sydnes L K 1999 Neighbouring-group Influence on the Ring Opening of 2-Aryloxymethyl-1,1,2-tribromoacyclopropanes under Phase-transfer Conditions Acta Chemica Scandinavica 53 pp 465-472
[17] Sydnes L K, Bakstad E 1997 A new and simple synthesis of cyclonon-2-ynone Acta Chem. Scand. 51 pp 1132-1133
[18] Seyferth D, Mai V A, Mui J Y-P, Darragh K 1966 Halomethyl metal compounds. IX. The reaction of phenyl(bromodichloromethyl)mercury with alcohols J. Org. Chem. vol 31 12 pp 4079-4081
[19] Doering W E, Hoffman A K 1954 The additions of dichlorocarbene to olefins J. Am. Chem. Soc. vol 76 pp 6162-6165
[20] Wagner W M 1959 *J. Chem. Soc. Proc.* vol 8 p 229

[21] Demlov E V 1976 Anwendungen der Phasen-transfer-katalyse: eine variante der dichlorcarben-erzeugung *Tetrahedron Lett.* 2 pp 91-94

[22] Demlov E V, Remmler T 1977 Applications of phase transfer catalysis Part 5 Phase transfer catalysis generation of dihalocarbenes from sodino – acetales *J. Chem. Res. (S)* 3 p 72