Alkaline hydrolysis of cyclopentanespiro-5-(2,4-dithiohydantoin)

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Alkaline hydrolysis of cyclopentanespiro-5-(2,4-dithiohydantoin): *It is known that the treatment of cycloalkanespiro-5-(2,4-dithiohydantoins) with barium hydroxide and heating at 100 °C in the presence of ethanol leads to obtaining of the corresponding 2-thioanalogues. In this paper we present a study of the alkaline hydrolysis of cyclopentanespiro-5-(2,4-dithiohydantoin), using different reaction conditions. It was found that the conducting the reaction at a high pressure in an autoclave and heating at 160 °C leads to obtaining of a mixture of products.*

Key words: *Cyclopentanespiro-5-(2,4-dithiohydantoin), Alkaline hydrolysis.*

INTRODUCTION

In our previous study, we presented a new method for cycloalkanespiro-5-(2-thiohydantoins) synthesis [1]. The experiments were conducted by a treatment of a series of cycloalkanespiro-5-(2,4-dithiohydantoins) with barium hydroxide at normal pressure and heating at 100 °C in the presence of ethanol. As a result of this interaction the relevant cycloalkanespiro-5-(2-thiohydantoins) as the only products were obtained. The purpose of this article is to study the alkaline hydrolysis of cyclopentanespiro-5-(2,4-dithiohydantoin) by conducting the reaction at a high pressure in an autoclave and heating at 160 °C. It was found that besides the main product cyclopentanespiro-5-(2-thiohydantoin), the presence of 1-aminocyclopentanecarboxylic acid, 1-aminocyclopentanecarbothioic acid and 1-aminocyclopentanecarbodithioic acid was observed.

RESULTS AND DISCUTION

1. Materials and methods

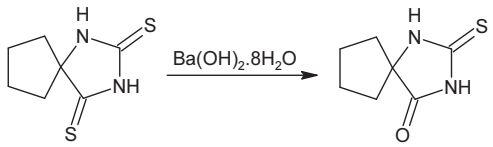
All used chemicals were purchased from Merck and Sigma-Aldrich. The initial cyclopentanespiro-5-(2,4-dithiohydantoin) (compound 1, Scheme 1) was synthesized in accordance to Marinov et. al. [2]. The melting points were determined with a Koffler apparatus. The elemental analysis data were obtained with an automatic analyzer Carlo Erba 1106. IR spectra were taken on spectrometers Bruker-113 and Perkin-Elmer FTIR-1600 in KBr discs. NMR spectra were taken on a Bruker DRX-250 spectrometer, operating at 250.13 and 62.90 MHz for ^{1}H and ^{13}C, respectively, using the standard Bruker software. Chemical shifts were referenced to tetramethylsilane (TMS). Measurements were carried out at ambient temperature. The Raman spectrum of cycopentanespiro-5-(2-thiohydantoin) (compound 2, Scheme 1) (the stirred crystals placed in aluminium disc) was measured on RAM II (Bruker Optics) with a focused laser beam of 200 mW power of Nd:YAG laser (1064 nm) from 4000 cm^{-1} to 51 cm^{-1} at resolution 2 cm^{-1} with 25 scans. Its Diffuse Reflectance FTIR (DRIFT) and Attenuated Total Reflection FTIR (ATR) spectra were recorded with a VERTEX 70 FT-IR spectrometer (Bruker Optics). The used DRIFT accessory is Praying Mantis™ (Harrick Scientific) and crystals of 2 were stirred with KBr; the spectrum is from 4000 cm^{-1} to 400 cm^{-1} at resolution 2 cm^{-1} with 49 scans. The ATR accessory is MIRacle with one-reflection ZnSe element (Pike) and the stirred crystals of 2 were pressed by an anvil to the reflection element; the spectrum is from 4500 cm^{-1} to 600 cm^{-1} at resolution 2 cm^{-1} with 16 scans. Mass spectra were recorded using LCQ-DUO $LCMS^2$ System Electrospray Interface on CH-5 Varian MAT spectrometer at 70 eV.

2. Alkaline hydrolysis of cyclopentanespiro-5-(2,4-dithiohydantoin)

The alkaline hydrolysis of cyclopentanespiro-5-(2,4-dithiohydantoin) was held in accordance to Scheme 1. A suspension of 2.00 g (0.011 mol) of cyclopentanespiro-5-(2,4-dithiohydantoin) (**1**) and 6.00 g (0.019 mol) of $Ba(OH)_2$.8H2O in 40 ml of water was heated at 160 °C in an autoclave in a salt bath (50 % KNO_3 + 50 % $NaNO_2$) for two hours. After heating completion the reaction mixture was cooled to room temperature, then filtered

under vacuum and the filtrate was treated with 2.00 g (0.021 mol) $(NH_4)_2CO_3$. The solution was filtered under vacuum, then concentrated and cooled to room temperature. As a result of this action the cyclopentanespiro-5-(2-thiohydantoin) (**2**) was obtained. The resulting compound (2) was filtered off and acetone was added to the filtrate. The reaction mixture was left for 24 hours in a freezer. In consequence, the 1-aminocyclopentanecarboxylic acid (3, Figure 1) was obtained. The mass spectral data of the second sample showed the presence of 1-aminocyclopentanecarbothioic acid (4, Figure 1) and 1-aminocyclopentanecarbodithioic acid (5, Figure 1).

Yield of cyclopentanespiro-5-(2-thiohydantoin) (2): 0.60 g (33 %).



1 **2**

Scheme 1

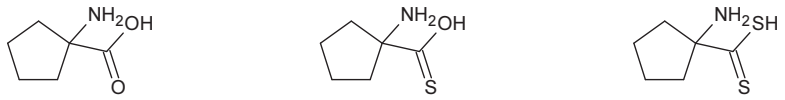
The cyclopentanespiro-5-(2,4-dithiohydantoin) (1) and cyclopentanespiro-5-(2-thiohydantoin) (2) were characterized by physicochemical parameters, IR and NMR spectral data. The results obtained from these analyses are identical with the previously published in the literature [2]. In addition in this paper we present Raman, ATR and DRIFT spectral data for compound 2. These data are as follows:

Raman spectral bands for 2, cm^{-1}: 2973, 2920, 2877, 2595, 1746, 1726, 1515, 1453, 1440, 1404, 1323, 1196, 1157, 1077, 1013, 948, 905, 750, 613, 503, 373, 322, 202.

ATR spectral bands for 2, cm^{-1}: 3126, 3090, 3028, 2976, 2879, 2584, 1736, 1720, 1533, 1470, 1453, 1438, 1383, 1316, 1297, 1241, 1195, 1159, 1071, 1014, 952, 909, 892, 794, 733, 670, 645, 621.

DRIFT spectral bands for 2, cm^{-1}: 3822, 3450, 3154, 2975, 2586, 2477, 2344, 2270, 2147, 1897, 1741, 1540, 1471, 1453, 1439, 1395, 1318, 1243, 1197, 1161, 1074, 1014, 954, 891, 805, 674, 648, 622, 506, 458, 435, 420, 410, 406.

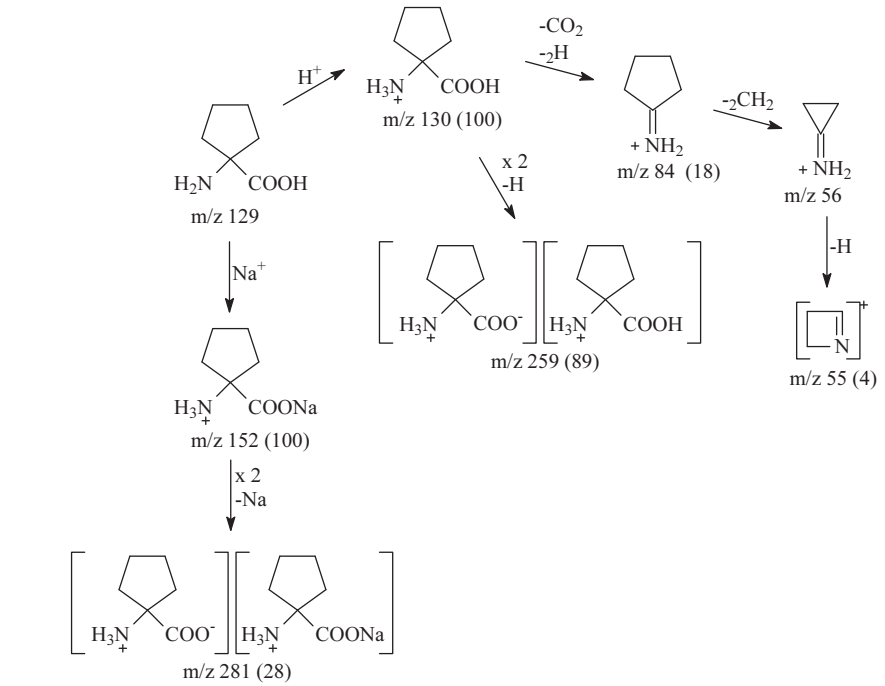
The fragmentation of 1-aminocyclopentanecarboxylic acid (3, Figure 1), 1-aminocyclopentanecarbothioic acid (4, Figure 1) and 1-aminocyclopentanecarbodithioic acid (5, Figure 1) is presented in Scheme 2, Scheme 3 and Scheme 4, respectively.



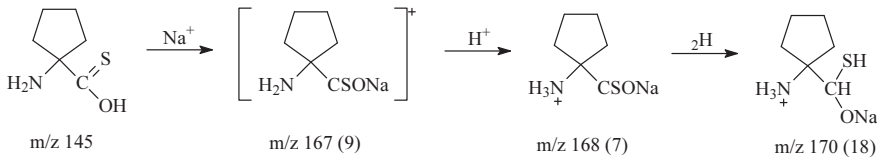
3 **4** **5**

Figure 1

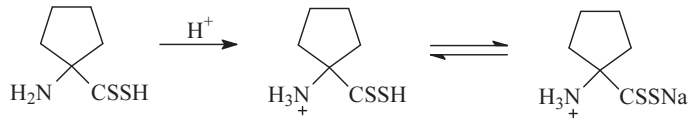
ms [50.00-200.00]
ms [50.00-400.00]



Scheme 2



Scheme 3



Scheme 4

CONCLUSIONS

It was shown that the alkaline hydrolysis of dithiospirohydantoins with barium hydroxide in an alcoholic environment under normal conditions led to the obtaining only of monothiospirohydantoins. The application of the hydrolysis by autoclaving at 160 ^{o}C led to obtaining of a mixture of acids, which are proven by their mas spektral fragmentation.

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REFERENCES

[1] Stoyanov,N., M.Marinov. Two Methods for spirothiohydantoin synthesis. Acta Chim. Slov., 2012, 59 (3), 680-685.

[2] Marinov,M., S.Minchev, N.Stoyanov, G.Ivanova, M.Spassova, V.Enchev. Synthesis, spectroscopic characterization and ab initio investigation of thioanalogues of spirohydantoins. Croat. Chem. Acta., 2005, 78, 9-16.

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The paper is reviewed.