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THE SYNTHESIS AND MOLECULAR CRYSTALLINE STRUCTURE OF ETHYL-1-ACETYL-3-(4-CHLOROPHENYL) -2,2-DICYANOCYCLOPROPANE CARBOXYLATE

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Three-component condensation reaction of malonodinitrile, 4-chloro- benzaldehyde and ethyl 4-chloro-3-oxobutanoate has been analyzed to establish that in the presence of NaOH base, the reaction proceeds by Knoevenagel-Michael-Perkin cascade carbocyclization to form ethyl-1-acetyl-3-(4-chlorophenyl)-2,2-dicyanocyclopropane carboxylate. The structure of the reaction product examined through with X-ray analysis

Keywords: three-component condensation reactions, malonodinitrile, cyclopropane carboxylates.

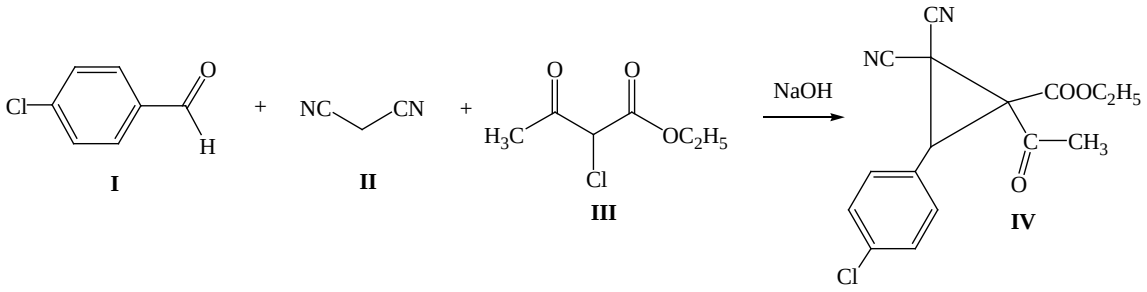
INTRODUCTION

It should be noted that multicomponent reactions, involving simultaneous interaction of, at least, three compounds and forming one final product together with parts of all the initial components, contribute to the development of new methods to synthesize polyfunctional carbo- and hetero-cycles with useful properties. Typically, the developed multicomponent reactions proceed in one-step ("one-pot"), by using commercially available substrates and reagents, which significantly reduce the cost of final products as well as harmful environmental consequences of the synthesis occurrence [1-5]. A large number of multicomponent reactions have been discovered, analyzed and described.

Among variety of multicomponent reactions, of particular interest are reactions that include compounds like malonodinitrile, alkyl cyanoacetates, etc. with active methylene group. These compounds together with nitrile groups have great synthetic potentials and through changing the structure of other reagents that react with them it is possible to synthesize many structured complex carbo and heterocyclic compounds [6-11].

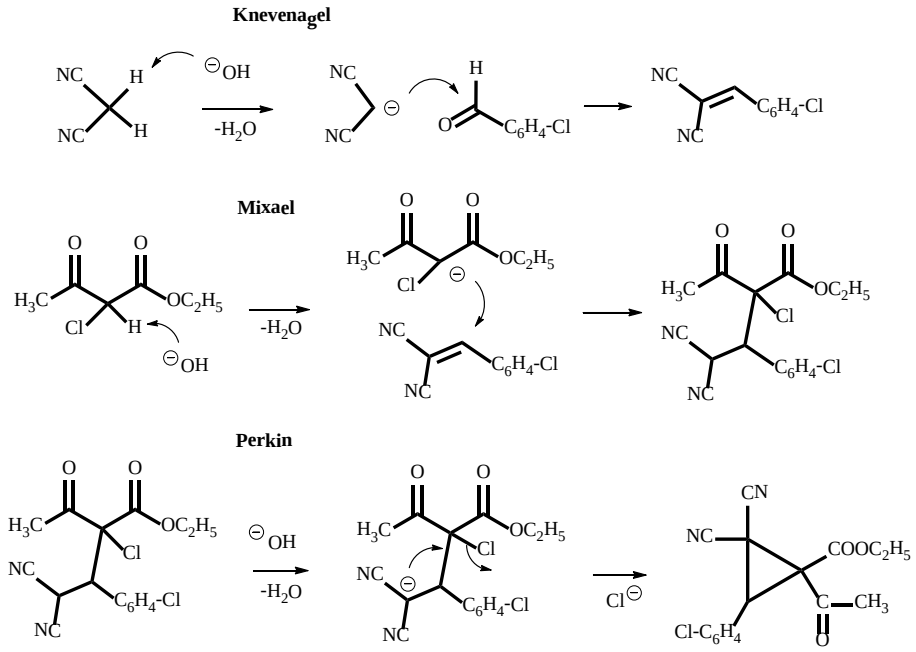
RESULTS

The current research work examined the three-component condensation reaction based on the interaction of malonodinitrile (1), 4-chlorobenzaldehyde (2) and ethyl 4-chloro-3-oxobutanoate (3), which has not been described in the literature. As a base component of reaction, an equimolecular amount of NaOH was used. It revealed that 72% of ethyl ethyl-1-acetyl-3-(4-chlorophenyl)-2,2-dicyanocyclopropane carboxylate (4) was obtained as a result of reaction (Scheme 1).



Scheme 1. The reaction between malonodinitrile, 4-chlorobenzaldehyde and ethyl 4-chloro-3-oxobutanoate.

The reaction product is, perhaps, Knoevenagel-Michael-Perkin cascade carbocyclization which proceeds by means of step-by-step mechanism (Scheme 2).



Scheme 2: Proposed mechanism of the reaction.

To prove the molecular structure of the compound synthesized, we used X-ray diffraction method. Single crystals for X-ray diffraction analysis were obtained by crystallization of compound IV from ethanol.

Note that the crystals are monoclinic: a=8.176(3) Å, b=10.443(4) Å, c=18.375(7)Å, α=ß=γ=90°, V=1568.8(10) Å3, spatial group P21 21 21, Z=4. The structure deciphered by the direct method and specified by the least squares in respect of F^2 in the anisotropic approximation for non-hydrogen atoms. The coordinates of the remaining H atoms are calculated geometrically and specified in the model of the "rider."

All calculations were carried out through the use of SHELXTL software package [12].

A perspective view of the molecule IV together with the numeration of non-hydrogen atoms shown in Fig. 1.

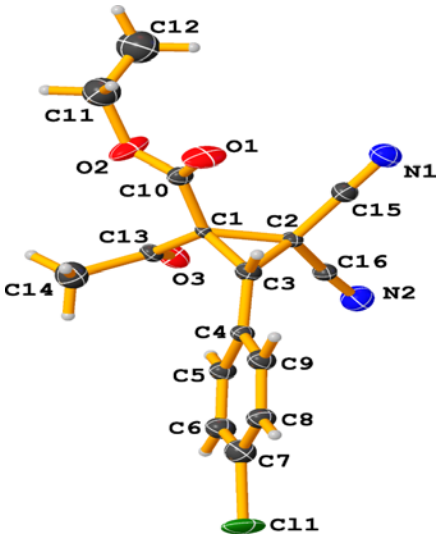


Figure 1. A perspective view of molecule IV together with the numeration of non-hydrogen atoms

In the molecular structure IV, there is a chiral center where carbon atom C_3 crystallizes in the space group $P2_1\ 2_1\ 2_1$. Note that the angle between the plane of phenyl and the cyclopropane fragment is 87.27 °

Table 1. Basic crystallographic data and specifying parameters of compound IV

Parameters	**IV**
Empirical formula	C16H13Cl2N2O3
Molecular weight, M	316.73
Temperature, K	296
Dimensions of the crystal, mm^3	0.220 x 0.170 x 0.160
Shingonia	Monoclinic
Spatial group	$P2_12_12_1$
a, Å	8.176(3)
b, Å	10.443(4)
c, Å	18.375(7)
α, deg.	90.00
β, deg.	90.00
γ, deg.	90.00
V, $Å^3$	1568.8(10)
Z	4
d(calc.), g/sm^3	1.341
μ, mm^{-1}	0.257
F(000)	656
Data collection area for θ, deg	25
Measured reflections	6525
Independent reflections	1301
Number of parameters to be specified	199
R_1 [I>2σ(I)]	0.2096
wR2(all data)	0.5963
GOOF	1.009
Tmin; Tmax	0.355; 0.746
Residual electron density (ρ_{min}/ρ_{max})/e.$Å^{-3}$	-0.901 / 1.484

EXPERIMENTAL PART

The monitoring of reaction as well as the purity of the synthesized compound were specified by thin layer chromatography on Sulifol plates (eluent acetone-hexane 1: 1) and subsequent evaporation with iodine vapor (UV detector).

The infrared spectrum was recorded on Fourier spectrometer Varian 3600 FT-IR Excalibur Series in KBr tablets.

^1H and ^{13}C NMR spectra was recorded on Brucker AC-300 devices (300 and 75 MHz, respectively).

Note that the X-ray diffraction analysis of compound IV was carried out on a Brucker SMART APEXII CCD diffractometer (MoKα - radiation, graphite monochromator, φ- and ω-scanning). Measured 6525 diffraction reflections, θ_{max} = 25 °. Intensities of symmetrically equivalent reflections were averaged. As a result of averaging, 2755 independent diffraction reflections with R (int) = 0.0664 were obtained to implement decoding and specifying the crystal structure (Table 1).

Ethyl-1-acetyl-3-(4-chlorophenyl)-2,2-dicyanocyclopropane carboxylate (IV)

Added to a solution of 1.40 g (10 mmol) 4-chlorobenzaldehyde (I) and 0.66 g (10 mmol) malonodinitrile (II) in 15 ml of ethanol were 0.3 g (10.71 mmol) 1 ml of aqueous solution of KOH, and then mixed. Also, 1.64 g (10 mmol) of ethyl 4-chloro-3-oxobutanoate (III) was added to the rapidly formed precipitated solution. After mixing it at room temperature for 6 hours, the reaction mixture was rinsed with water. The formed precipitate was filtered off, dried and recrystallized from ethanol. The yield of reaction is 2.2 grams (69%), m.p =130^{0}C

IR spectrum (γ, sm^{-1}): 2200, 2250 (CN), 1720 (C=O), 1650(C=O)

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^{1}H spectrum (DMSO-d_6, ppm): 1,29 (3H,t,CH_3), 2.1(1H,s,CH), 4.2(2H, m, O-CH_2), 7.24(2H,CH,arom), 7.41(2H,CH, arom)

^{13}C spectrum (DMSO-d_6): 12, 15, 20, 28, 62, 109, 110, 115, 126, 127, 128, 129, 131, 143,163

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СИНТЕЗ И МОЛЕКУЛЯРНАЯ КРИСТАЛЛИЧЕСКАЯ СТРУКТУРА ЭТИЛ-1-АЦЕТИЛ-3-(4-ХЛОРОФЕНИЛ)-2,2- ДИЦИАНЦИКЛОПРОПАНКАРБОКСИЛАТА

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Исследована трехкомпонентная реакция конденсации с участием малонодинитрила, 4-хлорбензальдегида и этил-4-хлор-3-оксобутаноата. Установлено, что в присутствии основания NaOH реакция протекает как реакция каскадной карбоциклизации Кневенагеля-Михаэля-Перкина с образованием этил-1-ацетил-3-(4-хлорфенил)-2,2-дицианциклопропан кар-боксилата. Строение продукта реакции установлено методом рентгеноструктурного анализа

Ключевые слова: *трехкомпонентные реакции конденсации, малонодинитрил, циклопропанкарбоксилаты*

ETİL 1-ASETİL-3-(4-XLORFENİL)-2,2-DİSİANTSİKLOPROPAN KARBOKSİLATIN SİNTEZİ VƏ MOLEKULYAR KRİSTALLİK QURULUŞU

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Malonodinitril, 4-xlorbenzaldehid və etil 4-xlor-3-oksobutanoatın iştirakı ilə üçkomponentli kondensləşmə reaksiyası tədqiq edilmişdir. Müəyyən edilmişdir ki, reaksiya NaOH əsasının iştirakında Knevenagel-Mixael-Perkin kaskad karbotsiklləşmə reaksiyası kimi gedərək etil 1-asetil-3-(4-xlorfenil)-2,2-disiantsiklopropankarboksilatın alınması ilə nəticələnir. Reaksiya məhsulunun quruluşu rentgen quruluş analizi üsulu ilə təsdiq edilmişdir

Açar sözlər *: üçkomponentli reaksiyalar, malonodinitril, tsiklopropan karboksilatlar*

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