THE RESEARCH «RING-CHAIN» TAUTOMERISM OF 2-(1-H-1,2,4-TRIAZOL-5-YLTHIO)ACETALDEHYDES

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Abstract

Due to the complex using of instrumental methods of analysis(GC-MS, IR, ^{1}H NMR, X-ray) and chemical reactions (condensation, recovery, cyclization) is set a presence of «ring-chain» tautomerism in 2-((3-phenyl-1H-1,2,4-triazol-5-yl)thio)acetaldehyde (***1a***). As a result of the research revealed, that in solid form is dominated a «ring»-form, and in solution - a «chain»-form. Also, in a result of the X-ray research is revealed a crystal structure of 3-phenyl-5,6-dihydrothiazolo[2,3-c][1,2,4]triazol-5-ol.

Keywords:
2-(1-H-1,2,4-triazol-5-ylthio)acetaldehydes, «ring-chain», tautomerism.

1. Introduction

For the first time term «tautomery» was proposed by german scientist Konrad Laar for the characteristic of the dynamic equilibrium between two substances, that containing a mobile hydrogen atom [1]. On this stage of the chemical science development are examined different kinds of tautomeries [7-9]. Enough interesting kind is a «ring-chain» tautomerism (RCT). P.R. Jons in his own work characterizes RCT concept pretty detail [1]. For example, in his view realization of RCT phenomenonis possible in tautomery with open chain in case of the presence at least of two functional groups. First group must contain a double connection, second – is able to join this connection.On ***Scheme 1*** is depicted an example of two possible cyclic tautomers (II, III), form of which depends from the direction of functional groups connecting.

Analyzing a scientific literature is possible to note, that a«ring-chain» tautomerism in derivatives of heterocyclic systems, containing atoms of nitrogen is studied good enough [2-6]. However, to the derivatives of 1,2,4-triazole, namely 2-(1-H-1,2,4- triazol-5-ylthio)acetaldehydes is not given proper attention.

In a process of confirmation of the synthesized aldehydes structure, we faced with a problem of the data absence, typical for carbonyl group, in report Infrared

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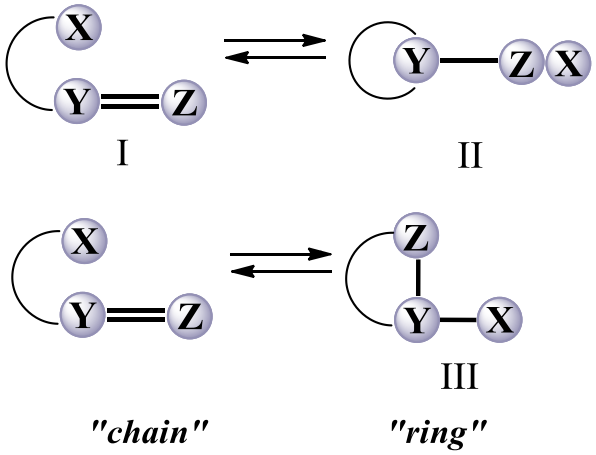
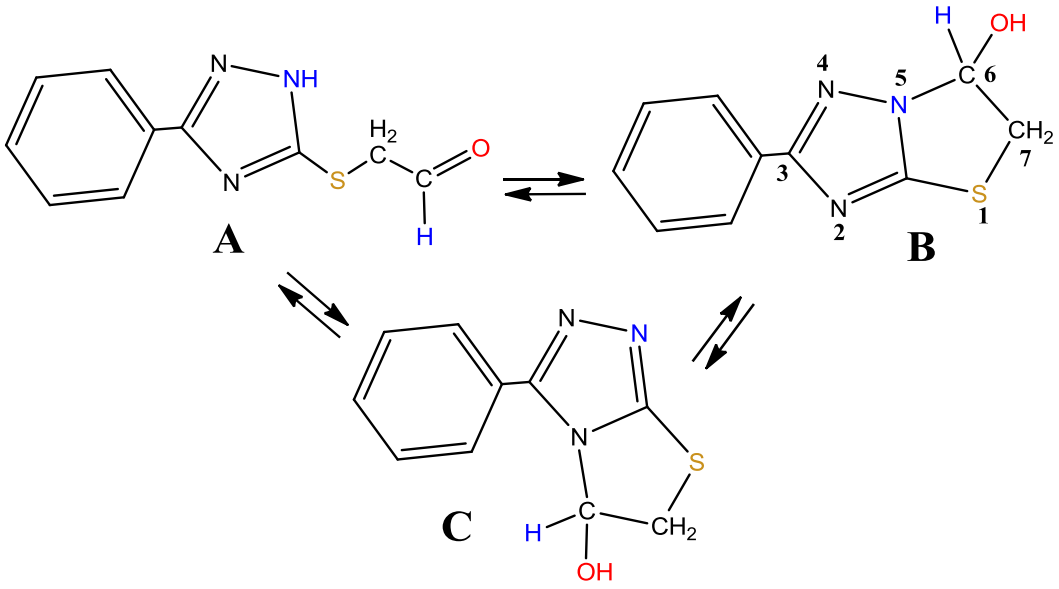
spectroscopy (KBr), Nuclear magnetic resonance spectroscopy, X-ray crystallography. Based on specified higher, we did a supposition about the existence of 2-((3-phenyl-1H-1,2,4-triazol-5-yl)thio)acetaldehyde (***1a***) in a form of tritautomers (***Scheme 2***).So, aim of this work is setting of the presence and form of RCT 2-(1-H-1,2,4-triazol-5-ylthio)acetaldehydes, on example of ***1a*** compound, which was synthesized by us earlier[10].



Scheme 1.*«Ring-chain» tautomerism of compounds with double connection.(**YZ**-functional group with double connection , is able to **X**-group linking)*



Scheme2. *Possible tautomery forms for 2-((3-phenyl-1H-1,2,4-triazol-5-yl)thio)acetaldehyde (**1a**).*

2. Results and discussion

For achieve of the main aim we used two ways of the set task decision.First way – using of instrumental methods of analysis – chromatography-mass spectrometry (GC-MS), Infrared spectroscopy(IR), ^{1}H Nuclear magnetic resonance spectroscopy (^{1}HNMR), X-ray crystallography (X-ray). Second– application of chemical reactions: condensation , restoration,cyclization.

2.1.Instrumental analysis

For the conduction of research, ***1a*** connection was purified by recrystallization [10].

For installation of purity and identity of synthesized ***1a*** compound GC-MS was conducted. In a result of research installed, that in report is available peak with 100% area and with output time 0,866 min. Such facts give us an opportunity to confirm during the further research , that a connection is individual, and responsible with calculations of relative molecular mass.

At analysis of the received IR-spectra, which were obtained in KBr, were fixed bands of oscillation of the –C–S– groups at 690 $см^{-1}$, instead are absent bands of oscillation within the limits of 2600-2550 cm^{-1}, that can point at the absence in a molecule – SH. At the detail analysis was observed the absence of oscillation groups, typical for 1,2,4-triazole core, namely NH- within the limits of 3100-3400 cm^{-1}. Characteristic feature is that in spectra are absence bands of aliphatic carbonyl group absorption within the limits of 1740-1720 cm^{-1}.

To confirm the presence of carbonyl group in synthesized compound, we obtained IR-spectra in chloroform. Enough important fact is that chloroform solution appears a band of low intensity absorption, typical for carbonyl group with the meaning 1715 cm^{-1}.

On the next stage we used ^{1}H Nuclear magnetic resonance spectroscopy. In ^{1}HNMR spectra available signals of phenyl radical protons in a form of doublet and multiplet with meanings 7,95 and 7,43 ppm. suitably. Also, available the proton resonating, connected with C_6 atom of 1,2,4-tiazole cycle in a triplet form by 6,1 ppm. (***Scheme 2***, form **B** and **C**). Conducted further analysis, it's possible to note, that a signal of the hydroxyl group proton (***Scheme 2,*** form **B** and **C**) is screened by the signals of methylene groups proton of 1,2,4-tiazole cycle. So, methylene protons resonate as triplet and quartet at 4,3 and 3,65 ppm. suitably.

For the final verification of synthesized compound structure, we applied X-ray analysis (Fig.1). As a result of such analysis, installed a structure of synthesized compound, which responds 2-phenyl-5,6-dihydrothiazolo[3,2-b][1,2,4]triazol-6-ol (Scheme 2, form **B**).

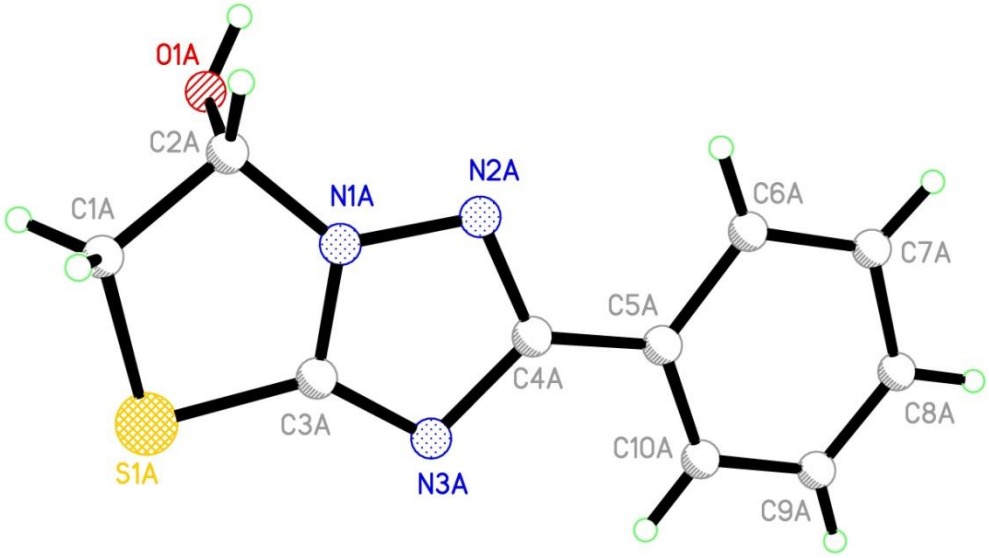
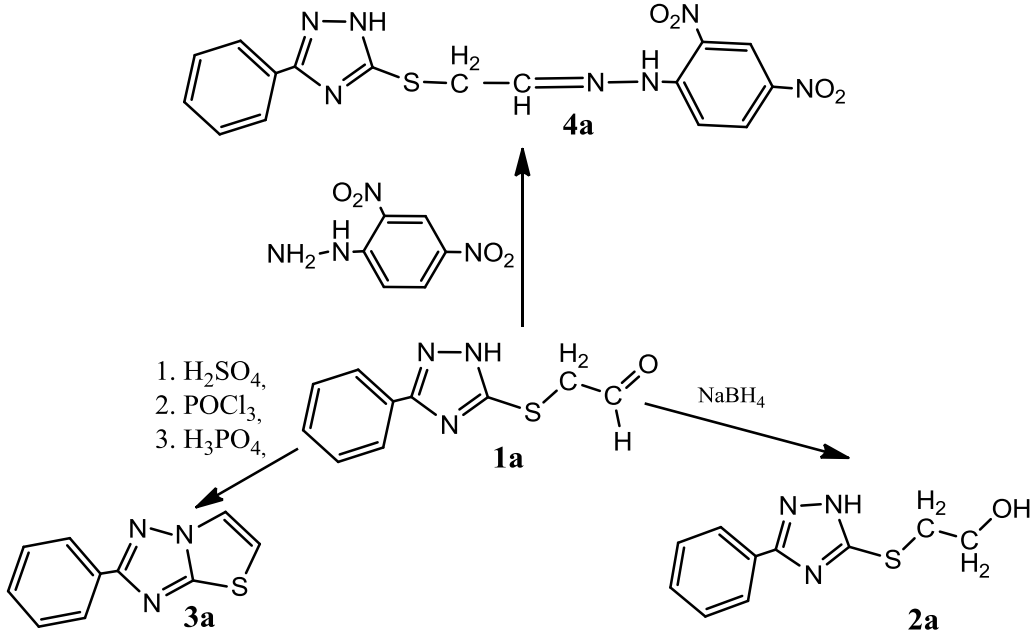


Figure 1.Structure of 2-phenyl-5,6-dihydrothiazolo[3,2-b][1,2,4]triazol-6-ol.

2.2. Methods of chemical reaction

For establishment of RCT presence with using of instrumental analysis methods, we used series of reactions, typical for carbonyl compounds. Aldehyde ***1a*** condensation with aromatic hydrazines in acidic environment leads to the reception of 5-((2-(2-(2,4-dinitrophenyl)hydrazono)ethyl)thio)-3-phenyl-1H-1,2,4-triazole (***Scheme 3***, ***4a***). At the recovering of compound ***1a*** by sodium borohydride formed 2-((3-phenyl-1H-1,2,4-triazol-5-yl)thio)ethanol (***2a***). Cyclization of 2-((3-phenyl-1H-1,2,4-triazol-5-yl)thio)acetaldehyde in concentrated sulfate acid environment, phosphorus oxychloride and phosphoric acid in all cases leads to reception of 2-phenylthiazolo[3,2-b][1,2,4]triazole (***3a***).



Schema 3. Reactions of condensation, recovering and cyclization 2-((3-phenyl-1H-1,2,4-triazol-5-yl)thio)acetaldehyde.

3. Conclusions

It is set the presence of the «ring-chain» tautomerism for 2-((3-phenyl-1H-1,2,4-triazol-5-yl)thio)acetaldehyde, which caused by proton transition from imino-group of 1,2,4-triazolecore to oxygen atom of carbonil group. In a result of conduction IR-spectroscopy (KBr), ^{1}HNMR-spectroscopy, X-ray crystallography installed, that ***1a*** compound in solid form is being as 2-phenyl-5,6-dihydrothiazolo[3,2-b][1,2,4]triazol-6-ol. (**Schema 2,B**). Records of the IR-spectra, received in chloroform, indicate on the existence of 2-phenyl-5,6-dihydrothiazolo[3,2-b][1,2,4]triazol-6-olin open form (***Scheme 2,*****A**). This statement is confirmed by the row of chemical reactions. So, 2-phenyl-5,6-dihydrothiazolo[3,2-b][1,2,4]triazol-6-ol forms corresponding hydrazone (***4a***), reducedto2-((3-phenyl-1H-1,2,4-triazol-5-yl)thio)ethanol (***2a***), dehydrated under the action of water absorbing reagents into 2-phenyl thiazolo[3,2-b][1,2,4]triazole (***3a***). Summing above specified, it is possible to note, that in solid form studied

compound is beingin a «ring» form (***Scheme 2*,B**), in solution prevails a «chain»form (***Scheme2*, A**).

4. Experimental protocols

Research physic-chemical properties of received compounds were conducted according with the methods, which are listed in State Pharmacopoeia of Ukraine. The melting temperature point identified by open capillary method on example of PTP (M). The structure of matter confirmed by means of elementary analysis on the example of Elementar Vario L cube (CHNS), IR-spectra (4000-400 cm^{-1}) were taken off on the module ALPHA-T (KBr, $CHCl_{3HPLC}$) of spectrometer Bruker ALPHA FT-IR. ^1H NMR-spectra of compounds were recorded by the means of spectrometer «Mercury 400», solvent - $DMSO_{d6}$, internal standard–tetramethylsilan (TMS). Chromatomas-spectral research conducted on the example of Agilent 1100 Series LC/MSD System, method of ionization - chemical ionization at atmospheric pressure (APCI). X-ray diffraction research conducted on the diffractometer «Xcalibur-3» (MoKα radiation, CCD-detector, graphitic monochromator ω-scanning , 2θmax. =50°).

The structure is decrypted by direct method for complex of programs SHELXTL [12].

4.1.2-((3-Phenyl-1H-1,2,4-triazol-5-yl)thio)acetaldehyde (1a):

General procedure for the preparations of 2-((3-Phenyl-1H-1,2,4-triazol-5-yl)thio)acetaldehyde and IR(KBr) records were described by us in previous work [10].

Yield, 90%, m.p.: 202‑204°C. IR ($CHCl_{3HPLC}$) cm^{-1}: 3068 (NH); 1715 (-COH); 689 (-C-S-); ^{1}HNMR (400 Mz, $DMSOd_6$) δppm: 7.95 (d, 2H, Ar), 7.43 (m, 3H, Ar), 6.1 (t, 1H, -C-H), 4.3 (t, 2H, $-CH_2$), 3.65(q, 2H, $-CH_2$). GCMS; m/z 220; Elemental analysis: $C_{10}H_9N_3OS$, Calc.(%)/Found (%): C:54.78/54.74, H:4.14/4.18, N: 19.16/19.14 S: 14.62/14.64

Crystaldata:

In symmetrically independent part of elementary crystal cell situated two molecules(A i B), which are differ by measure of dihydrodiazol heterocyclic folding. At both conformers cycle is situated in a twist conformation. Deviation of C(1) and C(2) atom from plane, conducted through the atoms of the cycle, is 0.24 A and 0.18 A in molecule A, 0.29 A i 0.10 A in B.

Hydroxyl group is situated in pseudoaxial position (torsion angles C(3)-N(1)-C(2)-O(1)-96(1)° in A and 95(1)° in B). Phenyl substituent is practically coplanar to area of the triazolcycle (torsion angles N(2)-C(4)-C(5)-C(6) 2(1)° A, -8(2)° B). Such its conformation, perhaps additionally stabilized by the attractive interactions C(6)-H(6)…N(2) 2.60 Å (molecule A), 2.57 Å (B) (sum of the vandervaaldse radius 2.66 Å) [11], C(10)-H(10)…N(3) 2.62 Å (A), 2.59 Å (B) (2.66 Å), which are cannot be considered as intermolecular hydrogen connections because of very sharp corners C-H...N (99° and 102° in A and B,accordingly).

In a crystal molecules A and B form zigzag similar chains along the crystallographic direction at the expense of intermolecular hydrogen connections

C(10)-H(10)…N(3)' (x-1, y, z) H…N 1.98 Å, C-H…N 158º A in A, 1.96 Å, 162º in B.. Neighboring chains connected between each other at the expense of intermolecular hydrogen chains C(2)-H(2)…N(2)' (-x-1, -y+1, -z+1 - A, -x, -y+1, -z - B) H…N 2.52 Å, A,B, C-H…N 172º A, 167º B. Between each other molecules A and B connected at the expense of intermolecular hydrogen connections C(1B)-H(1BB)…C(7A)' (-x, -y+1, -z+1) H…C 2.81 Å, C-H…C 117º, C(8B)-H(8B)…S(1A)' (-x+1, -y+2, -z) H…S 2.89 Å, C-H…S 164. Length of the connections (Å) in **A** structure**:**S(1)-C(3)-1.70(1), S(1)-C(1)-1.81(1), O(1)-C(2)-1.37(1), N(1)-C(3)-1.36(1), N(1)-N(2)-1.40(1), N(1)-C(2)-1.40(1), N(2)-C(4)-1.36(1), N(3)-C(3)-1.32(1), N(3)-C(4)-1.43(1), C(1)-C(2)-1.55(1), C(4)-C(5)-1.42(1), C(5)-C(10)-1.38(1), C(5)-C(6)-1.45(1), C(6)-C(7)-1.41(1), C(7)-C(8)-1.45(1), C(8)-C(9)-1.35(1), C(9)-C(10)-1.40(2).**B:**S(1)-C(3)-1.68(1), S(1)-C(1)-1.80(1), O(1)-C(2)-1.38(1), N(1)-C(3)-1.37(1), N(1)-N(2)-1.38(1), N(1)-C(2)-1.48(1), N(2)-C(4)-1.32(1), N(3)-C(3)-1.29(1), N(3)-C(4)-1.38(1), C(1)-C(2)-1.55(1), C(4)-C(5)- 1.44(1), C(5)-C(10)-1.34(1), C(5)-C(6)-1.41(1), C(6)-C(7)-1.43(1), C(7)-C(8)- 1.41(1), C(8)-C(9)-1.40(1), C(9)-C(10)-1.39(1).

4.2.General procedure for the preparations of 2-((3-phenyl-1H-1,2,4-triazol-5-yl)thio)ethanol (2a):

To 2,19 g (0,01 mol) ***1a*** in 50 methyl alcohol in portions, during 3 hours is added 0,74 g (0,02 mol) $NaBH_4$. Received solution remained at room temperature on 12 hours, diluted 100 ml H_2O and neutralized CH_3COOH to pH=7. Target compound extraget chloroform, which evaporated on the water heater. For the next experiences compound ***2a*** has cleaned by the recrystallization from n-butanol.

Yield, 45%, m.p.: 128‑130^oC. IR (KBr) cm^{-1}: 3071 (NH);1075 (-OH);689 (-C-S-); ^{1}HNMR (400 Mz, $DMSOd_6$) δppm: 8.21 (d, 2H, Ar), 7.26 (t, 3H, Ar),3.73 (s, 4H, $-CH_2$), 3.62 (s, 1H, -OH). GCMS; m/z 220; Elemental analysis: $C_{10}H_{11}N_3OS$, Calc.(%)/Found (%): C:54.28/54.19, H:5.01/5.09, N: 18.99/19.07 S: 14.49/14.52

4.3. General procedure for the preparations of 2-phenylthiazolo[3,2-b][1,2,4]triazole (3a):

a)To 2,19 g (0,01 mol) of compound ***1a*** adds 10 ml H_2SO_4(98%). Compound stayed on 36 hours to full dissolution of sediment, added 50 ml H_2O and neutralizing $NaHCO_3$ to pH=7. Forms a sediment, which filtered and washed by water.

b)To 2,19 g (0,01 mol) of compound ***1a*** is added 15 ml $POCl_3$ (98%).Compound boils on the water heater, equipped by the inverse refrigerator during 4 hours. Received solution pours out on a crushed ice and neutralized $NaHCO_3$ to pH=7. Forms a sediment, which filtered and washed by water.

c)To 2,19 g (0,01 mol) of compound ***1a*** is added 20 ml H_3PO_4(85%). Compound boils on the water heater, equipped by the inverse refrigerator during 20 hours, is added 50 ml H_2O and neutralized $NaHCO_3$ to pH=7. Forms a sediment, which filtered and washed by water.

For the next experience ***3a*** compound has cleaned by recrystallization from n-butanol.

Yield, 81%(a), 44%(b), 68%(c),m.p.: 108‑110^{o}C. IR (KBr) cm^{-1}: 3084 (Ar-H);1466 (-Ar); 701 (tiophen), 667 (-C-S-);^{1}HNMR (400 Mz, DMSOd_6) δppm: 8.28 (d, 2H, Ar), 8.06 (d, 1H, thiazole), 7.36 (q, 3HAr); GCMS; m/z 201; Elemental analysis: $C_{10}H_{11}N_3OS$, Calc.(%)/Found (%): C:59.68/59.76, H:3.51/3.45, N: 20.88/20.85 S: 15.93/15.99.

4.4. General procedure for the preparations of 5-((2-(2-(2,4-dinitrophenyl)hydrazono)ethyl)thio)-3-phenyl-1H-1,2,4-triazole (4a):

To 2,19 g (0,01 mol) of compound ***1a*** is added 15 ml CH_3COOH. Compound is warmed on water heater to dissolution and adds 1,98 g (0,01 mol) (2,4-dinitrophenyl)hydrazine. Continue the heating during 5 minutes, and leaved at room temperature on 24 hours for the formation of sediment, which filters. For next experiences ***4a*** compound cleans by recrystallization with CH_3COOH.

Yield, 85%, m.p.: 123‑125^{o}C. IR (KBr) cm^{-1}:1681 (-CH=N-);1329 (-NO_2), 696(-C-S-); ^{1}HNMR (400 Mz, DMSOd_6) δppm: 11.52 (s, 1H, NH-triazole), 8.88 (s, 1H,Ar), 8.20 (q, 3H,Ar), 7.99 (d, 2H, Ar); 7.88 (d, 1H, -CH=N-);7.45 (s, 1H, -NH-);4.08 (s, 2H, -CH_2);GCMS; m/z 399; Elemental analysis: $C_{16}H_{13}N_7O_4S$, Calc.(%)/Found (%): C:48.12/48.08, H:3.28/3.32, N: 24.55/24.50 S: 8.03/8.08.

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