Indian Journal of Chemistry
Vol. 49B, January 2010, pp. 89-95

# Synthesis and biological screening of some halogenated thiadiazoles and triazoles

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*Received 9 July 2009; accepted (revised) 9 September 2009*

Acid hydrazide **1** is treated with aryl isothiocyanates to get corresponding thiosemicarbazides **2**. Compounds **2** in acidic medium give thiadiazoles **3** and in basic medium give triazoles **4**. These compounds are synthesized by conventional method and ultra sound irradiation method. Some of the synthesized compounds are tested for their antimicrobial, antiviral and antioxidant activities.

**Keywords**: Ultrasonication, fluorine, chlorine, thiosemicarbazides, thiadiazoles, triazoles

In recent days active research has been initiated on halogen containing heterocycles. A number of fluoro and perfluoroalkyl substituted pharmaceuticals, agrochemicals, dyes and polymers have been commercialized. Fluorine containing heterocycles are very fascinating targets for synthetic organic chemists because of their potentially high physiological activities[1]. Fluorine containing organic compounds are associated with antimicrobial[2], antitumor[3], antibacterial[4] and anticancer[5] activities. They also act as selective inhibitors of biosynthesis of aminergic neurotransmitters[6].

Activity of all agrochemicals depends on their toxicity. The toxicity of chemical entity is related to substitutions like halogen, sulfur, phosphorus and nitrile groups. Nowadays number of herbicides and insecticides[7-10] are commercially available which proves the above fact. The chlorinated organic compounds like picloram, pyrichlor, erbon, chlorpyrifos etc are proved to be good herbicides and insecticides. The chlorine containing heterocycles are associated with antibacterial and insecticidal activities[11]. Chloro-pyridines are used in pharmaceutical and agrochemical industries[12].

Thiosemicarbazides are associated with important biological activities and industrial applications. Thiosemicarbazides are found to show antibacterial, antifungal[13], plant growth promoting[14], anticonvulsant[15] and antiviral[16] activities.

Compounds containing 1,3,4-thiadiazole nucleus has been reported with variety of biological activities such as antimicrobial[17,18], antitubercular[17,19] and anticancer activity[17].

Triazoles are an important class of heterocyclic compounds. Triazoles are known for their fungicidal[20], pesticidal[21] and antimycotic[22] activities.

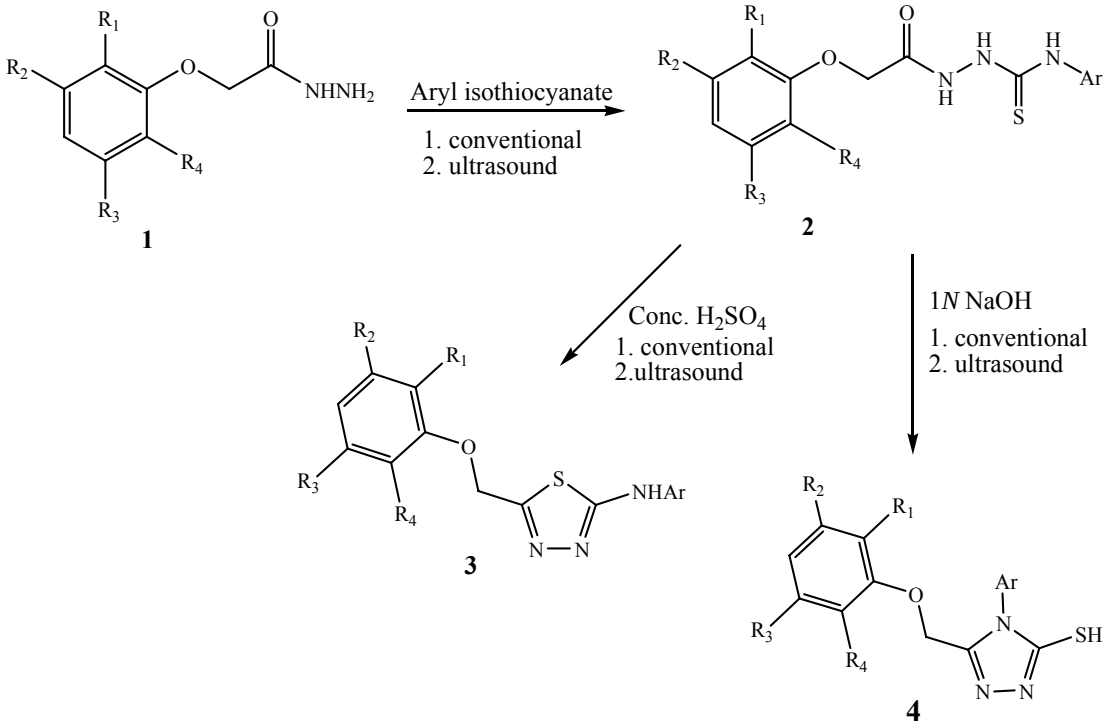
Holla *et al*. have reported the synthesis of thiadiazoles and triazoles by conventional method[23-25]. Now-a-days one pot reactions[26] are gaining prominence due to their environmental advantages and cost effectiveness. Similarly, application of ultrasound[27] in chemistry is reaching a stage of importance because of its proven ability to accelerate even very robust transformations[28].

Biological activities associated with fluorine, chlorine and azoles prompted us to synthesize these compounds by conventional and non-conventional method (**Scheme I**, **Table I**) and to screen them for various biological activities.

## Biological activities

### Antimicrobial activity

Synthesized compounds were screened for their antifungal and antibacterial activities. The *in vitro* antimicrobial activities of the synthesized compounds were assessed against fungi and bacteria. The fungi used were *C. albicans* and *A. fumigatus*. The bacteria used were *S. aureus* and *E. coli.*




**Scheme I**

**Table I** — Characterization data for compounds **2a-j, 3a-j** and **4a-j**

| Compd | $R_1$ | $R_2$ | $R_3$ | $R_4$ | Ar | m.p. (°C) | Conventional | | Ultrasound | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Time (min) | Yield (%) | Time (min) | Yield (%) |
| **2a** | H | Cl | Cl | H | Phenyl | 159 | 45 | 78 | 22 | 90 |
| **2b** | H | Cl | Cl | H | 2-methylphenyl | 105 | 45 | 79 | 18 | 91 |
| **2c** | H | Cl | Cl | H | 3-methylphenyl | 164 | 45 | 75 | 18 | 89 |
| **2d** | H | Cl | Cl | H | 4-methylphenyl | 182 | 45 | 77 | 20 | 88 |
| **2e** | H | Cl | Cl | H | 3-methoxyphenyl | 160 | 45 | 70 | 22 | 85 |
| **2f** | F | F | F | F | Phenyl | 170 | 45 | 70 | 22 | 86 |
| **2g** | F | F | F | F | 2-methylphenyl | 129 | 45 | 73 | 19 | 85 |
| **2h** | F | F | F | F | 3-methoxyphenyl | 149 | 45 | 69 | 22 | 82 |
| **2i** | F | F | F | F | 4-methylphenyl | 187 | 45 | 78 | 21 | 89 |
| **2j** | F | F | F | F | 4-methoxyphenyl | 169 | 45 | 76 | 22 | 87 |
| **3a** | H | Cl | Cl | H | Phenyl | 179 | 180 | 55 | 20 | 78 |
| **3b** | H | Cl | Cl | H | 2-methylphenyl | 148 | 180 | 70 | 18 | 80 |
| **3c** | H | Cl | Cl | H | 3-methylphenyl | 156 | 180 | 65 | 22 | 88 |
| **3d** | H | Cl | Cl | H | 4-methylphenyl | 192 | 180 | 68 | 20 | 86 |
| **3e** | H | Cl | Cl | H | 3-methoxyphenyl | 172 | 180 | 71 | 22 | 85 |
| **3f** | F | F | F | F | Phenyl | 300 | 180 | 58 | 20 | 75 |
| **3g** | F | F | F | F | 2-methylphenyl | 284 | 180 | 65 | 24 | 80 |
| **3h** | F | F | F | F | 3-methoxyphenyl | 265 | 180 | 68 | 20 | 79 |
| **3i** | F | F | F | F | 4-methylphenyl | 283 | 180 | 66 | 18 | 85 |
| **3j** | F | F | F | F | 4-methoxyphenyl | 255 | 180 | 58 | 22 | 89 |

—*Contd*

**Table I** — Characterization data for compounds **2a-j, 3a-j** and **4a-j**—*Contd*

| Compd | $R_1$ | $R_2$ | $R_3$ | $R_4$ | Ar | m.p. (°C) | Conventional | | Ultrasound | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Time (min) | Yield (%) | Time (min) | Yield (%) |
| **4a** | H | Cl | Cl | H | Phenyl | 169 | 90 | 58 | 30 | 78 |
| **4b** | H | Cl | Cl | H | 2-methylphenyl | 200 | 90 | 60 | 29 | 80 |
| **4c** | H | Cl | Cl | H | 3-methylphenyl | 181 | 90 | 57 | 28 | 83 |
| **4d** | H | Cl | Cl | H | 4-methylphenyl | 185 | 90 | 48 | 32 | 85 |
| **4e** | H | Cl | Cl | H | 3-methoxyphenyl | 177 | 90 | 55 | 35 | 88 |
| **4f** | F | F | F | F | Phenyl | 300 | 90 | 50 | 32 | 75 |
| **4g** | F | F | F | F | 2-methylphenyl | 284 | 90 | 51 | 35 | 78 |
| **4h** | F | F | F | F | 3-methoxyphenyl | 265 | 90 | 54 | 34 | 79 |
| **4i** | F | F | F | F | 4-methylphenyl | 283 | 90 | 57 | 35 | 86 |
| **4j** | F | F | F | F | 4-methoxyphenyl | 255 | 90 | 58 | 32 | 84 |

**Table II** — Antimicrobial activity of **2a-e** and **4a-d** – Zone of inhibition in mm

| Compd | Conc. (μg/mL) | Antifungal Test | | Antibacterial Test | | Remark |
|---|---|---|---|---|---|---|
| | | *C. albicans* ATCC 14503 | *A. fumigatus* ATCC 16424 | *S. aureus* 209P | *E. coli* ATCC 25922 | |
| **2a** | 100 | - | - | - | - | inactive |
| | 1000 | - | 14hr | 15 | - | activity in both indication |
| **2b** | 100 | - | - | - | - | inactive |
| | 1000 | - | 13hr | 17 | - | activity in both indication |
| **2c** | 100 | - | - | 9 | - | poor antibacterial spectrum |
| | 1000 | - | - | 16 | - | poor antibacterial spectrum |
| **2d** | 100 | - | 10hr | 10 | - | activity in both indication |
| | 1000 | - | 11hr | 15 | - | activity in both indication |
| **2e** | 100 | - | - | - | - | inactive |
| | 1000 | - | 12hr | 11hr | - | activity in both indication |
| **4a** | 100 | - | - | - | - | inactive |
| | 1000 | - | - | 13 | - | poor antibacterial spectrum |
| **4b** | 100 | - | - | 9 | - | poor antibacterial spectrum |
| | 1000 | - | - | 18 | - | poor antibacterial spectrum |
| **4c** | 100 | - | - | 51hr | - | poor antibacterial spectrum |
| | 1000 | - | - | 18hr | - | poor antibacterial spectrum |
| **4d** | 100 | - | - | 9 | - | poor antibacterial spectrum |
| | 1000 | - | - | 18hr | - | poor antibacterial spectrum |
| Vancomycin (10 μg/mL) | | NT | NT | 15 | 14 | - |
| Amphotericin B (20 μg/mL) | | 22 | 24 | NT | NT | - |

NT: Not tested, h: hazy, slh: slightly hazy. Compounds **2g-j** and **3a-j** are inactive.

Amphotericin B and vancomycin were used as standards for comparison for antifungal and antibacterial activities respectively. The activities were determined by measuring the diameter of the inhibition zone in mm.

None of the compounds is a suitable candidate for antifungal and antibacterial indication as shown in **Table II**.

**Antiviral activity**

The antiviral activity of some of the compounds was determined against *Herpes Simplex virus-2* by CPE inhibition assay. Vero cells (African green monkey kidney cell line-ATCC CCL-81) were cultivated as monolayers in 5% carbon dioxide at 37°C, in Dulbecco's modified Eagle medium (MEM) with 5% fetal bovine serum (FBS).

**Table III** — Antiviral activity of **2a-e, 2g-j, 3a-g, 3i-j** and **4a-e**

| Compd | % CPE inhibition | Compd | % CPE inhibition | Compd | % CPE inhibition |
|---|---|---|---|---|---|
| **2a** | - | **2j** | - | **3j** | - |
| **2b** | - | **3a** | - | **4a** | - |
| **2c** | - | **3b** | - | **4b** | - |
| **2d** | - | **3d** | - | **4c** | - |
| **2e** | - | **3e** | - | **4d** | - |
| **2g** | + | **3f** | - | **4e** | + |
| **2h** | - | **3g** | - | | |
| **2i** | + | **3i** | - | | |

Standard Famciclovir (10 µg/mL)
Scoring: - 0-25%, ++ 26-50%, +++ 51-75%, ++++ 76-100%
Samples **2g**, **2i** and **4e** were considered as positive and selected for dose response study.

**Table IIIa** — Evaluation of primary positives by dose dependent study

| Compd | Anti-HSV-2 activity (%CPE inhibition) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1.56 µg/mL | 3.12 µg/mL | 6.25 µg/mL | 12.5 µg/mL | 25 µg/mL | 50 µg/mL | 100 µg/mL | 200 µg/mL |
| **2g** | - | - | - | - | - | + | - | - |
| **2i** | - | - | - | - | - | + | - | - |
| **4e** | - | - | - | - | - | + | + | + |

Scoring: - 0-25%, ++ 26-50%, +++ 51-75%, ++++ 76-100%
Compound **4e** get precipitated at higher concentrations. Compounds **2g** and **2i** showed no dose dependent activity.

The diluted extracts (100 g/mL) were transferred to the aspirated Vero cell monolayers. Cultures were incubated at 37°C for 60 minutes. 100 µL of virus (100 $TCID_{50}$) was added to each well. The tray was transferred to an environmental chamber (37°C).

Cultures were inspected periodically for virus-induced cytopathic effect (viral CPE). Absence of CPE indicated complete inactivation of the virus. Partial inhibition was considered to be a negative result. Some of the synthesized compounds were found to be active as shown in **Table III** and **Table IIIa**.

**Antioxidant activity**

The antioxidant activity of some of the synthesized compounds was determined by DPPH method using Trolox as a reference standard. Amongst the compounds screened for antioxidant activity, some of the synthesized compounds were found to be active as shown in **Tables IV, IVa** and **IVb**.

**Results and Discussion**

To prepare the targeted compounds, the required acid hydrazides **1** were prepared from corresponding phenoxy esters by treating them with hydrazine hydrate. Acid hydrazides **1** were treated with aryl isothiocyanates to get corresponding thiosemicarbazides **2**. Compounds **2** under acidic condition get cyclised to give thiadiazoles **3** and under basic condition to give triazoles **4**. The structures of the synthesized compounds were confirmed by spectral analysis (IR, $^1$H NMR and mass). The IR spectrum of compound **2a** showed a peak at 3331 $cm^{-1}$ due to –NH stretch. In $^1$H NMR spectrum it exhibited three singlets, one at δ 4.72 due to $–CH_2$, second at 9.65 due to two –NH protons and third at 10.25 due to one –NH proton. Mass spectrum was consistent with the assigned structure.

As expected the $^1$H NMR spectrum of compound **3a** showed singlet at δ 10.40 due to –NH proton while another singlet at δ 9.65 due to two –NH protons get disappeared due to the cyclisation of thiosemicarbazide into thiadiazole. Similarly, the $^1$H NMR spectrum of compound **4a** showed deshielded singlet at δ 11.23 attributed to –SH proton. The IR and mass spectral data of **3a** and **4a** were consistent with the assigned structures.

Some of the synthesized compounds were tested for their antimicrobial, antiviral and antioxidant

**Table IV** — Antioxidant activity of **2a-e, 2g-j, 3a-g, 3i-j** and **4a-e**
(Primary screening data of DPPH assay with test Conc. 125 µg/mL)

| Compd | % AO activity | Compd | % AO activity | Compd | % AO activity |
|---|---|---|---|---|---|
| **2a** | 92.52 | **2j** | 90.60 | **3j** | -9.23 |
| **2b** | 92.71 | **3a** | -3.08 | **4a** | 73.29 |
| **2c** | 92.66 | **3b** | -2.22 | **4b** | 70.76 |
| **2d** | 92.55 | **3d** | 11.85 | **4c** | 90.88 |
| **2e** | 92.52 | **3e** | 3.87 | **4d** | 76.60 |
| **2g** | 92.24 | **3f** | -14.10 | **4e** | 87.80 |
| **2h** | 92.38 | **3g** | -12.39 | | |
| **2i** | 92.40 | **3i** | -13.87 | | |

Compounds **2a-j** and **4a-e** were found to be active in primary screening and were further tested in a dose dependent manner using DPPH assay

**Table IVa** — Evaluation of primary positives by dose dependent DPPH assay

| Compd | Test Conc. (µg/mL) | | | | Compd | Test Conc. (µg/mL) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **62.5** | **31.25** | **15.6** | **7.3** | | **62.5** | **31.25** | **15.6** | **7.3** |
| **2a** | 91.95 | 90.60 | 65.62 | 35.35 | **2i** | 91.74 | 90.18 | 63.78 | 35.80 |
| **2b** | 89.94 | 80.66 | 53.69 | 43.48 | **2j** | 90.39 | 89.40 | 61.26 | 8.98 |
| **2c** | 91.62 | 89.46 | 61.08 | 32.13 | **4a** | 61.67 | 45.31 | 27.62 | 16.11 |
| **2d** | 91.79 | 90.60 | 67.65 | 36.64 | **4b** | 55.19 | 39.72 | 26.48 | 17.13 |
| **2e** | 91.64 | 90.03 | 65.22 | 36.08 | **4c** | 61.67 | 45.31 | 27.62 | 16.11 |
| **2g** | 90.72 | 81.98 | 45.02 | 29.16 | **4d** | 55.19 | 39.74 | 26.54 | 16.12 |
| **2h** | 91.59 | 89.82 | 58.62 | 23.90 | **4e** | 64.66 | 46.51 | 27.81 | 16.39 |

Compounds **2a, 2c, 2d, 2e, 2h, 2i, 2j,** were found active in dose dependent DPPH assay. These were further tested using riboflavin-methionine assay.

**Table IVb** — Evaluation by riboflavin-methionine assay. (% SOD activity)

| Compd | Test Conc. (µg/mL) | | | |
|---|---|---|---|---|
| | **250** | **125** | **62.5** | **31.25** |
| **2a** | 37.943 | 32.933 | 37.742 | 25.785 |
| **2c** | 14.896 | 18.570 | 16.900 | 12.759 |
| **2d** | -40.080 | 8.016 | 29.125 | 33.667 |
| **2e** | 55.716 | 46.631 | 43.141 | 41.276 |
| **2h** | 35.003 | 51.503 | 36.273 | 29.593 |
| **2i** | 20.174 | 26.186 | 26.987 | 23.046 |
| **2j** | 40.347 | 48.965 | 42.218 | 28.257 |

None of the screened compounds showed high % superoxide dismutase (SOD) activity.

activities. Some derivatives of thiosemicarbazides and triazoles showed poor antimicrobial activity. In primary screening of antiviral activity, compounds **2g**, **2i** and **4e** were found to be active. Hence they were selected for dose dependent study but compound **4e** get precipitated at higher concentration while **2g** and **2i** showed no dose dependent activity. These compounds were also tested for antioxidant activity. In primary screening, compounds **2a-j** and **4a-e** were found to be active and were further tested for dose dependent study. Compounds **2a**, **2c**, **2d**, **2e**, **2h**, **2i**, **2j** were found active in dose dependent study and were further tested for percent superoxide dismutase activity. But none of the compound showed high percentage of SOD activity.

## Experimental Section

Melting points were recorded in open capillaries in liquid paraffin-bath and are uncorrected. IR spectra were recorded on a Perkin-Elmer FTIR spectrometer in KBr disc. $^1$H NMR spectra were recorded on a Bruker 400 MHz NMR spectrometer using DMSO-$d_6$ as a solvent and TMS as an internal standard. Peak values are shown in δ (ppm). Mass spectra were recorded on Finnigan mass spectrometer.

### 1-(2-(3,5-Dichlorophenoxy)acetyl)-4-phenylthiosemicarbazide and 1-(2-(2,3,5,6-tetrafluorophenoxy)-acetyl)-4-phenylthiosemicarbazide, 2a-j

#### Conventional method

A mixture of compound **1** (0.01 mole) and aryl isothiocyanate (0.01 mole) in 15 mL of ethanol was heated under reflux for 45 minutes. The progress of reaction was monitored by TLC. After completion of reaction the contents were cooled and the solid obtained was filtered and crystallized from ethanol to get compound **2**. The compounds synthesized by above procedure are listed in **Table I**.

#### Ultrasound method

A mixture of compound **1** (0.01 mole) and aryl isothiocyanate (0.01 mole) in 15 mL ethanol was subjected to ultrasound irradiation for 18-22 minutes. The progress of reaction was monitored by TLC. After completion of reaction the product obtained was filtered and crystallized from ethanol. Formation of compound **2** was confirmed by melting point, mixed melting point, TLC and spectral analysis. The data of synthesized compounds is given in **Table I**.

**2a**: IR (KBr): 3331, 3221, 1690 and 1043 cm$^{-1}$; $^1$H NMR (DMSO-$d_6$): δ 4.72 (s, 2H), 7.12 (m, 4H), 7.32 (m, 4H), 9.65 (s, 2H), 10.25 (s, 1H); MS: *m/z* 370 ($M^+$) with isotopic peaks.

**2e**: IR (KBr): 3320, 3203, 1699 and 1055 cm$^{-1}$; $^1$H NMR (DMSO-$d_6$): δ 3.81 (s, 3H), 4.53 (s, 2H), 6.85 (d, 1H), 6.96 (m, 3H), 7.04 (d, 2H), 7.30 (d, 1H) 9.48 (s, 2H), 10.21 (s, 1H); MS: *m/z* 400 ($M^+$) with isotopic peaks.

**2f**: IR (KBr): 3354, 3267, 1694 and 1131 cm$^{-1}$; $^1$H NMR (DMSO-$d_6$): δ 4.92 (s, 2H), 7.08 (m, 1H), 7.38 (m, 4H), 7.61 (m, 1H), 9.75 (s, 2H), 10.26 (s, 1H); MS: *m/z* 373 ($M^+$).

**2g**: IR (KBr): 3350, 3263, 1698 and 1137 cm$^{-1}$; $^1$H NMR (DMSO-$d_6$): δ 2.27 (s, 3H), 4.89 (s, 2H), 6.94 (m, 1H), 7.22 (m, 3H), 7.52 (m, 1H), 9.12 (s, 2H), 10.15 (s, 1H); MS: *m/z* 387 ($M^+$).

### 5-[(3,5-Dichlorophenoxy)methyl]-*N*-phenyl-1,3,4-thiadiazol-2-amine and 5-[(2,3,5,6-tetrafluorophenoxy)methyl]-*N*-phenyl-1,3,4-thiadiazol-2-amine, 3a-j

#### Conventional method

Thiosemicarbazide **2** (0.001 mole) was dissolved in 3 mL of conc. $H_2SO_4$ in 50 mL beaker and stirred at RT for 3 hr. After completion of reaction 10 g of crushed ice was added in it. The solid obtained was separated by filtration and crystallized from 1:1 mixture of DMF and water to afford thiadiazole **3**. The data of synthesized compounds is given in **Table I**.

#### Ultrasound method

Thiosemicarbazide **2** (0.001 mole) was dissolved in 3 mL of conc. $H_2SO_4$ and subjected to ultrasound irradiation for 18-25 minutes. The progress of reaction was monitored with the help of TLC. After completion of reaction 10 g of crushed ice was added in it. The solid obtained was separated by filtration and crystallized from 1:1 mixture of DMF and water to afford thiadiazole **3**. Formation of compound **3** was confirmed by melting point, mixed melting point, TLC and spectral analysis. The data of synthesized compounds is given in **Table I**.

**3a**: IR (KBr): 3359, 1590 and 1055 cm$^{-1}$; $^1$H NMR (DMSO-$d_6$): δ 5.48 (s, 2H), 7.01 (t, 1H), 7.22 (d, 3H), 7.35 (t, 2H), 7.61 (d, 2H), 10.40 (s, 1H); MS: *m/z* 352 ($M^+$) with isotopic peaks.

**3e**: IR (KBr): 3368, 1587 and 1053 cm$^{-1}$; $^1$H NMR (DMSO-$d_6$): δ 3.80 (s, 3H), 5.27 (s, 2H), 6.89 (m, 3H), 6.98 (d, 1H), 7.26 (m, 3H), 8.78 (s, 1H); MS: *m/z* 382 ($M^+$) with isotopic peaks.

**3f**: IR (KBr): 3370, 1584 and 1172 cm$^{-1}$; $^1$H NMR (DMSO-$d_6$): δ 5.59 (s, 2H), 7.02 (m, 1H), 7.35 (t, 2H), 7.60 (m, 3H), 10.50 (s, 1H); MS: *m/z* 355 ($M^+$).

**3g**: IR (KBr): 3368, 1581 and 1173 cm$^{-1}$; $^1$H NMR (DMSO-$d_6$): δ 2.29 (s, 3H), 5.59 (s, 2H), 6.97 (m, 1H), 7.22 (m, 3H), 7.31 (m, 1H), 10.42 (s, 1H); MS: *m/z* 369 ($M^+$).

### 5-[(3,5-Dichlorophenoxy)methyl]-4-phenyl-4*H*-1,2,4-triazol-3-thiol and 5-[(2,3,5,6-tetrafluorophenoxy)-methyl]-4-phenyl-4*H*-1,2,4-triazol-3-thiol, 4a-j

#### Conventional method

A mixture of thiosemicarbazide **2** and 10 mL of 1*N* NaOH was heated under mild reflux for 1.5 hr. The progress of reaction was monitored by TLC. After completion of reaction the contents were cooled and poured into crushed ice. Then it was acidified with gl.

acetic acid. The product was separated by filtration and crystallized from the mixture (1:1) of DMF and water to get corresponding triazole **4**. The data of synthesized compounds is given in **Table I**.

### Ultrasound method

A mixture of thiosemicarbazide **2** and 10 mL of 1*N* NaOH in 100 mL RBF was subjected to ultrasound irradiation for 25-35 minutes. The progress of reaction was monitored by TLC. After completion of reaction the contents were cooled and poured into crushed ice. Then it was acidified with gl. acetic acid. The product was separated by filtration and crystallized from the mixture (1:1) of DMF and water to get corresponding triazole **4**. The data of synthesized compounds is given in **Table I**.

**4a**: IR (KBr): 3440, 1582, 1578 and 1050 $cm^{-1}$; $^1H$ NMR (DMSO-$d_6$): δ 4.98 (s, 2H), 6.95 (d, 2H), 7.18 (d, 1H), 7.5 (m, 5H), 11.23 (s, 1H); MS: *m*/*z* 353 (M+H) with isotopic peaks.

**4e**: IR (KBr): 3444, 1588, 1574 and 1041 $cm^{-1}$; $^1H$ NMR (DMSO-$d_6$): δ 3.85 (s, 3H), 4.84 (s, 2H), 6.71 (d, 1H), 6.98 (m, 3H), 7.26 (m, 3H), 11.55 (s, 1H); MS: *m*/*z* 383 (M+H) with isotopic peaks.

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