SYNTHESIS AND CHARACTERIZATION OF [(5-MERCAPTO-1,3,4-OXADIAZOL-2-YL)ARYL]-3,5-DIARYL-4,5-DIHYDRO-1*H*-PYRAZOLE-1-CARBOTHIOAMIDES

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Dedicated to academician Pavel F. Vlad on the occasion of his 75th birthday

Abstract: The synthesis and characterization of [(5-mercapto-1,3,4-oxadiazol-2-yl)aryl]-3,5-diaryl-4,5-dihydro-1*H*-pyrazole-1-carbothioamides - derivatives of pyrazolines and 5-[4(3)-isothiocyanatophenyl]-2-thio-1,3,4-oxadiazoles were realized. The synthesized compounds, are crystalline substances, stable in storage and when exposed to air and light.

Keywords: carbothioamides, pyrazolines, isothiocyanatophenyl-2-thio-1,3,4-oxadiazoles.

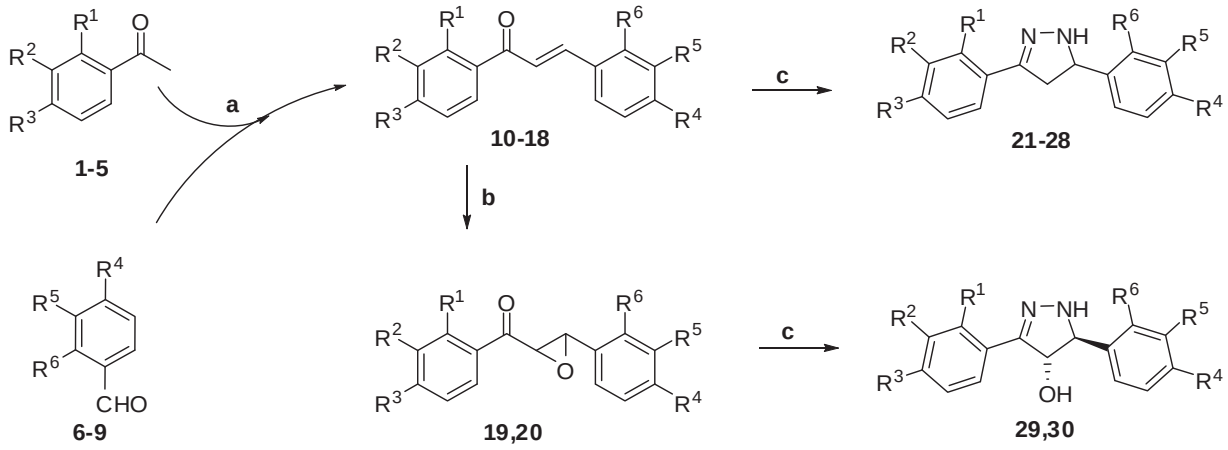
1. Introduction

1,3,4-Oxadiazoles as well as pyrazolines conform an important class of bioactive five-member heterocyclic compounds [1-45]. They possess an antiamoebic [2], analgesic [3], anti-inflammatory [3,18,33,34,43], anti-bacterial [4,6,8,9,10,15,22,36,37,38], anti-mycobacterial [5], anti-depressant [7], hypotensive [11], anti-microbial [12,16,21,26, 27,31,32,35,39,41,42,43], insecticidal [13,14], anti-oxidant [15], anti-convulsant [17], anti-helmintic [18], anti-fungal [19,20,23,24,25,28], genotoxic [23], hypoglycemic [29,30], anti-HIV [40] and antitubercular [44,45] activities. On the other side, some carbothioamides are known as antibacterial, antimicrobial, antiviral compounds, like thiosemicarbazones of 5-nitrofurfurylideneacetone, Dodecanone, Metisazone [11,12,13,46,47]. Because of their high toxicity these agents are not widely used drugs.

This prompted us to find new compounds having a thioamide moiety attached to a pyrazoline as well as 1,3,4-oxadiazole rings. These compounds can be considered as cyclic thiosemicarbazide derivatives as well. In order to obtain bioactive compounds, we have synthesized a series of [(5-mercapto-1,3,4-oxadiazol-2-yl)aryl]-3,5-diaryl-4,5-dihydro-1*H*-pyrazole-1-carbothioamides.

2. Results and discussion

The presence of a double bond in chalcones and easy introduction of epoxide group into the molecule of this enone make it as convenient starting material for the synthesis of functionalized pyrazolines [3,4,6,9,10,12,13,48]. On the other hand, 5-substituted 1,3,4-oxadiazole-2-thiones are interesting in view of their chemistry [47-65].



a: NaOH cat., EtOH, r.t. ; **b**: NaOH/ H_2O_2 in MeOH/acetone, 5°C; **c**: NH_2NH_2 in EtOH, reflux

Scheme 1

We chose the simplest method involving the Claisen-Schmidt reaction. This is the reaction of acetophenones with benzaldehydes in the presence of aqueous alkali or sodium ethylate, resulting in formation of α,β-unsaturated ketone.

The key compounds in the synthesis of pyrazolines **21-28** are 1,3-diaryl-2-propene-1-ones **10-18**, which were obtained by NaOH catalyzed condensation of various substituted acetophenones **1-5** with benzaldehydes **6-9** (see scheme 1 and table 1). The reaction was carried out at room temperature for five hours. On the formation of the products **10-18** indicate characteristic signal of the newly formed double bond CH=CH in the region of absorption 976-991 cm^{-1} as well as a signal of the carbonyl group in the region 1651-1668 cm^{-1} in the IR spectrum of compounds **10-18**. In ^{1}H NMR spectra of the compounds obtained, the characteristic signals of two protons of methine group (CH=CH) appear as two doublets in the region 7.68-7.97 ppm and 7.81-8.04 ppm and are overlapped by the signals of the aromatic system in the region vary from 6.91 to 8.21 ppm. Inspection of the coupling constant values of the protons belonging to methine group in ^{1}H NMR spectra proves their non aromatic nature ($J_{H\alpha\text{-}H\beta}$ = 15-16 Hz), suggested that chalcones were geometrically pure and configured as *trans*-isomer. In ^{13}C-NMR spectra chemical shift values of the CH group appear in the region 111.25-164.25 ppm, together with the signals of aromatic carbon system. Another characteristic peak is signal of the C=O group at 187.24-191.94 ppm.

Table 1

Substituent group and physical data of synthesized compounds

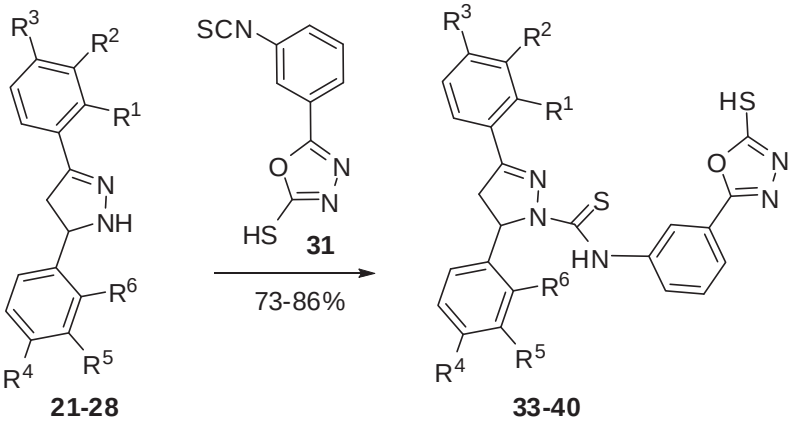
Comps	R^1	R^2	R^3	R^4	R^5	R^6	Formula	M.p. (°C) Registered/Reference	Yield (%)
10	H	H	H	H	H	H	$C_{15}H_{12}O$	55-56	[a]81
11	H	H	H	H	H	OH	$C_{15}H_{12}O_2$	155-157	[a]85
12	H	Cl	Cl	Cl	H	Cl	$C_{15}H_8Cl_4O$	112-113	[a]78
13	Cl	H	Cl	Cl	H	Cl	$C_{15}H_8Cl_4O$	130-133	[a]75
14	H	H	OMe	OMe	H	H	$C_{17}H_{16}O_3$	95	[a]82
15	H	H	H	OMe	OMe	H	$C_{17}H_{16}O_3$	91-92	[a]61
16	H	Cl	Cl	OMe	OMe	H	$C_{17}H_{14}Cl_2O_3$	120	[a]76
17	Cl	H	Cl	OMe	OMe	H	$C_{17}H_{14}Cl_2O_3$	124-125	[a]68
18	H	H	Me	OMe	H	H	$C_{17}H_{16}O_2$	95-97	[a]72
19	H	H	OMe	OMe	H	H	$C_{17}H_{16}O_4$	oil	[b]98
20	H	H	Me	OMe	H	H	$C_{17}H_{16}O_3$	oil	[b]99
21	H	H	H	H	H	H	$C_{15}H_{14}N_2$	85/88 [80]	[a]85
22	H	H	H	H	H	OH	$C_{15}H_{14}N_2O$	195-197	[a]87
23	H	Cl	Cl	Cl	H	Cl	$C_{15}H_{10}Cl_4N_2$	74-76	[a]92
24	Cl	H	Cl	Cl	H	Cl	$C_{15}H_{10}Cl_4N_2$	61-64	[a]91
25	H	H	OMe	OMe	H	H	$C_{17}H_{18}N_2O_2$	80-82	[a]84
26	H	H	H	OMe	OMe	H	$C_{17}H_{18}N_2O_2$	80-81	[a]84
27	H	Cl	Cl	OMe	OMe	H	$C_{17}H_{16}Cl_2N_2O_2$	102-104	[a]89
28	Cl	H	Cl	OMe	OMe	H	$C_{17}H_{16}Cl_2N_2O_2$	96-97	[a]76
29	H	H	OMe	OMe	H	H	$C_{17}H_{18}N_2O_3$	159-161	[a]86
30	H	H	Me	OMe	H	H	$C_{17}H_{18}N_2O_2$	168-169	[a]75
33	H	H	H	H	H	H	$C_{24}H_{19}N_5OS_2$	230-233	[a]86
34	H	H	H	H	H	OH	$C_{24}H_{19}N_5O_2S_2$	199-202	[a]79
35	H	Cl	Cl	Cl	H	Cl	$C_{24}H_{15}Cl_4N_5OS_2$	168-170	86
36	Cl	H	Cl	Cl	H	Cl	$C_{24}H_{15}Cl_4N_5OS_2$	136-139	81
37	H	H	OMe	OMe	H	H	$C_{26}H_{23}N_5O_3S_2$	154-157	73
38	H	H	H	OMe	OMe	H	$C_{26}H_{23}N_5O_3S_2$	227-230	81
39	H	Cl	Cl	OMe	OMe	H	$C_{26}H_{21}Cl_2N_5O_3S_2$	246-248	83
40	Cl	H	Cl	OMe	OMe	H	$C_{26}H_{21}Cl_2N_5O_3S_2$	230-232	82
41	H	H	H	H	H	H	$C_{24}H_{19}N_5OS_2$	139-142	81
42	H	H	H	H	H	OH	$C_{24}H_{19}N_5O_2S_2$	168-172	77
43	H	Cl	Cl	Cl	H	Cl	$C_{24}H_{15}Cl_4N_5OS_2$	244-247	81
44	Cl	H	Cl	Cl	H	Cl	$C_{24}H_{15}Cl_4N_5OS_2$	228-230	78
45	H	H	OMe	OMe	H	H	$C_{26}H_{23}N_5O_3S_2$	143-145	68
46	H	H	H	OMe	OMe	H	$C_{26}H_{23}N_5O_3S_2$	207-210	74
47	H	Cl	Cl	OMe	OMe	H	$C_{26}H_{21}Cl_2N_5O_3S_2$	148-150	87
48	Cl	H	Cl	OMe	OMe	H	$C_{26}H_{21}Cl_2N_5O_3S_2$	231-234	87

49	H	H	OMe	OMe	H	H	$C_{26}H_{23}N_5O_4S_2$	142-145	83
50	H	H	Me	OMe	H	H	$C_{26}H_{23}N_5O_3S_2$	151-154	75
51	H	H	OMe	OMe	H	H	$C_{26}H_{23}N_5O_4S_2$	222-224	78
52	H	H	Me	OMe	H	H	$C_{26}H_{23}N_5O_3S_2$	216-218	81

[a] On the isolated product.

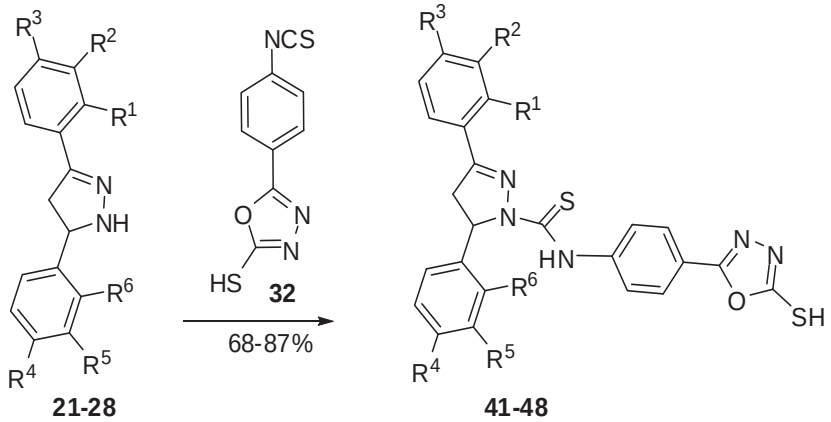
[b] Detected by ^{1}H NMR.

It is known that hydrogen peroxide reacts with α,β-unsaturated carbonyl compounds to give α,β-epoxy ketones [66,67,68]. This reaction has now been applied to the chalcone **14,18**, with the aim of synthesizing some new oxirane derivatives. Thus, treatment of a NaOH solution of the chalcone **14,18** in MeOH/acetone mixture with hydrogen peroxide yielded the corresponding unstable oxirane derivatives **19,20**, respectively (scheme 1), which used for next step without purifications. The structure for **19,20**, is supported by the following evidences: IR spectra indicated strong bands characteristic of carbonyl (1700-1685 cm^{-1}) and epoxylinkage at 1290 cm^{-1}; the ^{1}H NMR spectrum of **19,20** reveals the presence of the both OMe as well as Me as to singlets at 3.94, 3.96 ppm, the oxirane ring as a doublet at 4.35 ppm and at 6.9-8.49 ppm for the hydrogen protons of the aromatic rings.



Scheme 2

It should be note, that the synthesis of pyrazolines was broadly investigated earlier [1-13,60]. In continuation of our work on acetophenones derivatives [45, 69-74] it was contemplated to synthesize some new pyrazolines derivatives 21-28. In analogy with the recently reported reactions [70] our synthesized chalcones **10-18** with hydrazine hydrate in boiling EtOH afforded the pyrazolines **21-28**, respectively (scheme 1). The physicochemical data for synthesized compounds **21-28** are given in table 1.



Scheme 3

Structures of pyrazolines **21-28** were proved by spectral data. Its infrared spectrum shown well defined absorbed bands at 1588-1681, 3293-3367 cm^{-1} attributable to νC=N and νNH respectively. In the ^{1}H NMR spectrum of compounds **21-28**, the pyrazoline NH proton resonated as singlet which is overlaped by the signals of aromatic system. The CH_2 protons of the pyrazoline cycles resonated as a pair of doublets of doublets at δ 2.70-2.92 ppm and δ 3.34-3.89

ppm (*J*=10.24-12 Hz, *J*=16-16.4 Hz). The CH protons appeared as triplet in the region 4.74-5.15 ppm due to vicinal coupling with the two magnetically non-equivalent protons of the methylene group (*J*=10.24-12 Hz). The phenyl protons resonated at δ 6.72-8.16 ppm as a multiplet. The hydroxy group appeared as singlet at δ 9.45 ppm in compound **22**. The MeO protons appeared as singlet at δ 3.69, 3.73 ppm in compounds **25**, in **26** at δ 3.87, δ 3.89 ppm and for substances **27**, **28** at δ 3.73, δ 3.74 ppm and δ 3.75, δ 3.77 ppm, respectively.

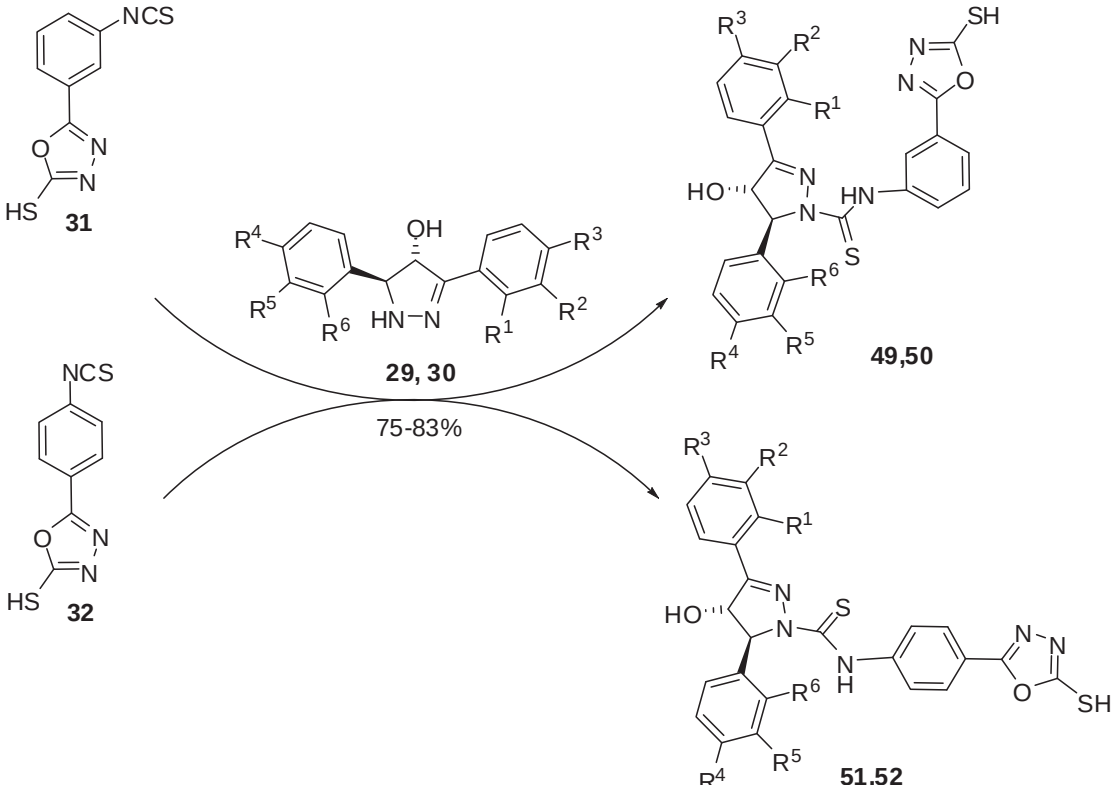
In ^{13}C-NMR spectra the carbon atoms came into resonance at 40.92–41.54 (C_4), 58.53-64.36 (C_5) and 146.18-160.03 ppm (C_3). The aromatic carbons resonated from δ 110.17-126.67 ppm to δ 133.65-159.95 ppm. The methoxy groups displayed their signals at δ 55.31-56.05 ppm.

Recently [67,68,75-77] it has been reported that the epoxide ring in the chalcone epoxide was readily cleaved with amines at the β-carbon atom. In our present investigation it was found that the oxirane ring is readily opening when the oils containing derivatives **19,20** are allowed to react with hydrazine hydrate in boiling EtOH, and yielded the aryl 4-hydroxypyrazoline derivate **29,30** (scheme 1).

The IR spectrum of 4-hydroxypyrazoline derivate **29,30** showed absorption bands in the region of 3675 and 3574 cm^{-1}characteristic of OH group and at 3323 and 3324 cm^{-1} of NH group. The structure of the compounds was further confirmed by ^{1}H and ^{13}C NMR. In ^{1}H NMR spectra of the compounds **29,30**, bearing hydroxy group at C_4 atom of the carbon, appear hydrogens of C_4 and C_5 atoms of carbon as doublets in the region of 4.44-4.46 ppm and 4.9 ppm. The pyrazolones **29,30** were configured as *trans*-isomer due to the coupling constant values *J* =6.8 Hz and *J* =7.2 Hz. The hydroxy group at C_4 atom of carbon appears as a broad singlet at 5.89 ppm and 5.9 ppm. In the ^{13}C-NMR chemical, the C_3, C_4, and C_5 carbons of the pirazoline ring were observed at 159.51 and 162.78 ppm, 71.89 and 71.97 ppm, 82.94 and 82.54 ppm, respectively. The protons belonging aromatic rings and phenyl substituents were observed at expected chemical shift and integral values and shown in the experimental section.

The reaction of isotiocyanates with pyrazolines has been reported [78]. Our initial studies were performed on pyrazolines **21-28** and known isothiocyanate **31**[79]. Our pyrazolines reacted with compound **31** in boiling EtOH to give N-(3-(5-mercapto-1,3,4-oxadiazol-2-yl)phenyl)-3,5-diaryl-4,5-dihydro-1H-pyrazole-1-carbothioamides **33-40** (scheme 2)**.** Similarly, the isothiocyanate **32** [79] reacts with 4,5-dihydro-1*H*-pyrazols **21-28** to give expected carbothioamides **41-48** (scheme 3).

It well known that thiocarbamates as well as carbamates are prepared when isothiocyanates or isocyanates are treated with alcohols. This is an excellent reaction, of wide scope, and gives good yields. In the reaction of 4,5-dihydro-1H-pyrazol-4-ols **29,30** with isothiocyanates **31, 32** the formation of carbothioamides as well as and thiocarbamates derivatives (or mixture of both) is possible. Under the reaction conditions, used in our experiment, formation of mixture was not observed (scheme 4).



Scheme 4

The structure of compounds **33-52** was proved by analytical data. In the IR spectra, the C=N band exhibited a weak absorption in the range 1604-1653 cm-1. Compounds exhibited N-H stretching absorption bands in the region of 3289-3365 cm-1.

In ^{1}H NMR spectra of the compounds **33-48** there are three characteristic signals of ABX spin system. These signals of pyrazoline system appear as a doublet of doublets at 3.09-3.35 ppm, 3.78-4.24 ppm and 5.98-6.26 ppm (J_{AB}=2.8-3.9 Hz, J_{AX}=10.8-12.00 Hz, J_{BX}=16.00-18.70 Hz). Formation of the carbothioamides are proved by the signals of new NH group a well as mercapto group (SH), which observed in region of 10.16-10.49 ppm and 14.24-14.80 ppm, respectively. In the ^{13}C-NMR chemical, the C_4 and C_5 carbons of the pirazoline ring were resonated at 41.09-45.30 ppm and 59.97-64.05 ppm, while the thione carbon of the keto tautomer resonated at δ 177.78-178.11 ppm.

The ^{1}H NMR spectrum of the compounds **51** and **52** shown signals of protons at C_4, C_5 as doublets at 4.9 and 5.6 ppm with coupling constant value *J*=1.2 Hz. However, signals of protons at C_4, C_5 of compounds **49** and **50** appear as singlets at 4.89, 5.64 ppm and 4.91, 5.65 ppm, respectivly. The signals of NH and SH groups resonated at 10.24-10.51 ppm and 14.55-14.72 ppm. The signals due to the aromatic carbons and the carbons of methoxy and methyl groups resonate at expected region, chemical shifts and the coupling constant values are shown in the experimental section. It should be note, that the C=N group of oxadiazole part was characterized by the presence of the signals in the range of δ 160.61-160.92 ppm and δ 173.35-173.95 ppm and pyrazoline ring system at δ 140.85-143.54 ppm in their ^{13}C NMR spectra.

It is worth noting that synthesized pyrazolines as well as carbothioamides, are crystalline substances, stable in storage and when exposed to air and light.

3. Conclusions

The reported methods present a straightforward procedure for the efficient and facile synthesis of stable in storage and when exposed to air and light of [(5-mercapto-1,3,4-oxadiazol-2-yl)aryl]-3,5-diaryl-4,5-dihydro-1*H*-pyrazole-1-carbothioamides from moderate to excellent yields. The reactions have remarkable synthetic utility and are valuable addition to the synthesis of carbothioamides derivatives via manipulation of isothiocyanates and pyrazolines because of the simplicity of the procedure. Being ambient anions in alkali medium 2-mercapto-1,3,4-oxadiazoles can show diverse reactions towards electrophilic reagents, and they are able to form either S- or $N_{(3)}$ – substituted compounds. The studies on the reactivity of [(5-mercapto-1,3,4-oxadiazol-2-yl)aryl]-3,5-aryl-4,5-dihydro-1*H*-pyrazole-1-carbothioamides **33-52** are underway in our laboratory.

4. Experimental methods

All used solvents were of reagent quality, and all commercial reagents were used without additional purification. Removal of all solvents was carried out under reduced pressure. Analytical TLC plates were Silufol® UV-254 (Silpearl on aluminium foil, Czecho-Slovakia). IR spectra were recorded on a Spectrum 100 FT-IR spectrophotometer (Perkin –Elmer) using the universal ATR sampling accessory. ^{1}H and ^{13}C NMR spectra have been recorded for $(CD_3)_2SO$ 2-% solution on a "Bruker -Avance III" (400.13 and 100.61 MHz)

General procedure for the synthesis of 1,3-diaryl-2-propene-1-one (chalcone) 10-18. To a solution of NaOH (2.18 g, 0.055 mol) in mixture of water (20 g) and EtOH (10 g, 12.25 ml, 95%) was added acetophenone (0.043 mol). The mixture was cooled to 5^{0}C, and then corresponding benzaldehyde (0.043 mol) was added. The reaction mixture was stirred for about 5 hours while maintaining the temperature to 25^{0}C. The solid mass obtained was kept on the ice chest over night, washed with water, dried, and was recrystallized using ethanol to afford the target compounds **10-18**.

(2E)-1,3-Diphenyl-2-propene-1-one 10. IR ν, cm^{-1}: 1662 (C=O); 988 (CH=CH). ^{1}H NMR δ, ppm, *J*/Hz: 7.76 d (1Hα, *J* 15.65 Hz), 7.96 d (1Hβ, *J* 15.65 Hz), 7.45-8.18 m (10H, ArH). ^{13}C NMR, δ, ppm: 122.37, 126.44, 127.90, 128.27, 128.44, 128.79, 128.97, 129.08, 130.61, 132.98, 135.15, 137.20, 138.19, 144.28, 189.13. Found, %: C 86.48; H 5.84. Calculated, %: C 86.51; H 5.81.

(2E)-3-(2-Hydroxyphenyl)-1-phenyl-2-propene-1-one 11. IR ν, cm^{-1}: 1651 (C=O); 987 (CH=CH). ^{1}H NMR δ, ppm, *J*/Hz: 7.74 d (1Hα, *J* 15.6 Hz), 7.85 d (1Hβ, *J* 15.6 Hz), 7.34-7.93 (9H, ArH), 9.47 s (1H, OH). ^{13}C NMR, δ, ppm: 118.51, 119.40, 121.97, 122.66, 128.74, 128.94, 130.02, 132.15, 132.71, 142.63, 143.14, 156.44, 189.97. Found, %: C 80.28; H 5.42. Calculated, %: C 80.34; H 5.39.

(2E)-3-(2,4-Dichlorophenyl)-1-(3,4-dichlorophenyl)-2-propene-1-one 12. IR ν, cm^{-1}: 1663 (C=O); 990 (CH=CH). ^{1}H NMR δ, ppm, *J*/Hz: 7.97 d (1Hα, *J* 15.20 Hz), 8.04 d (1Hβ, *J* 15.20 Hz), 7.51-8.12 m (6H, ArH). ^{13}C NMR, δ, ppm: 125.05, 128.37, 129.07, 129.97, 130.46, 131.09, 131.63, 132.50, 135.80, 136.40, 136.84, 137.73, 138.63, 187.24. Found, %: C 52.09; H 2.29. Calculated, %: C 52.06; H 2.33.

(2E)-1,3-Di(2,4-dichlorophenyl)-2-propene-1-one 13. IR ν, cm^{-1}: 1665 (C=O); 991 (CH=CH). ^{1}H NMR δ, ppm, *J*/Hz: 7.84 d (1Hα, *J* 16.00 Hz), 7.96 d (1Hβ, *J* 16.00 Hz), 7.27-8.09 m (6H, ArH). ^{13}C NMR, δ, ppm: 128.18, 128.59, 129.22, 130.07, 130.30, 131.19, 131.53, 131.95, 135.60, 136.66, 137.31, 139.81, 191.94. Found, %: C 52.08; H 2.31. Calculated, %: C 52.06; H 2.33.

(2E)-1,3-Di(4-methoxyphenyl)-2-propene-1-one 14. IR ν, cm^{-1}: 1657 (C=O); 976 (CH=CH). ^{1}H NMR δ, ppm, *J*/Hz: 3.82 s, 3.86 s (6H, 2MeO), 7.68 d (1Hα, *J* 15.2 Hz), 7.81 d (1Hβ, *J* 15.2 Hz), 7.01 d (2H, ArH, *J* 8.4 Hz), 7.08 d (2H, ArH, *J* 8.8 Hz), 7.94 d (2H, ArH, *J* 8.4 Hz), 8.15 d (2H, ArH, *J* 8.8 Hz). ^{13}C NMR, δ, ppm: 55.97, 56.12, 112.82, 115.31, 120.54, 128.63, 131.18, 131.45, 131.97, 145.68, 162.74, 164.25, 189.76. Found, %: C 76.08; H 6.05. Calculated, %: C 76.10; H 6.01.

(2E)-3-(3,4-Dimethoxyphenyl)-1-phenyl-2-propene-1-one 15. IR ν, cm^{-1}: 1653 (C=O); 984 (CH=CH). ^{1}H NMR δ, ppm, *J*/Hz: 3.82 s, 3.87 s (6H, 2MeO), 7.72 d (1Hα, *J* 15.52 Hz), 7.84 d (1Hβ, *J* 15.52 Hz), 7.02-8.17 m (8H, ArH). ^{13}C NMR, δ, ppm: 55.93, 56.11, 111.25, 111.87, 120.04, 124.09, 128.02, 128.78, 128.87, 132.92, 138.46, 144.86, 149.59, 151.81, 189.23. Found, %: C 76.12; H 6.05. Calculated, %: C 76.10; H 6.01.

(2E)-1-(3,4-Dichlorophenyl)-3-(3,4-dimethoxyphenyl)-2-propene-1-one 16. IR ν, cm^{-1}: 1662 (C=O); 990 (CH=CH). ^{1}H NMR δ, ppm, *J*/Hz: 3.69 s, 3.71 s (6H, 2MeO), 7.68 d (1Hα, *J* 15.83 Hz), 7.85 d (1Hβ, *J* 15.83 Hz), 7.26-8.03 m (6H, ArH). ^{13}C NMR, δ, ppm: 55.89, 56.01, 113.25, 114.44, 120.98, 123.09, 128.12, 128.56, 128.62, 131.37, 132.94, 138.17, 138.36, 144.03, 149.19, 151.66, 190.23. Found, %: C 60.58; H 4.15. Calculated, %: C 60.55; H 4.18.

(2E)-1-(2,4-Dichlorophenyl)-3-(3,4-dimethoxyphenyl)-2-propene-1-one 17. IR ν, cm^{-1}: 1668 (C=O); 979 (CH=CH). ^{1}H NMR δ, ppm, *J*/Hz: 3.78 s, 3.82 s (6H, 2MeO), 7.76 d (1Hα, *J* 15.01 Hz), 7.94 d (1Hβ, *J* 15.01 Hz), 7.31-8.21 m (6H, ArH). ^{13}C NMR, δ, ppm: 55.67, 55.98, 111.25, 111.67, 122.04, 122.96, 127.12, 128.15, 130.56, 131.23, 136.94, 137.41, 138.22, 143.51, 149.08, 151.87, 189.21. Found, %: C 60.48; H 4.21. Calculated, %: C 60.55; H 4.18.

(2E)-3-(4-Methoxyphenyl)-1-(4-methylphenyl)-2-propene-1-one 18. IR ν, cm^{-1}: 1663 (C=O); 984 (CH=CH). ^{1}H NMR δ, ppm, *J*/Hz: 2.32 s (3H, Me), 3.73 s (3H, MeO), 7.68 d (1Hα, *J* 15.67 Hz), 7.83 d (1Hβ, *J* 15.67 Hz), 6.91 d (2H, ArH, *J* 8.4 Hz), 7.16 d (2H, ArH, *J* 8.00 Hz), 7.53 d (2H, ArH, *J* 8.4 Hz), 7.92 d (2H, ArH, *J* 8.00 Hz). ^{13}C NMR, δ, ppm: 21.79, 56.18, 113.76, 118.94, 127.55, 128.39, 129.17, 130.63, 136.12, 144.33, 149.36, 189.77. Found, %: C 80.98; H 6.35. Calculated, %: C 80.93; H 6.39.

General procedure for the epoxidation of chalcones. A solution of the chalcone **14** or **18** (0.01 mol) in 50 ml of acetone and 20 ml MeOH was treated with 10 ml of the 10 % aqueous NaOH followed by the addition 15 ml of 30% aqueous H_2O_2. The mixture was stirred for 5 hours. Oil like products 4-methoxyphenyl-3-(4-methoxyphenyl)-2-oxiranylmethanone **19,** 3-(4-methoxyphenyl)-2-oxiranyl-4-methylphenylmethanone **20** were separated with approximately quantities yield and used for next step without purifications.

General procedure for the synthesis of 3,5-diaryl-4,5-dihydro-1H-pyrazole 21-30. The solution of appropriate chalcones or epoxides (0.026 mol) and hydrazine hydrate (4 ml, 0.07 mol, 85%) in EtOH (10 ml) was refluxed for 4 h. The reaction mixture was cooled with ice-cold water and the crude product which separated out was filtered and recrystallized using EtOH.

3,5-Diphenyl-4,5-dihydro-1*H*-pyrazole 21. IR ν, cm^{-1}: 3342 (NH); 1668 (C=N); 1445 (CH_2). ^{1}H NMR δ, ppm, *J*/Hz: 2.86 dd (1H, CH_2, *J* 10.24 Hz, *J* 16.13 Hz), 3.44 dd (1H, CH_2, *J* 10.24 Hz, *J* 16.13 Hz), 4.85 t (1H, $\underline{CH}CH_2$, *J* 10.24 Hz), 7.17-7.81 m (10H, ArH, 1H, NH). ^{13}C NMR, δ, ppm: 41.27, 64.21, 125.52, 125.76, 126.80, 127.31, 128.08, 128.45, 128.56, 128.74, 133.65, 143.38, 148.75. Found, %: C 81.09; H 6.31; N 12.68. Calculated, %: C 81.05; H 6.35; N 12.60.

2-(3-Phenyl-4,5-dihydro-1*H*-pyrazole-5-yl)phenol 22. IR ν, cm^{-1}: 3337 (NH); 1588 (C=N); 1458 (CH_2). ^{1}H NMR δ, ppm, *J*/Hz: 2.82 dd (1H, CH_2, *J* 10.44 Hz, *J* 16.21 Hz), 3.44 dd (1H, CH_2, *J* 10.44 Hz, *J* 16.21 Hz), 5.04 t (1H, $\underline{CH}CH_2$, *J* 10.44 Hz), 6.73-7.64 m (9H, ArH, 1H, NH), 9.45 s (1H, OH). ^{13}C NMR, δ, ppm: 59.37, 115.66, 119.14, 125.94, 127.10, 128.14, 128.38, 128.59, 133.65, 155.39. Found, %: C 75.66; H 5.88; N 11.79. Calculated, %: C 75.61; H 5.92; N 11.76.

5-(2,4-Dichlorophenyl)-3-(3,4-dichlorophenyl)-4,5-dihydro-1*H*-pyrazole 23. IR ν, cm^{-1}: 3340 (NH); 1662 (C=N); 1464 (CH_2). ^{1}H NMR δ, ppm, *J*/Hz: 2.70 dd (1H, CH_2, *J* 12 Hz, *J* 16 Hz), 3.59 dd (1H, CH_2, *J* 12 Hz, *J* 16 Hz), 5.14 t (1H, $\underline{CH}CH_2$, *J* 12 Hz), 7.36-7.81 m (6H, ArH, 1H, NH). ^{13}C NMR, δ, ppm: 60.81, 125.59, 127.29, 127.80, 129.13, 129.46, 130.88, 130.95, 132.04, 133.05, 133.15, 134.05, 139.73, 146.18. Found, %: C 50.02; H 2.88; N 7.75. Calculated, %: C 50.04; H 2.80; N 7.78.

3,5-Bis(2,4-dichlorophenyl)-4,5-dihydro-1H-pyrazole 24. IR ν, cm^{-1}: 3293 (NH); 1670 (C=N); 1466 (CH_2). ^{1}H NMR δ, ppm, *J*/Hz: 2.83 dd (1H, CH_2, *J* 10.6 Hz, *J* 16.4 Hz), 3.42 dd (1H, CH_2, *J* 10.6 Hz, *J* 16.4 Hz), 5.15 t (1H, $\underline{CH}CH_2$, *J* 10.6 Hz), 6.78-7.79 m (6H, ArH, 1H, NH). ^{13}C NMR, δ, ppm: 41.23, 64.01, 126.67, 130.89, 130.98, 131.63, 132.61, 133.97, 134.92, 136.28, 138.13, 138.35, 138.89, 140.04, 150.22. Found, %: C 50.08; H 2.84; N 7.76. Calculated, %: C 50.04; H 2.80; N 7.78.

3,5-Bis(4-methoxyphenyl)-4,5-dihydro-1*H*-pyrazole 25. IR ν, cm^{-1}: 3337 (NH); 1634 (C=N); 1449 (CH_2). ^{1}H NMR δ, ppm, *J*/Hz: 2.76 dd (1H, CH_2, *J* 10.4 Hz, *J* 16.4 Hz), 3.34 dd (1H, CH_2, *J* 10.4 Hz, *J* 16.4 Hz), 3.69 s, 3.73 s (6H, 2MeO), 4.74 t (1H, $\underline{CH}CH_2$, *J* 10.4 Hz), 6.87-8.16 m (8H, ArH, 1H, NH). ^{13}C NMR, δ, ppm: 41.54, 55.22, 55.31, 60.89, 115.02, 115.98, 127.75, 129.64, 129.81, 136.00, 151.97, 159.95, 160.03. Found, %: C 72.35; H 6.41; N 9.88. Calculated, %: C 72.32; H 6.43; N 9.92.

5-(3,4-Dimethoxyphenyl)-3-phenyl-4,5-dihydro-1*H*-pyrazole 26. IR ν, cm^{-1}: 3336 (NH); 1670 (C=N); 1444 (CH_2). ^{1}H NMR δ, ppm, *J*/Hz: 2.92 dd (1H, CH_2, *J* 10.25 Hz, *J* 16.01 Hz), 3.37 dd (1H, CH_2, *J* 10.25 Hz, *J* 16.01 Hz), 3.87 s, 3.89 s (6H, 2MeO), 4.81 t (1H, CHCH$_2$, *J* 10.25 Hz), 6.72-8.12 m (8H, ArH, 1H, NH). ^{13}C NMR, δ, ppm: 41.38, 55.62, 55.78, 64.36, 110.52, 112.31, 118.65, 125.52, 125.83, 127.99, 132.59, 133.55, 135.63, 149.07, 149.88. Found, %: C 72.35; H 6.41; N 9.88. Calculated, %: C 72.32; H 6.43; N 9.92.

3-(3,4-Dichlorophenyl)-5-(3,4-dimethoxyphenyl)-4,5-dihydro-1H-pyrazole 27. IR ν, cm^{-1}: 3367 (NH); 1679 (C=N); 1457 (CH_2). ^{1}H NMR δ, ppm, *J*/Hz: 2.87 dd (1H, CH_2, *J* 11.2 Hz, *J* 16.4 Hz), 3.73 s, 3.74 s (6H, 2MeO), 3.89 dd (1H, CH_2, *J* 11.2 Hz, *J* 16.4 Hz), 4.83 t (1H, CHCH$_2$, *J* 11.2 Hz), 6.85-7.95 m (6H, ArH, 1H, NH). ^{13}C NMR, δ, ppm: 41.08, 55.87, 55.98, 61.04, 111.15, 111.97, 112.02, 114.88, 116.85, 120.13, 129.25, 130.34, 131.40, 135.36, 135.48, 149.22, 151.12. Found, %: C 58.18; H 4.58; N 7.95. Calculated, %: C 58.13; H 4.59; N 7.98.

3-(2,4-Dichlorophenyl)-5-(3,4-dimethoxyphenyl)-4,5-dihydro-1H-pyrazole 28. IR ν, cm^{-1}: 3344 (NH); 1681 (C=N); 1463 (CH_2). ^{1}H NMR δ, ppm, *J*/Hz: 2.79 dd (1H, CH_2, *J* 12.00 Hz, *J* 16.00 Hz), 3.75 s, 3.77 s (6H, 2MeO), 3.87 dd (1H, CH_2, *J* 12.00 Hz, *J* 16.00 Hz), 5.09 t (1H, CHCH$_2$, *J* 12.00 Hz), 6.94-8.14 m (6H, ArH, 1H, NH). ^{13}C NMR, δ, ppm: 40.92, 55.95, 56.05, 58.53, 110.17, 111.20, 111.95, 114.06, 116.93, 119.79, 128.26, 129.56, 130.34, 134.34, 149.32. Found, %: C 58.15; H 4.62; N 7.99. Calculated, %: C 58.13; H 4.59; N 7.98.

3,5-Bis(4-methoxyphenyl)-4,5-dihydro-1H-pyrazol-4-ol 29. IR ν, cm^{-1}: 3675 (OH); 3324 (NH); 1665 (C=N). ^{1}H NMR δ, ppm, *J*/Hz: 3.79 s, 3.82 s (6H, 2MeO), 4.44 d (1H, CHCHOH, *J* 7.2 Hz), 4.9 d (1H, CHCHOH, *J* 7.2 Hz), 5.89 s (1H, OH), 6.91- 6.94 m (4H, ArH), 7.24 d (2H, ArH, *J* 8.8 Hz), 7.61 s (1H, NH), 7.69 d (2H, ArH, *J* 8.4 Hz). ^{13}C NMR, δ, ppm: 55.23, 71.89, 82.94, 113.81, 114.02, 125.88, 127.60, 127.86, 134.06, 150.18, 158.95, 159.51. Found, %: C 68.46; H 6.04; N 9.42. Calculated, %: C 68.44; H 6.08; N 9.39.

3-(4-Methoxyphenyl)-5-p-tolyl-4,5-dihydro-1H-pyrazol-4-ol 30. IR ν, cm^{-1}: 3574 (OH); 3323 (NH); 1628 (C=N). ^{1}H NMR δ, ppm, *J*/Hz: 2.30 s (3H, Me), 3.73 s (3H, MeO), 4.46 d (1H, CHCHOH, *J* 6.8 Hz), 4.9 d (1H, CHCHOH, *J* 6.8 Hz), 5.9 s (1H, OH), 6.90 d (2H, ArH, *J* 8.4 Hz), 7.16 d (2H, ArH, *J* 8.00 Hz), 7.22 d (2H, ArH, *J* 8.4 Hz), 7.51 s (1H, NH), 7.63 d (2H, ArH, *J* 8.00 Hz). ^{13}C NMR, δ, ppm: 21.35, 55.59, 71.97, 82.54, 114.38, 126.05, 128.06, 129.31, 130.53, 133.97, 137.49, 149.80, 159.03, 162.78. Found, %: C, 72.36; H, 6.41; N, 9.94. Calculated, %: C 72.32; H 6.43; N 9.92.

5-(3-Isothiocyanatophenyl)-1,3,4-oxadiazol-2-thiol 31 and **5-(4-isothicyanatophenyl)-1,3,4-oxadiazol-2-thiol 32** prepared by known procedure [79].

General procedure for the synthesis of N-((3)4-(5-mercapto-1,3,4-oxadiazol-2-yl)phenyl)-3,5-diaryl-4,5-dihydro-1H-pyrazole-1-carbothioamide 33-52. To the stirred solution of pyrazoline (0.02 mol) in ethanol, was added 5-((3)4-isothicyanatophenyl)-1,3,4-oxadiazol-2-thiol **31** or **32** (4.7 g, 0.02 mol) and refluxed for 4–6 h. The reaction mixture was concentrated and kept over night. The crude product was filtered, washed with ethanol, dried, and recrystallized from methanol to afford the title compounds.

N-(3-(5-Mercapto-1,3,4-oxadiazol-2-yl)phenyl)-3,5-diphenyl-4,5-dihydro-1*H*-pyrazole-1-carbothioamide 33. IR ν, cm^{-1}: 3315 (NH); 2913 (CH); 1620 (C=N); 1373 (C=S); 1097 (C-N). ^{1}H NMR δ, ppm, *J*/Hz: 3.23 dd (1H, CH_2, *J* 2.8 Hz, *J* 17.6 Hz), 3.97 dd (1H, CH_2, *J* 11.2 Hz, *J* 17.6 Hz), 6.08 dd (1H, CHCH$_2$, *J* 2.8 Hz, *J* 11.2 Hz), 7.21-8.22 m (14H, ArH), 10.19 s (1H, NH), 14.53 s (1H, SH). ^{13}C NMR, δ, ppm: 42.61, 63.73, 122.26, 122.43, 122.87, 125.76, 127.30, 127.69, 128.53, 128.81, 128.98, 130.83, 131.20, 140.79, 142.67, 160.58, 173.88, 177.99. Found, %: C 63.03; H 4.17; N 15.35. Calculated, %: C 63.00; H 4.19; N 15.31.

5-(2-Hydroxyphenyl)-N-(3-(5-mercapto-1,3,4-oxadiazol-2-yl)phenyl)-3-phenyl-4,5-dihydro-1H-pyrazole-1-carbothioamide 34. IR ν, cm^{-1}: 3318 (NH); 2942 (CH); 1634 (C=N); 1378 (C=S); 1023 (C-N). ^{1}H NMR δ, ppm, *J*/Hz: 3.11 dd (1H, CH_2, *J* 3.32 Hz, *J* 18.05 Hz), 3.94 dd (1H, CH_2, *J* 11.2 Hz, *J* 18.05 Hz), 6.16 dd (1H, CHCH$_2$, *J* 3.32 Hz, *J* 11.2 Hz), 6.71-8.24 m (13H, ArH), 9.72 s (1H, OH), 10.39 s (1H, NH), 14.73 s (1H, SH). ^{13}C NMR, δ, ppm: 41.39, 60.22, 115.96, 119.21, 122.45, 122.50, 122.71, 126.26, 127.90, 128.19, 128.45, 128.86, 129.13, 129.62, 131.25, 131.35, 141.04, 154.28, 157.00, 160.83, 173.72, 177.98. Found, %: C 60.82; H 4.09; N 14.75. Calculated, %: C 60.87; H 4.04; N 14.79.

5-(2,4-Dichlorophenyl)-3-(3,4-dichlorophenyl)-N-(3-(5-mercapto-1,3,4-oxadiazol-2-yl)phenyl)-4,5-dihydro-1H-pyrazole-1-carbothioamide 35. IR ν, cm^{-1}: 3308 (NH); 2954 (CH); 1614 (C=N); 1348 (C=S); 1175 (C-N). ^{1}H NMR δ, ppm, *J*/Hz: 3.14 dd (1H, CH_2, *J* 3.9 Hz, *J* 18.3 Hz), 4.01 dd (1H, CH_2, *J* 11.8 Hz, *J* 18.3 Hz), 6.26 dd (1H, CHCH$_2$, *J* 3.9 Hz, *J* 11.8 Hz), 7.07-8.25 m (10H, ArH), 10.44 s (1H, NH), 14.71 s (1H, SH). ^{13}C NMR, δ, ppm: 60.83, 61.69, 122.63, 122.91, 127.27, 127.42, 127.58, 127.77, 128.93, 129.03, 129.28, 129.54, 130.58, 130.94, 131.48, 132.05, 132.71, 133.23, 134.20, 138.35, 140.65, 153.23, 160.49, 174.39, 178.11. Found, %: C 48.45; H 2.57; N 11.72. Calculated, %: C 48.42; H 2.54; N 11.76.

3,5-Bis(2,4-dichlorophenyl)-N-(3-(5-mercapto-1,3,4-oxadiazol-2-yl)phenyl)-4,5-dihydro-1H-pyrazole-1-carbothioamide 36. IR ν, cm^{-1}: 3365 (NH); 2910 (CH); 1650 (C=N); 1373 (C=S); 1198 (C-N). ^{1}H NMR δ, ppm, *J*/Hz: 3.23 dd (1H, CH_2, *J* 3.9 Hz, *J* 18.3 Hz), 4.22 dd (1H, CH_2, *J* 11.8 Hz, *J* 18.3 Hz), 6.26 dd (1H, CHCH$_2$, *J* 3.9 Hz, *J* 11.8

Hz), 7.11-8.26 m (10H, ArH), 10.36 s (1H, NH), 14.63 s (1H, SH). ^{13}C NMR, δ, ppm: 43.89, 61.74, 122.66, 122.71, 122.94, 127.88, 127.97, 128.79, 128.86, 129.34, 129.63, 130.58, 132.02, 132.90, 133.22, 133.63, 136.37, 138.25, 140.62, 153.66, 160.53, 174.48, 178.02. Found, %: C 48.41; H 2.50; N 11.78. Calculated, %: C 48.42; H 2.54; N 11.76.

N-(3-(5-Mercapto-1,3,4-oxadiazol-2-yl)phenyl)-3,5-bis(4-methoxyphenyl)-4,5-dihydro-1H-pyrazole-1-carbothioamide 37. IR ν, cm^{-1}: 3321 (NH); 2920 (CH); 1628 (C=N); 1356 (C=S); 1120 (C-N). ^{1}H NMR δ, ppm, *J*/Hz: 3.16 dd (1H, CH_2, *J* 2.4 Hz, *J* 17.6 Hz), 3.78 s, 3.83 s (6H, 2MeO), 3.89 dd (1H, CH_2, *J* 10.8 Hz, *J* 17.6 Hz), 5.98 dd (1H, $\underline{CH}CH_2$, *J* 2.4 Hz, *J* 10.8 Hz), 6.88-8.21 m (12H, ArH), 10.22 s (1H, NH), 14.73 s (1H, SH). ^{13}C NMR, δ, ppm: 42.73, 55.46, 55.82, 63.22, 114.33, 114.56, 122.23, 122.42, 122.92, 123.62, 127.17, 128.52, 129.36, 129.66, 134.89, 140.97, 156.11, 158.78, 160.92, 161.94, 173.35, 177.78. Found, %: C 60.35; H 4.52; N 13.55. Calculated, %: C 60.33; H 4.48; N 13.53.

5-(3,4-Dimethoxyphenyl)-N-(3-(5-mercapto-1,3,4-oxadiazol-2-yl)phenyl)-3-phenyl-4,5-dihydro-1H-pyrazole-1-carbothioamide 38. IR ν, cm^{-1}: 3330 (NH); 2912 (CH); 1604 (C=N); 1398 (C=S); 1039 (C-N). ^{1}H NMR δ, ppm, *J*/Hz: 3.22 dd (1H, CH_2, *J* 3.2 Hz, *J* 17.6 Hz), 3.76 s, 3.79 s (6H, 2MeO), 3.92 dd (1H, CH_2, *J* 11.6 Hz, *J* 17.6 Hz), 6.01 dd (1H, $\underline{CH}CH_2$, *J* 3.2 Hz, *J* 11.6 Hz), 6.69-8.23 m (12H, ArH), 10.16 s (1H, NH), 14.53 s (1H, SH). ^{13}C NMR, δ, ppm: 42.65, 55.92, 55.96, 63.47, 110.53, 112.57, 117.67, 122.24, 122.42, 122.86, 127.68, 128.51, 128.82, 129.01, 130.83, 131.25, 135.19, 140.85, 148.64, 149.51, 155.61, 160.60, 173.92, 178.00. Found, %: C 60.29; H 4.49; N 13.54. Calculated, %: C 60.33; H 4.48; N 13.53.

3-(3,4-Dichlorophenyl)-5-(3,4-dimethoxyphenyl)-N-(3-(5-mercapto-1,3,4-oxadiazol-2-yl)phenyl)-4,5-dihydro-1H-pyrazole-1-carbothioamide 39. IR ν, cm^{-1}: 3331 (NH); 2879 (CH); 1632 (C=N); 1375 (C=S); 1103 (C-N). ^{1}H NMR δ, ppm, *J*/Hz: 3.31 dd (1H, CH_2, *J* 3.56 Hz, *J* 18.13 Hz), 3.70 s, 3.72 s (6H, 2MeO), 3.83 dd (1H, CH_2, *J* 11.44 Hz, *J* 18.13 Hz), 6.01 dd (1H, $\underline{CH}CH_2$, *J* 3.56 Hz, *J* 11.44 Hz), 6.88-8.33 m (10H, ArH), 10.46 s (1H, NH), 14.67 s (1H, SH). ^{13}C NMR, δ, ppm: 42.30, 55.75, 55.79, 64.01, 110.39, 112.53, 117.65, 122.72, 122.80, 122.90, 128.08, 129.27, 129.35, 129.75, 131.41, 132.00, 132.29, 133.64, 135.13, 140.88, 148.47, 149.31, 154.39, 160.75, 172.45, 177.94. Found, %: C 53.19; H 3.65;N 11.97. Calculated, %: C 53.24; H 3.61;N 11.94.

3-(2,4-Dichlorophenyl)-5-(3,4-dimethoxyphenyl)-N-(3-(5-mercapto-1,3,4-oxadiazol-2-yl)phenyl)-4,5-dihydro-1H-pyrazole-1-carbothioamide 40. IR ν, cm^{-1}: 3332 (NH); 2921 (CH); 1634 (C=N); 1379 (C=S); 1110 (C-N). ^{1}H NMR δ, ppm, *J*/Hz: 3.16 dd (1H, CH_2, *J* 3.6 Hz, *J* 18.00 Hz), 3.77 s, 3.82 s (6H, 2MeO), 3.99 dd (1H, CH_2, *J* 11.6 Hz, *J* 18.00 Hz), 6.21 dd (1H, $\underline{CH}CH_2$, *J* 3.6 Hz, *J* 11.6 Hz), 6.95-8.19 m (10H, ArH), 10.34 s (1H, NH), 14.80 s (1H, SH). ^{13}C NMR, δ, ppm: 45.30, 56.16, 56.35, 61.45, 110.80, 111.92, 122.17, 122.74, 122.89, 123.05, 123.42, 128.27, 129.56, 129.77, 132.05, 132.80, 139.01, 140.91, 149.35, 152.04, 156.70, 160.74, 163.39, 172.43, 173.67, 177.95. Found, %: C 53.27; H 3.65;N 11.88. Calculated, %: C 53.24; H 3.61;N 11.94.

N-(4-(5-Mercapto-1,3,4-oxadiazol-2-yl)phenyl)-3,5-diphenyl-4,5-dihydro-1H-pyrazole-1-carbothioamide 41. IR ν, cm^{-1}: 3305 (NH); 2908 (CH); 1628 (C=N); 1375 (C=S); 1067 (C-N). ^{1}H NMR δ, ppm, *J*/Hz: 3.19 dd (1H, CH_2, *J* 3.2 Hz, *J* 17.6 Hz), 3.99 dd (1H, CH_2, *J* 11.6 Hz, *J* 17.6 Hz), 6.08 dd (1H, $\underline{CH}CH_2$, *J* 3.2 Hz, *J* 11.6 Hz), 7.13-8.11 m (14H, ArH), 10.28 s (1H, NH), 14.52 s (1H, SH). ^{13}C NMR, δ, ppm: 42.67, 63.76, 118.36, 124.46, 125.82, 126.29, 127.02, 127.40, 127.83, 128.89, 128.94, 131.08, 142.63, 156.00, 160.75, 173.20, 177.79. Found, %: C 63.05; H 4.14; N 15.33. Calculated, %: C 63.00; H 4.19; N 15.31.

5-(2-Hydroxyphenyl)-N-(4-(5-mercapto-1,3,4-oxadiazol-2-yl)phenyl)-3-phenyl-4,5-dihydro-1H-pyrazole-1-carbothioamide 42. IR ν, cm^{-1}: 3308 (NH); 2873 (CH); 1635 (C=N); 1368 (C=S); 1025 (C-N). ^{1}H NMR δ, ppm, *J*/Hz: 3.09 dd (1H, CH_2, *J* 3 Hz, *J* 16 Hz), 3.98 dd (1H, CH_2, *J* 12 Hz, *J* 16 Hz), 6.19 dd (1H, $\underline{CH}CH_2$, *J* 3 Hz, *J* 12 Hz), 6.64-8.03 m (13H, ArH), 9.51 s (1H, OH), 10.18 s (1H, NH), 14.47 s (1H, SH). ^{13}C NMR, δ, ppm: 41.47, 59.97, 116.01, 118.31, 118.99, 123.99, 126.26, 127.64, 127.76, 128.12, 128.77, 130.76, 131.37, 143.45, 154.23, 156.43, 160.70, 172.95, 177.87. Found, %: C 60.83; H 4.08; N 14.77. Calculated, %: C 60.87; H 4.04; N 14.79.

5-(2,4-Dichlorophenyl)-3-(3,4-dichlorophenyl)-N-(4-(5-mercapto-1,3,4-oxadiazol-2-yl)phenyl)-4,5-dihydro-1H-pyrazole-1-carbothioamide 43. IR ν, cm^{-1}: 3303 (NH); 2962 (CH); 1613 (C=N); 1348 (C=S); 1166 (C-N). ^{1}H NMR δ, ppm, *J*/Hz: 3.16 dd (1H, CH_2, *J* 3.2 Hz, *J* 18 Hz), 3.81 dd (1H, CH_2, *J* 11.77 Hz, *J* 18 Hz), 6.26 dd (1H, $\underline{CH}CH_2$, *J* 3.2 Hz, *J* 11.77 Hz), 7.06-8.27 m (10H, ArH), 10.46 s (1H, NH), 14.35 s (1H, SH). ^{13}C NMR, δ, ppm: 61.67, 118.97, 124.98, 126.26, 127.58, 127.81, 129.36, 129.56, 131.01, 131.43, 132.09, 132.66, 133.21, 134.22, 138.30, 143.14, 153.56, 160.62, 173.68, 177.92. Found, %: C 48.44; H 2.51; N 11.75. Calculated, %: C 48.42; H 2.54; N 11.76.

3,5-Bis(2,4-dichlorophenyl)-N-(4-(5-mercapto-1,3,4-oxadiazol-2-yl)phenyl)-4,5-dihydro-1H-pyrazole-1-carbothioamide 44. IR ν, cm^{-1}: 3361 (NH); 2908 (CH); 1653 (C=N); 1374 (C=S); 1115 (C-N). ^{1}H NMR δ, ppm, *J*/Hz: 3.27 dd (1H, CH_2, *J* 3.9 Hz, *J* 18.3 Hz), 4.24 dd (1H, CH_2, *J* 11.8 Hz, *J* 18.3 Hz), 6.24 dd (1H, $\underline{CH}CH_2$, *J* 3.9 Hz, *J* 11.8 Hz), 7.12-8.18 m (10H, ArH), 10.47 s (1H, NH), 14.71 s (1H, SH). ^{13}C NMR, δ, ppm: 43.80, 61.74, 118.81, 125.09, 126.64, 128.09, 128.28, 128.91, 129.65, 130.74, 132.03, 133.01, 133.64, 136.25, 138.46, 143.25, 154.60, 160.82, 173.87, 177.84. Found, %: C 48.44; H 2.55; N 11.74. Calculated, %: C 48.42; H 2.54; N 11.76.

N-(4-(5-Mercapto-1,3,4-oxadiazol-2-yl)phenyl)-3,5-bis(4-methoxyphenyl)-4,5-dihydro-1H-pyrazole-1-carbothioamide 45. IR ν, cm^{-1}: 3319 (NH); 2920 (CH); 1640 (C=N); 1348 (C=S); 1115 (C-N). ^{1}H NMR δ, ppm, *J*/Hz: 3.15 dd (1H, CH_2, *J* 3.2 Hz, *J* 18.4 Hz), 3.74 s, 3.81 s (6H, 2MeO), 3.91 dd (1H, CH_2, *J* 11.2 Hz, *J* 18.4 Hz), 5.98 dd (1H,

CHCH$_2$, *J* 3.2 Hz, *J* 11.2 Hz), 6.84-7.97 m (12H, ArH), 10.21 s (1H, NH), 14.56 s (1H, SH). ^{13}C NMR, δ, ppm: 42.75, 55.41, 55.76, 63.13, 114.28, 114.51, 118.20, 123.52, 124.39, 126.29, 127.17, 129.65, 134.71, 143.57, 156.17, 158.81, 160.81, 161.99, 172.61, 177.79. Found, %: C 60.36; H 4.49; N 13.51. Calculated, %: C 60.33; H 4.48; N 13.53.

5-(3,4-Dimethoxyphenyl)-N-(4-(5-mercapto-1,3,4-oxadiazol-2-yl)phenyl)-3-phenyl-4,5-dihydro-1H-pyrazole-1-carbothioamide 46. IR ν, cm^{-1}: 3325 (NH); 2842 (CH); 1607 (C=N); 1392 (C=S); 1042 (C-N). ^{1}H NMR δ, ppm, *J*/Hz: 3.44 dd (1H, CH$_2$, *J* 3.2 Hz, *J* 18.0 Hz), 3.74 s, 3.77 s (6H, 2MeO), 3.93 dd (1H, CH$_2$, *J* 11.2 Hz, *J* 18.0 Hz), 6.00 dd (1H, CHCH$_2$, *J* 3.2 Hz, *J* 11.2 Hz), 6.67-7.97 m (12H, ArH), 10.24 s (1H, NH), 14.24 s (1H, SH). ^{13}C NMR, δ, ppm: 42.69, 55.95, 55.98, 63.44, 110.51, 112.51, 117.63, 118.36, 124.38, 126.27, 127.77, 128.92, 131.04, 131.12, 135.08, 143.43, 148.58, 149.44, 156.06, 160.75, 173.20, 177.81. Found, %: C 60.32; H 4.47; N 13.58. Calculated, %: C 60.33; H 4.48; N 13.53.

3-(3,4-Dichlorophenyl)-5-(3,4-dimethoxyphenyl)-N-(4-(5-mercapto-1,3,4-oxadiazol-2-yl)phenyl)-4,5-dihydro-1H-pyrazole-1-carbothioamide 47. IR ν, cm^{-1}: 3329 (NH); 2874 (CH); 1631 (C=N); 1368 (C=S); 1109 (C-N). ^{1}H NMR δ, ppm, *J*/Hz: 3.35 dd (1H, CH$_2$, *J* 3.44 Hz, *J* 18.3 Hz), 3.69 s, 3.73 s (6H, 2MeO), 3.78 dd (1H, CH$_2$, *J* 11.2 Hz, *J* 18.3 Hz), 6.24 dd (1H, CHCH$_2$, *J* 3.44 Hz, *J* 11.2 Hz), 6.88-8.35 m (10H, ArH), 10.49 s (1H, NH), 14.56 s (1H, SH). ^{13}C NMR, δ, ppm: 45.33, 55.94, 55.98, 64.05, 110.51, 112.58, 114.30, 125.46, 126.56, 128.25, 128.58, 129.38, 131.94, 132.30, 133.71, 135.08, 143.50, 148.51, 149.34, 154.54,160.91, 172.43, 177.86. Found, %: C 53.21; H 3.64;N 11.98. Calculated, %: C 53.24; H 3.61;N 11.94.

3-(2,4-Dichlorophenyl)-5-(3,4-dimethoxyphenyl)-N-(4-(5-mercapto-1,3,4-oxadiazol-2-yl)phenyl)-4,5-dihydro-1H-pyrazole-1-carbothioamide 48. IR ν, cm^{-1}: 3320 (NH); 2915 (CH); 1631 (C=N); 1376 (C=S); 1195 (C-N). ^{1}H NMR δ, ppm, *J*/Hz: 3.23 dd (1H, CH$_2$, *J* 3.8 Hz, *J* 18.7 Hz), 3.71 s, 3.81 s (6H, 2MeO), 4.04 dd (1H, CH$_2$, *J* 11.6 Hz, *J* 18.7 Hz), 6.21 dd (1H, CHCH$_2$, *J* 3.8 Hz, *J* 11.6 Hz), 7.02-8.13 m (10H, ArH), 10.42 s (1H, NH), 14.74 s (1H, SH). ^{13}C NMR, δ, ppm: 41.09, 56.13, 56.30, 61.39, 110.89, 111.95, 118.70, 122.22, 126.60, 129.13, 129.57, 132.09, 132.82, 138.92, 143.51, 149.37, 152.11, 156.87, 158.56, 158.93, 160.89, 163.37, 172.41, 177.83. Found, %: C 53.25; H 3.63;N 11.89. Calculated, %: C 53.24; H 3.61;N 11.94.

4-Hydroxy-N-(3-(5-mercapto-1,3,4-oxadiazol-2-yl)phenyl)-3,5-bis(4-methoxyphenyl)-4,5-dihydro-1H-pyrazole-1-carbothioamide 49. IR ν, cm^{-1}: 3587 (OH); 3289 (NH); 2914 (CH); 1638 (C=N); 1377 (C=S); 1042 (C-N). ^{1}H NMR δ, ppm, *J*/Hz: 3.74 s, 3.84 s (6H, 2MeO), 4.89 s (1H, CHCHOH), 5.64 s (1H, CHCHOH), 6.75-8.25 m (12H, ArH), 10.24 s (1H, NH), 14.55 s (1H, SH). ^{13}C NMR, δ, ppm: 49.11, 55.34, 72.56, 81.27, 114.33, 122.18, 122.31, 122.85, 126.91, 127.11, 128.35, 129.03, 129.84, 131.27, 140.88, 155.96, 158.90, 160.61, 161.66, 173.70, 178.02. Found, %: C 58.51; H 4.32; N 13.14. Calculated, %: C 58.52; H 4.34; N 13.12.

4-Hydroxy-N-(3-(5-mercapto-1,3,4-oxadiazole-2-yl)phenyl)-5-(4-methoxyphenyl)-3-p-tolyl-4,5-dihydro-1H-pyrazole-1-carbothioamide 50. IR ν, cm^{-1}: 3498 (OH); 3342 (NH); 2918 (CH); 1637 (C=N); 1372 (C=S); 1098 (C-N). ^{1}H NMR δ, ppm, *J*/Hz: 2.37 s (3H, Me), 3.75 s (3H, MeO), 4.91 s (1H, CHCHOH), 5.65 s (1H, CHCHOH), 6.84-8.24 m (12H, ArH), 10.32 s (1H, NH), 14.68 s (1H, SH). ^{13}C NMR, δ, ppm: 21.67, 55.29, 72.65, 81.06, 114.37, 122.31, 122.53, 122.78, 125.49, 126.89, 127.73, 128.15, 128.66, 129.13, 129.44, 131.16, 140.56, 140.85, 156.05, 158.90, 160.62, 173.95, 177.97. Found, %: C 60.37; H 4.46; N 13.54. Calculated, %: C 60.33; H 4.48; N 13.53.

4-Hydroxy-N-(4-(5-mercapto-1,3,4-oxadiazol-2-yl)phenyl)-3,5-bis(4-methoxyphenyl)-4,5-dihydro-1H-pyrazole-1-carbothioamide 51. IR ν, cm^{-1}: 3560 (OH); 3302 (NH); 2871 (CH); 1645 (C=N); 1354 (C=S); 1100 (C-N). ^{1}H NMR δ, ppm, *J*/Hz: 3.70 s, 3.80 s (6H, 2MeO), 4.98 d (1H, CHCHOH, *J* 1.2 Hz), 5.65 d (1H, CHCHOH, *J* 1.2 Hz), 6.90 d (2H, ArH, *J* 1.6 Hz), 7.02-7.07 m (4H, ArH), 7.85 d (2H, ArH, *J* 7.2 Hz), 7.92 d (2H, ArH, *J* 7.2 Hz), 8.00 d (2H, ArH, *J* 9.2 Hz), 10.48 s (1H, NH), 14.72 s (1H, SH). ^{13}C NMR, δ, ppm: 55.57, 55.90, 72.69, 80.79, 114.65, 114.72, 118.51, 120.85, 122.60, 125.09, 126.56, 127.11, 130.11, 131.02, 143.54, 156.53, 158.99, 160.92, 161.85, 163.39, 172.43, 173.35, 177.81. Found, %: C 58.55; H 4.36; N 13.09. Calculated, %: C 58.52; H 4.34; N 13.12.

4-Hydroxy-N-(4-(5-mercapto-1,3,4-oxadiazole-2-yl)phenyl)-5-(4-methoxyphenyl)-3-p-tolyl-4,5-dihydro-1H-pyrazole-1-carbothioamide 52. IR ν, cm^{-1}: 3396 (OH); 3314 (NH); 2876 (CH); 1645 (C=N); 1362 (C=S); 1070 (C-N). ^{1}H NMR δ, ppm, *J*/Hz: 2.33 s (3H, Me), 3.69 s (3H, MeO), 4.98 d (1H, CHCHOH, *J* 1.2 Hz), 5.66 d (1H, CHCHOH, *J* 1.2 Hz), 6.90 d, 7.06 d, 7.29 d (6H, ArH, *J* 8.0 Hz), 7.84-7.97 m (6H, ArH), 10.51 s (1H, NH), 14.71 s (1H, SH). ^{13}C NMR, δ, ppm: 21.57, 55.56, 72.75, 80.67, 114.67, 118.60, 125.23, 126.57, 127.11, 127.47, 128.29, 129.78, 130.98, 141.23, 143.49, 156.63, 159.01, 160.91, 172.47, 173.63, 177.83. Found, %: C 60.35; H 4.47; N 13.56. Calculated, %: C 60.33; H 4.48; N 13.53.

5. References

[1]. Rahman, Md. A.; Siddiqui, A. A. International J. Pharm. Sciences and Drug Research. 2010, 2, 165-175.
[2]. Abdul, L.; Fareeda, A.; Amir, A. European Journal of Medicinal Chemistry. 2009, 44, 426-431.
[3]. Karabasanagouda, T.; Airody, V. A.; Girisha, M. Indian J. Chem. 2009, 48B, 430-437.
[4]. Solankee, A.; Lad, S.; Solankee, S.; Patel, G. Indian J. Chem. 2009, 48B, 1442-1446.

[5]. Navarrete-Vázquez, G.; Molina-Salinas, G.; Duarte-Fajardo, Z.; Vargas-Villarreal, Z.; Estrada-Soto, S.; González- Salazar, F.; Hernández-Núñez, E.; Said-Fernández, S. Bioorganic & Medicinal Chemistry. 2007, 15, 5502-5508.
[6]. Holla, B. S.; Akberali, P. M.; Shivananda, M. K. II Farmaco. 2000, 55, 256-263.
[7]. Palaska, E.; Erol, D.; Demirdamar, R. Eur. J. Med. Chem. 1996, 31, 43-47.
[8]. Joshi, K. C.; Dandia, A.; Bhegat, S. J. Indian Chem. Soc. 1990, 67, 753-756.
[9]. Bayoumy, B. E.; El-Bahie, S.; El-Mobayed, M.; Abd El-Atif, G. Revue Roumaine de Chimie. 1993, 33, 701-706.
[10]. El-Hashashi, M. A.; Soliman, F. M. A.; Souka, L. M. A.; Salman, A. S. S. Revue Roumaine de Chimie. 1995, 40, 59-66.
[11]. Turan-Zitouni, G.; Chevallet, P.; Kilic, F. S.; Erol, K. Eur. J. Med. Chem. 2000, 35, 635-641.
[12]. Lorand, T.; Kocsis, B.; Emody, L.; Sohar, P. Eur. J. Med. Chem. 1999, 34, 1009-1018.
[13]. Duggan, A. J. US Patent 4767779.
[14]. Kumar, S.; Turk. J. Chem. 2011, 35, 99-108.
[15]. Rajasekaran, S.; Rao, G. K.; Sanjay, Pai P. N.; Vedavathy, J. J. Chem. Pharm. Res. 2010, 2, 101-106.
[16]. Kumar, S. J. Chil. Chem. Soc. 2010, 55, 126-129.
[17]. Zarghi, A.; Hamedi, S.; Tootooni, F.; Amini, B.; Sharifi, B.; Faizi, M.; Tabatabai, S. A.; Shafiee, A. Sci Pharm. 2008, 76, 185-201.
[18]. Bharathi, D.; Hemalatha, S.; Devadass, G.; Kumar, P. R.; Shanmugasundaram, P.; Aanandhi, M. V. International J. Chem.Tech. Research. 2010, 2, 1867-1870.
[19]. Rajak, H.; Kharya, M. D.; Mishra, P. 2009, 2, 390-406.
[20]. Husain, A.; Ajmal, M. Acta Pharm. 2009, 59, 223-233.
[21]. Bhardwaj, N.; Saraf, S. K.; Sharma, P.; Kumar, P. E-Journal of Chemistry. 2009, 6, 1133-1138.
[22]. Maslat, A. O.; Abussaud, M.; Tashtoush, H.; Al-Talib, M. Pol. J. Pharmacol. 2002, 54, 55-59.
[23]. Omar, F. A.; Mahfouz, N. M.; Rahman, M. A. Eur. J. Med. Chem. 1996, 31, 819-825.
[24]. Goswami, B. N.; Kataky, J. C. S.; Baruash, J. N. J. Heterocycl. Chem. 1984, 21, 205-208.
[25]. Beriger, E.; Echardt, W. Eur. Pat. Appl. Ep. 1990, 364, 396.
[26]. Brakhite, E.; Mohammed, T.; Rahman, A. J. Chem. Technol. Biotechnol. 1992, 55, 157-161.
[27]. Dabhi, T.; Shah, V.; Parikh, A. Indian J. Pharm. Studies. 1992, 54, 98–100.
[28]. Dubey, A.; Sangwan, N. Indian J. Chem. Sect. B, 1994, 33, 1043–1047.
[29]. Girges, M. M. Arzneim. Forsch.-Drug Res. 1994, 44, 490–495.
[30]. Hanna, M.; Girges, M.; Rasala, D.; Gawineck, R. Arzneim. Forsch.-Drug Res. 1995, 54–2, 1074–1078.
[31]. Hiremath, U.; Yelamaggad, C.; Badmal, B.; Puranik, G. J. Chem. Res. 1994, 12, 502–503.
[32]. Ladva, K.; Partel, P.; Upadhyay, P.; Parekh, H. Indian J. Chem. Sect. B, 1996, 35, 1062–1066.
[33]. Mullican, M.; Wilton, D.; Conner, D.; Kostlan, C. J. Med. Chem. 1993, 36, 1090-1099.
[34]. Omar, F.A.; Mahfouz, N. M.; Rahman, M. A. Eur. J. Med. Chem. 1996, 31, 819-825.
[35]. Papakonstantinou, G. S.; Markos, P.; Tsantili, K. A.; Chytyroglon, L. A. Pharmazie. 1998, 53, 300–302.
[36]. Rani, H. S.; Mogilaiah, K.; Rao, J. S.; Sreenivasulu, B. Indian J. Chem. Sect. B, 1996, 53, 745–747.
[37]. Santagati, M.; Modica, M.; Santagati, A.; Russo, F.; Caruso, A. Pharmazie. 1994, 49, 880–884.
[38]. Shafi, S. S.; Radhakrishnan, T. R. Indian J. Heterocycl. Chem. 1995, 5, 133–138.
[39]. Shah, V. R.; Vadodaria, M.; Parikh, A. R. Indian J. Chem. 1997, 36, 101-103.
[40]. Takayama, H.; Shirakawa, S.; Kitajima, M.; Aimi, N. Bioorg. Medicinal Chem. Letter. 1996, 6, 1993–1996.
[41]. Talawr, M. B.; Dejai, S. R.; Sommanavar, Y. S.; Marihal, S. C.; Bennur, S. C. Indian J. Heterocycl. Chem. 1996, 5, 215–218.
[42]. Vashi, B. S.; Mehta, D. S.; Shah, V. H. Indian J. Chem. Sect. B. 1996, 35, 111–115.
[43]. Kadi, A. A.; El-Brollosy, N. R.; Al-Deeb, O. A.; Habib, E. E.; Ibrahim, T. M.; El-Emam, A. A. European Journal of Medicinal Chemistry. 2007, 42, 235-242.
[44]. Jha, K. K.; Kumar, Y.; Shaharyar, M.; Singhal, S. Der Pharma Chemica. 2009, 1, 178-184.
[45]. Macaev, F.; Rusu, G.; Pogrebnoi, S.; Gudima, A.; Stingaci, E.; Vlad, L.; Shvets, N.; Kandemirli, F.; Dimoglo, A. and Reynolds, R. Bioorganic & Medicinal Chemistry. 2005, 13, 4842-4850.
[46]. Manowitz, M.; Walter, G. J. Pharm. Sci. 1965, 54, 650.
[47]. Bauer, D. J.; Sadler, P. W. British J. Pharmacol. 1960, 15, 101-110.
[48]. Dhar, D. N. The chemisrty of chalcones and related compounds; Wiley: NY, 1981.
[49]. Rasheed, R.; Mansoor, H.; Yousif, E.; Hameed, A.; Farina, Y.; Graisa, A. European Journal of Scientific Research. 2009, 30, 464-477.
[50]. Safieh, K. A. A.; Al-Titi, A. M. S.; Zahra, J. A.; Ayoub, M. T. Jordan Journal of Chemistry. 2007, 2, 211-218.
[51]. Padmavathi, V.; Reddy, G. S.; Mohan, A. V. N.; Mahesh, K. ARKIVOC. 2008, 12, 48-60.
[52]. Koparır, M.; Cetin, A.; Cansız, A. Moleciles. 2005, 10, 475-480.

[53]. Sharma, S.; Gangal, S.; Rauf, A. Acta Chim. Slov. 2009, 56, 369–372.
[54]. Kilburn, John P.; Jesper, Lau and Raymond, Jones C. F. Tetrahedron Letters. 2001, 42, 2583-2586.
[55]. Kiss-Szikszai, A.; Patonay, T.; Jeko, J. ARKIVOC. 2001, 3, 40-50.
[56]. Patsenker, L. D.; Ermolenko, I. G.; Fedyunyaeva, I. A.; Popova, N. A.; Krasovitskii, B. M. Chem. Heterocycl. Compd. (Engl. Transl.). 2000, 36, 623-625.
[57]. Pogorelova, N. V.; Patsenker, L. D.; Lokshin, A. I. Functional Materials. 2000, 7, 132–137.
[58]. Patsenker, L. D.; Surov, Yu. N.; Lokshin, A. I.; Shkumat, A. P. Russ. J. Gen. Chem. (Engl. Transl.). 1999, 69, 1810-1816.
[59]. Patsenker, L. D.; Baumer, V. N.; Kuznetsov, V. P. Functional Materials. 1999, 6, 110–115.
[60]. Kuznetsov, V. P.; Patsenker, L. D.; Lokshin, A. I.; Tolmachev, A. V. Functional Materials. 1996, 3, 460–469.
[61]. Patsenker, L. D.; Lysova, I. V.; Afanasiadi, L. Sh.; Kopina, I. V.; Galunov, N. Z.; Gunder, O. A. Functional Materials. 1996, 3, 535–542.
[62]. Yamashita, H.; Okumura, K.; Iuzuka, H.; Ohto, N. US Patent 4895947.
[63]. Gupta, R.; Gupta, N.; Jain, A. Indian Journal of Chemistry. 2010, 49B, 351-355.
[64]. Azarifar, D.; Ghasemnejad, H. Molecules. 2003, 8, 642-648.
[65]. Afsah, E. M.; Kandeel, Ez-el-Din M.; Khalifa M. M.; Hammouda, W. M. Z. Naturforsch. 2007, 62b, 540-548.
[66]. Wasserman, H. H.; Aubery, N. E. J. Amer. Chem. Soc. 1955, 77, 590.
[67]. El-Hashash, M. A.; El-Kady, M. Revue Roumaine de Chimie. 1978, 23, 1581-1588.
[68]. Saleh, R. M.; Soliman, A. Y.; Soliman, M. A. Revue Roumaine de Chimie. 1991, 36, 1337-1343.
[69]. Geronikaki, A.; Babaev, E.; Dearden, J.; Dehaen, W.; Filimonov, D.; Galaeva, I.; Krajneva, V.; Lagunin, A.; Macaev, F.; Molodavkin, G.; Poroikov, V.; Pogrebnoi, S.; Saloutin, V.; Stepanchikova, A.; Stingaci, E.; Voronina, T.; Vlad, L. Bioorganic & Medicinal Chemistry. 2004, 12, 6559-6568.
[70]. Macaev, F.; Pogrebnoi, S.; Vlad, L.; Stingaci, E. Buletinul Academiei de Ştiinţe a Moldovei. Ştiinţe, Biologice, Chimice şi Agricole. 2003, 2, 124-127.
[71]. Pogrebnoi, S. Cercetări în domeniul chimiei. Realizări şi perspective; Î.E.P. Ştiinţa: Chişinău, 2003; 2; pp 106-109.
[72]. Pogrebnoi, S. Cercetări în domeniul chimiei. Realizări şi perspective; Î.E.P. Ştiinţa: Chişinău, 2003; 2; pp 110-112.
[73]. Gudima, A.; Pogrebnoi, S.; Pogrebnoi, I.; Barba, A.; Panasenco, A.; Vlad, L.; Stingaci, E.; Macaev, F. Analele Ştiinţifice ale Universităţii de Stat din Moldova. 2002, 322-323.
[74]. Macaev, F. Z.; Stingaci, E. P.; Vlad, L. A.; Pogrebnoi, S. I. MD Pat. №2557, //BOPI, - 2004. №9, p. 38-39.
[75]. Piozzi, F.; Fugant, C. Ann. Chim. 1966, 56, 1248-1250. Chem. Abstr. 1967, 67, 73473.
[76]. Cromwell, N. H.; Martin, J. T. J. Org. Chem. 1968, 33, 1860-1866.
[77]. Cromwell, N. H.; Schunachere, F. H.; Adelfang, J. L. J. Amer. Chem. Soc. 1961, 83, 974.
[78]. Siddiqui, N.; Alam, P.; Ahsan, W. Arch. Pharm. Chem. Life Sci. 2009, 342, 173-181.
[79]. Rusu, G. G.; Gutu, E. E.; Barba, N. A. Russ. J. Org. Chem. 1995, 31, 1721.
[80]. Агрономов, А. Е.; Шабаров, Ю. С. Лабораторные работы в органическом практикуме; Химия: М., 1974; 2; pp 214.