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# Preparation of Bioactive Thiazole Derivatives using 1,2,3-triazole-linked Thiosemicarbazone Derivatives and their Antioxidant Activities

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***Abstract***

In this work, 1,2,3-triazole-linked thiosemicarbazones are used to synthesize bioactive thiazole derivatives, and their antioxidant properties are assessed. Using six 1,2,3-triazole-linked thiosemicarbazone derivatives combined with chloroacetone to create the final thiazole. Both the DPPH and ABTS assays were used to assess the synthetic compounds' antioxidant properties. Strong antioxidant potential was indicated by the compounds' lower IC50 values, as shown by the DPPH experiment. These findings show that the 1,2,3-triazole and thiazole moieties can be hybridized to increase their antioxidant properties, which makes them attractive options for potential medicinal development.

***Keywords*:** 1,2,3-triazole, thiosemicarbazone, antioxidant activity, DPPH, ABTS, IC50.

## 1.Introduction

The synthesis of new bioactive thiazole derivatives has emerged as an area of significant interest within medicinal chemistry because of the multiple pharmacological properties that have been ascribed to the thiazole nucleus. Thiazole and its members are involved in different types of interactions with diverse biological targets, which make them useful to treat number of diseases and disorder including infection, inflammation and cancer. The addition of a thiazole substituent to drug compounds enhances pharmacokinetic parameters, such as bioavailability and metabolic stability that are essential for drug candidates[1,2]. Thiazole containing compounds show multiple biological activities like antibacterial[3], antifungal [4], antiviral[5] , anticancer[6] and anti-inflammatory[7] There is something more promising that can be used to improve the bioactivity of thiazole derivatives, it is the presence of other bioactive fragments attached to the compound by chemical transformations. Of these, the 1,2,3-triazole ring has now tentatively stepped forward as a promising pharmacophore. The incorporation of a pendant 1,2,3-triazole moiety increases chemical stability, solubility, and target binding specificity because of interaction with hydrogen bonding and pi-stackable fragments with the target proteins[8,9]. Additionally, the triazole ring also improves solubility and lipophilicity of the drug molecules that enhance cell permeability and interaction with biological membrane[10,11]. Studies have shown

that the introduction of 1,2,3-triazoles to drug candidates increases biological activity in relation to different targets, such as bacteria[12], and viral[13] and cancer cells [14]. Except for thiazoles and triazoles[15], thiosemicarbazone derivatives have been found with good biological activities that include the antioxidant, antimicrobial and antineoplastic activity [16]. Thiosemicarbazones can chelate metals[17], act as enzyme inhibitors and antioxidants which justify their possible use in diseases mediated by oxidative stress[18]. Oxidative stress, which is defined by the presence of a disequilibrium between reactive oxygen species (ROS) and defenses against these products, is involved in diverse diseases and conditions, including cancer, cardiovascular diseases, neurodegenerative illness, and aging[19,20]. One of the best known therapeutic strategies implicating oxidative stress and is aimed to decrease the overly oxidative effects on cells and thus slow down disease progression. It is reasonable hypothesis that incorporation of these three pharmacophores thiazole, 1,2,3-triazole and thiosemicarbazone into one molecular framework could provide an opportunity to design new leads with superior and complementary bioactivities. Hybridization of bioactive moieties is a common strategy in drug design, particularly when targeting the development of multitarget ligands that will interact with both ends of additional pathways . These multi-functionalized molecules could bring significant antioxidant, antimicrobial, and anticancer property to contribute towards a new generation of therapeutic compounds)[21]. The combination of thiosemicarbazones with 1,2,3-triazole linked thiazole derivatives has yielded some fruitful outcomes, especially in improving the antioxidant potential that may be effective against oxidative stress factors[22]. Some of these hybrids may have better bioavailability, cellular permeability and metabolic profile than the normal antioxidant agents [23].

The present research aims at the synthesis and assessment of a number of thiazole derivatives coupled with 1,2,3-triazole-linked thiosemicarbazones for their antioxidant activity. Using the known bioactivities of every scaffold, these hybrid molecules can open new therapeutic approaches to managing oxidative stress-associated diseases. The study will help support recent literature in multi-focused therapeutic agents and the relationship between oxidative stress and cellular pathology in illnesses[24]. These changes will be determined using established methods that will include DPPH and ABTS radical scavenging and FRAP assays.

## 2. Experimental Section

### 2.1. Instrumentation and Materials

2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS, ≥98%), 2,2-diphenyl-1-picrylhydrazyl (DPPH, $C_{18}H_{12}N_5O_6$), butylated hydroxytoluene (BHT, $C_{15}H_{24}O$), and thiosemicarbazide ($CH_5N_3S$, 99%) were provided from Sigma-Aldrich (Switzerland). methanol ($CH_3OH$, 99.9%) and ethanol ($C_2H_6OH$, 99.7%) were supplied from Fluka (Buchs, Switzerland). Ascorbic acid ($C_6H_8O_6$) was rovided from ACS Chemicals (USA). All used chemicals were of analytical reagent grade and didn't require any additional purification.

Several methods were used to confirm the structures of the synthesized compounds . Merck (Germany) Silica Gel F254 plates were used for thin-layer chromatography (TLC). A Kofler hot stage device (System Kofler, LEICA VMHB, Germany) was used to measure melting points. An Agilent Cary 630 FTIR spectrometer (USA) was used to record Fourier-transform infrared spectroscopy (FTIR) spectra. Nuclear magnetic resonance (NMR) spectra of the proton ($^1H$) and carbon-13 ($^{13}C$) were acquired using a Bruker AV III spectrometer (France) running at 400 MHz and 75 MHz, respectively. Tetramethylsilane (TMS) served as the internal standard for NMR experiments, while DMSO-*d6* was employed as the solvent. A Biochrom Libra S6 Visible Spectrophotometer (Harvard Bioscience, USA) was used to perform antioxidant experiments in the wavelength range of 330–800 nm.

### 2.2. Preparation of thiazole derivatives

Chloroacetone (1.0 mmol) and thiosemicarbazone derivatives (1.0 mmol) were combined in ethanol. The reaction mixture was refluxed for two to three hours at 80°C, and its progress was monitored by TLC. The precipitate that resulted from the filtering process was recrystallized from ethanol, there was no need for additional purification because the resultant thiazoles were pure. The final products were produced in good yields.

**(Z)-2-(2-(4-((1-benzyl-1H-1,2,3-triazol-4-yl)methoxy)benzylidene)hydrazineyl)-4-methylthiazole (3a):** light hazel powder. M.p: 146-148°C.Yield: 86 %. FTIR (λmax, $cm^{-1}$): 1005, 1242, 1357, 1434, 1507, 1575, 2360, 2854, 2922, 3068, 3142.

**(Z)-4-methyl-2-(2-(4-((1-(4-methylbenzyl)-1H-1,2,3-triazol-4-yl)methoxy)benzylidene) hydrazineyl)thiazole (3b):** beige powder. M.p: 139-141°C. Yield: 27% FTIR (λmax, $cm^{-1}$): 1005, 1169, 1246, 1310, 1379, 1511, 1603, 2626, 3119, 3365.

**(Z)-2-(2-(4-((1-benzyl-1H-1,2,3-triazol-4-yl)methoxy)-3-methoxybenzylidene) hydrazineyl)-4-methylthiazole (3c):** light hazel powder. M.p: 95-97°C. Yield: 21%. FTIR (λmax, $cm^{-1}$): 3375, 3083, 2922, 1603, 1575,1511, 1439,1265,1124, 995. $^{1}$H NMR (400MHZ, DMSO-$d_6$) δ 8.27(s, 1H), 7.93(s, 1H), 7.42 -7.28 (m,6H), 7.24(d, 1H), 7.22- 7.10 (m,2H), 6.35 (s, 1H), 5.61 (s, 2H), 5.15 (s, 2H), 3.77(s, 3H), 2.16 (s,3H). $^{13}$C NMR (101 MHZ, DMSO-$d_6$)δ 149.8, 149.1, 143.3, 136.5, 129.3, 128.6, 128.4, 125.4, 120.4, 114.2, 109.2, 62.2, 55.8, 53.3.

**(Z)-2-(2-(3-methoxy-4-((1-(4-methylbenzyl)-1H-1,2,3-triazol-4-yl)methoxy)benzylidene) hydrazineyl)-4-methylthiazole (3d):** light hazel powder. M.p: 132-134°C. Yield: 49%. FTIR (λmax, $cm^{-1}$): 3576, 3343, 3150, 2941, 1575, 1511, 1439, 1265, 1128,981. $^{1}$H NMR (400MHZ, DMSO-$d_6$) δ 8.23(d, 2H), 7.37(s, 1H), 7.26 (d, 1H), 7.22 (q, 3H), 7.18 (d, 3H), 6.59 (s, 1H), 5.56 (s, 2H), 5.17 (s, 2H), 3.79(s, 3H), 2.28(s,3H), 2.24 (d, 3H). $^{13}$C NMR (101 MHZ, DMSO-$d_6$) δ 149.8, 143.1, 138.0, 133.5, 129.8, 128.5, 125.3, 113.9, 103.6, 62.2, 56.0, 53.1, 21.6.

**(E)-2-(2-(2-((1-benzyl-1H-1,2,3-triazol-4-yl)methoxy)benzylidene)hydrazineyl)-4-methylthiazole (3e):** beige powder. M.p: 154-156°C. Yield: 57%. FTIR (λmax, $cm^{-1}$): 3580, 3343, 3146, 2927, 1603, 1580, 1507, 1448, 1260, 1132, 1000. $^{1}$H NMR (400MHZ, DMSO-$d_6$) δ 11.71 (s, 1H), 8.29 (d, 2H), 7.76 (dd, 1H), 7.41 - 7.24 (m, 7H), 7.06 -6.93 (m, 1H), 6.36 (s, 1H), 5.63 (s, 2H), 5.23 (s, 2H), 2.15 (s, 3H), $^{13}$C NMR (101 MHZ, DMSO-$d_6$) δ 168.4, 156.3, 143.3, 136.5, 130.7, 129.3, 129.2, 128.7, 128.4, 128.4, 125.4, 125.3, 123.6, 121.7, 113.9, 62.2, 53.4, 17.5.

**(E)-4-methyl-2-(2-(2-((1-(4-methylbenzyl)-1H-1,2,3-triazol-4-yl)methoxy)benzylidene) hydrazineyl)thiazole (3f):** yellow powder. **M.p:** 166-168°C. **Yield:** 40%. **FTIR (λmax, $cm^{-1}$):** 3571, 3338, 3142, 2922, 1598, 1511, 1448, 1265, 1128,1000. $^{1}$H NMR (400MHZ, DMSO-d6) δ 11.35 (s, 1H), 8.39 (s, 1H), 8.27 (s,1H), 8.05-8.13 (m, 2H), 7.90 (s, 1H), 7.37 (m, 1H), 7.13-7.30 (m, 6H), 6.92-7.02 (m, 1H), 5.57 (s, 2H), 5.22 (s, 2H), 2.28 (s, 3H). $^{13}$C NMR (101 MHZ, DMSO-$d_6$)δ 178.4, 157.1, 143.3, 143.3, 138.5, 137.9, 133.5, 131.6, 129.8, 128.4, 128.4,126.7, 124.9, 123.2, 121.5, 113. 8, 62.5, 53.2, 21.2.

### 2.3. DPPH assay

The ability of functional meals, including synthetic ingredients, herbal extracts, and/or pure natural ingredients, to combat radicals can be assessed using the DPPH antioxidant assay. This is because the DPPH radical is stable, inexpensive, and simple to use in research. This technique involves adding antioxidants (AH) to a solution of DPPH. DPPH-H hydrazine is created when an antioxidant molecule reduces the DPPH radical by giving its nitrogen atom a hydrogen atom. The degree of DPPH radical quenching can be measured using spectrophotometric techniques. Between 515 and 520 nm, the absorbance reduction is usually recorded. The antioxidant capacity of a material is expressed as the concentration required to lower the initial DPPH radical concentration by 50% [1].

This widely used test is simple to set up and adaptable for evaluations with a high throughput. To assess the DPPH radical scavenging, Brand-Williams and his group's (1995) technique was applied. A DPPH solution in methanol at a concentration of 0.004% (w/v) was mixed with two milliliters of a 1 mL volume of various concentrations of the investigated compounds (1, 5, 10, 50, 100, 200, 300, 400, and 500 µg/mL) in methanol. The combination was allowed to sit at room temperature for 30 minutes in the dark. Using UV-visible spectroscopy, the hydrogen transfer reaction between the antioxidant and DPPH˙ was monitored by detecting the decrease in absorption at 517 nm .The percentage of inhibition (I%) of free radical generation from DPPH was calculated using the following formula:

$$\% \text{ DPPH scavenging} = \frac{\text{A control} - \text{A sample}}{\text{A control}} 100 \ldots\ldots (1)$$

In this case, the absorbance of the tested substance is $A_{sample}$, whereas the absorbance of the control reaction (simply the DPPH solution) is $A_{control}$. Furthermore, a vitamin C calibration curve was developed to establish a relationship between varying concentrations and their I%.

**2.4. ABTS assay**

The ABTS assay is based on a decolorization reaction in which an antioxidant interacts with a stable ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)) radical first. This approach has the benefit of yielding consistent results for pure chemicals, mixtures, and plant extracts, as well as for fat-soluble and water-soluble antioxidants. It is also known for its speed, affordability, and sensitivity, and it remains stable over a wide pH range [2]. The spectrophotometric method is used to assess the compound's total antioxidant activity in the ABTS assay.

A 7 mM ABTS solution in water is combined with a 2.4 mM potassium persulfate solution. To create the $ABTS^{\bullet+}$ radical cation, the two stock solutions are mixed proportionately and allowed to react for 12 hours at room temperature in the dark. The solution is diluted before use to achieve an absorbance of 0.700 ± 0.005 at 740 nm. For the evaluation, 990 µL of the diluted $ABTS^{\bullet+}$ radical solution is combined with 10 µL of the solutions containing various quantities of the substances to be examined. After seven minutes, the absorbance is measured at 734 nm using a spectrophotometer. The following formula is used to determine the $ABTS^{\bullet+}$ radical's percentage reduction:

$$\% \text{ ABTS scavenging} = \frac{\text{A control} - \text{A sample}}{\text{A control}} 100 \ldots\ldots (2)$$

Whereas the tested compound's absorbance is $A_{sample}$, the absorbance of the control reaction is $A_{control}$.

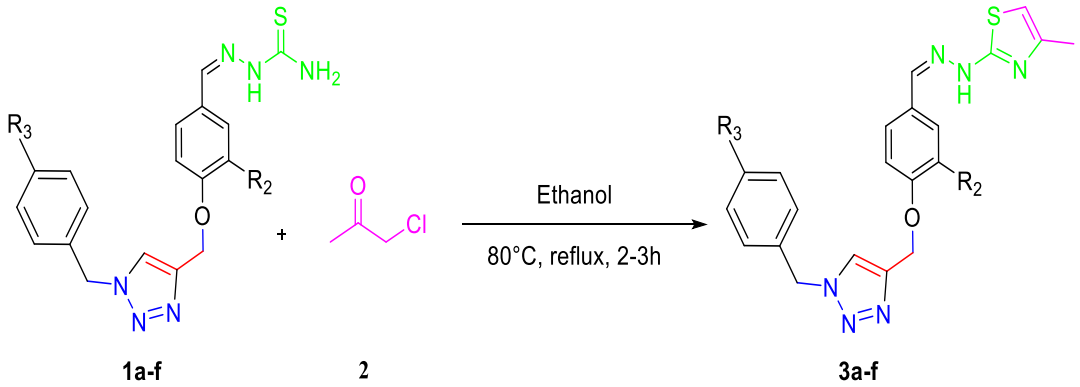
The findings of the ABTS assay are expressed using the IC50 value, which is the quantity of antioxidant required to eliminate 50% of the initial concentration of ABTS•+ radical cation. The compounds' antioxidant properties are greatly influenced by their chemical structures, which include the amount of hydroxyl groups, the degree of esterification, and their relative locations within the aromatic ring [1].

**3. Results and discussion**

This study focused on synthesizing bioactive thiazole derivatives (compounds **3a-f**) using six 1,2,3-linked thiosemicarbazone derivatives in a green synthetic approach for enhanced antioxidant activities.

**3.1. Characterization:**

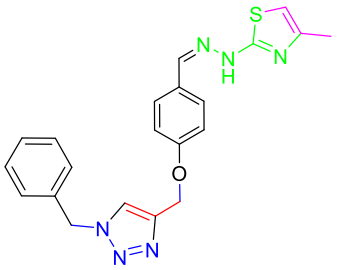
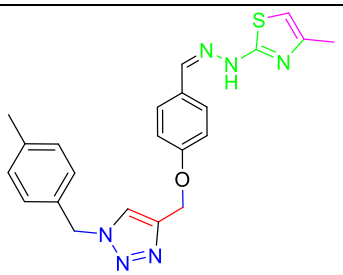
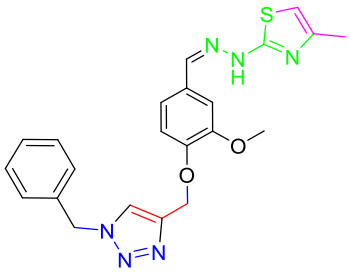
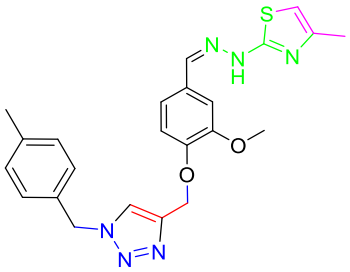
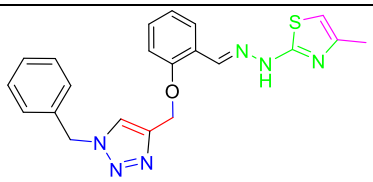
Standard spectroscopic methods (FTIR, 13C NMR, and 1H NMR) were used to determine the structures of the thiazole derivatives **3a–f**. The presence of the amine group (NH) in the structure is shown by the large peak in the thiazole derivatives' FT-IR spectra at 3380 $cm^{-1}$, which most likely corresponds to N-H stretching. The peak at 2922 $cm^{-1}$ indicates a stretching vibration of C–H, usually from aromatic or aliphatic C–H bonds. At 1603 $cm^{-1}$, the imine (CH=N) group's C=N stretching is seen. The C=C stretching of aromatic rings is probably present at 1500 $cm^{-1}$. The molecule's C-O stretching from the ether bond ($CH_2$-O) may correspond to 1100–1265 $cm^{-1}$. The predicted functional groups of the produced molecules are well-aligned with these peaks.

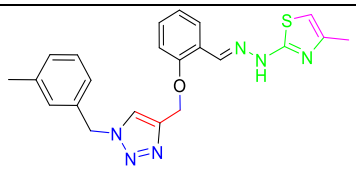



$R_2$: H, CHO, $OCH_3$
$R_3$: H,$CH_3$

**Figure 1.** Thiazole preparation

**Table 1. Thiazole derivatives (3a-f) and their characteristics**

| Ref | Thiazole derivatives | Yield % | Melting points (°C)* |
|---|---|---|---|
| | | | |
| **3a** |  | | 146-148 |
| **3b** |  | | 139-141 |
| **3c** |  | 21 | 95-97 |
| **3d** |  | 49 | 132-134 |
| **3e** |  | 57 | 154-156 |

| | | | |
|---|---|---|---|
| 3f |  | 40 | 166-168 |

*****Yield of pure products

### 3.2. Antioxidant activity of thiazole derivatives

Antioxidants are essential for preventing oxidative stress, which is a cause of many illnesses, including as cancer, heart disease, and neurological disorders [3].

A stock solution containing 1 mg/mL of the thiazole derivatives **3a–f**, a variety of dilutions from it was made, including 1, 5, 10, 50, 100, 200, 300, 400, and 500 µg/ml. The linear regression equation for each curve is found, and the concentration that corresponds to 50% inhibition is computed in order to establish the IC50.

**Table 2. the compounds 3a-f's IC50 values**

| Compounds | DPPH assay | ABTS assay |
|---|---|---|
| **3a** | **2.39** | **281.3** |
| **3b** | **0.62** | **293.6** |
| **3c** | **3.49** | **252.7** |
| **3d** | **2.12** | **350.7** |
| **3e** | **0.34** | **316.5** |
| **3f** | **0.07** | **253.2** |
| **Ascorbic acid** | **3.8** | - |
| **BHT** | - | **75.2** |

Table 2 provide a summary of the IC50 values obtained from the antioxidant activity tests. Standard antioxidants, ascorbic acid (IC50 = 3.76 µg/ml for the DPPH assay and BHT (IC50 = 75.17 µg/ml for the ABTS assay), were used to examine the scavenging activity of the thiazole derivatives (**3a–f**).

For the majority of chemicals in the DPPH assay, the proportion of DPPH scavenging rises with concentration. This suggests that increased antioxidant activity results from larger quantities of these substances. Every examined compound's IC50 value was higher than ascorbic acid's. As an example, the lower IC50 value at very low concentrations, compound **3f** is highly effective at scavenging DPPH radicals, as evidenced by its excellent IC50 value of 0.07 µg/mL. Compound **3b** exhibits a very high scavenging activity and the greatest antioxidant activity, surpassing ascorbic acid by approximately 98% at 500 µg/mL with an IC50 value of 0.62 µg/mL. Compound **3e**, which has a low IC50 value of 0.34 µg/ml and a high percentage of radical scavenging, also showed more potent antioxidant than ascorbic acid. In contrast, compounds **3c**, **3a**, and **3d** have lower antioxidant activity than compounds **3f**, **3b**, and **3e**, with IC50 values of 3.49, 2.39, and 2.12 µg/mL, respectively.

The range of IC50 values derived from these findings suggests that certain chemicals have a considerably stronger anti-free radical effect than others. It is evident from these data that certain studied substances may have higher efficiency when compared to well-known antioxidants like ascorbic acid. The processes behind their antioxidant properties and possible uses in a variety of industries could be investigated in further detail.

All of the thiazole derivatives (**3a–f**) showed weaker antioxidant activity than BHT in the ABTS experiment, with IC50 values more than 200 μg/ml. With IC50 values of 252.7 and 253.2 μg/ml, respectively, 10c and 10f showed the lowest levels of antioxidant activity among these compounds, suggesting that they were still inferior to BHT. The IC50 values of the other compounds (**3a**, **3b**, **3d**, and **3e**) were above 280 μg/ml, indicating that their antioxidant capacity was restricted.

For all chemicals, the proportion of ABTS scavenging generally rose with concentration; however, these percentages were not as high as those found in the DPPH assay. Compound **3a**, for example, demonstrated weaker antioxidant activity than the others, with a maximum scavenging percentage of just 76.6% at 500 μg/mL and an IC50 value of 281.3 μg/mL. Similarly, Compound **3b** showed modest antioxidant activity with an IC50 value of 293.6 μg/mL and a maximum scavenging percentage of 70.9% at the highest concentration tested (500 μg/mL). Compound **3f**, on the other hand, has an IC50 value of 253.2 μg/mL, which suggests that it is not as strong as many antioxidants but still fairly effective. With an IC50 value of only 75.2 μg/mL and a maximum scavenging percentage of 92.3% at 500 μg/mL, **BHT** showed noticeably higher efficacy than the tested compounds.

All investigated substances had high IC50 values, which indicates that larger concentrations are needed to produce noticeable antioxidant action against ABTS radicals. Notably, the ABTS assay suggests that certain compounds may not be as effective in neutralizing ABTS radicals as the DPPH assay, which showed very low IC50 values (e.g., Compound **3f** at 0.07 μg/mL). Because different approaches can produce different results depending on radical scavenging processes, this disagreement emphasizes the significance of using multiple tests to thoroughly investigate antioxidant efficacy.

The fundamental processes underlying these variations might be investigated further, and possible changes to improve these chemicals' antioxidant qualities for real-world uses could be evaluated.

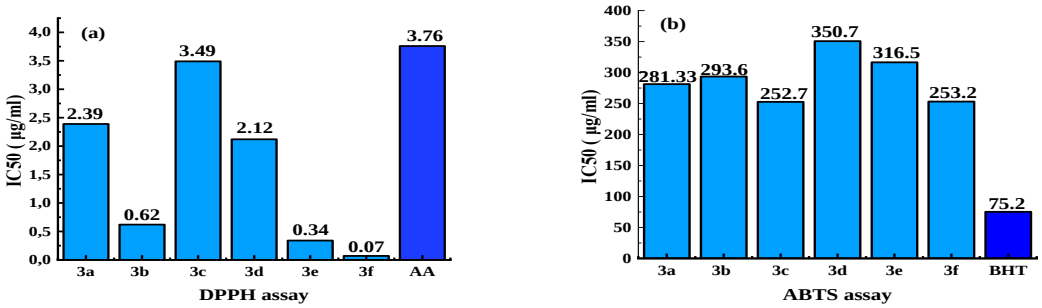



**Figure 2. $IC_{50}$ ( μg/ml) of the derivatives of thiazole 3a-f (a) DPPH assay (b) ABTS assay**

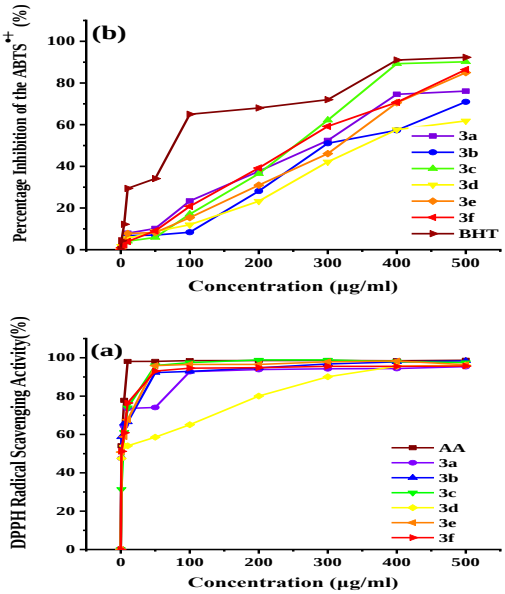



**Figure 3. thiazole derivatives 3a-f's antioxidant assays (a) % DPPH˙ free radical scavenging of 3a-f and (b) 3a-f's % ABTS$^{\bullet+}$ free radical scavenging of.**

**4. Conclusion:**

In conclusion, this study successfully synthesized a series of bioactive thiazole derivatives by linking 1,2,3-triazole to thiosemicarbazones, aiming to explore their potential as antioxidants.

The reaction involved six 1,2,3-triazole-linked thiosemicarbazones 4a-f, followed by reaction with chloroacetone to get the final thiazoles 5a-f. Free radical scavenging abilities of these synthesized compounds were analyzed systematically by using DPPH and ABTS assays which are efficient methods for measuring antioxidant activities. The data obtained in the DPPH assay, specifically low IC50 rates, testified to high antioxidant potential, which was also confirmed by the data of the ABTS assay. As such these results substantiate our idea of hybridizing 1,2,3-triazole and thiazole to improve the antioxidant activity by folds indicating that such structural fused strategy can be useful in the design of highly effective antioxidant reagents.

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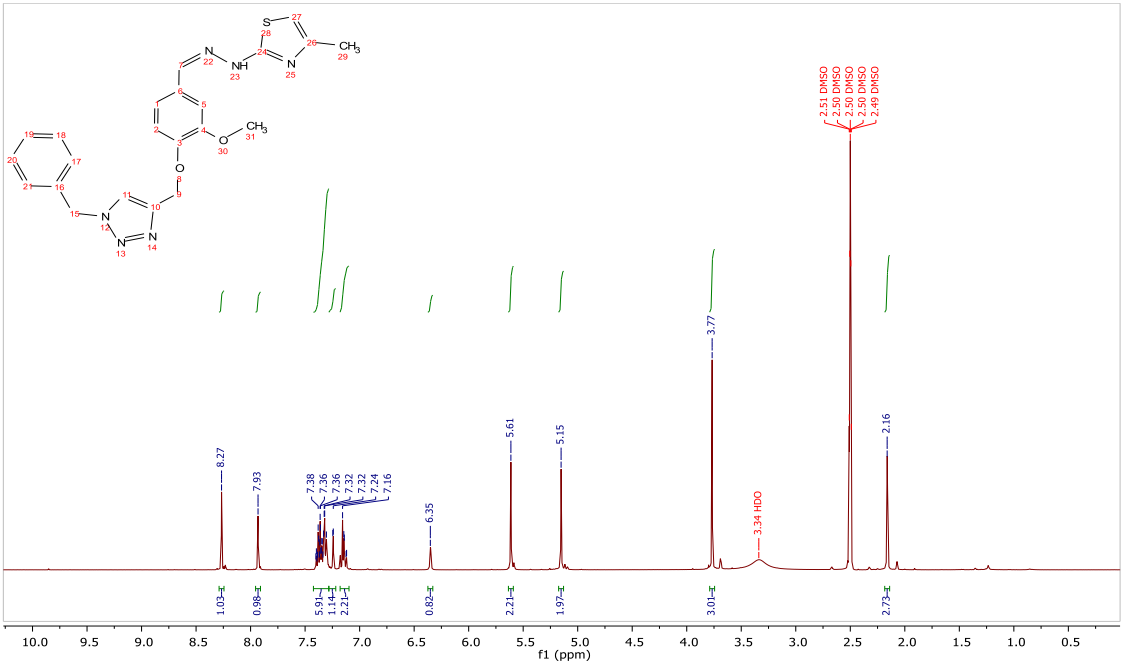
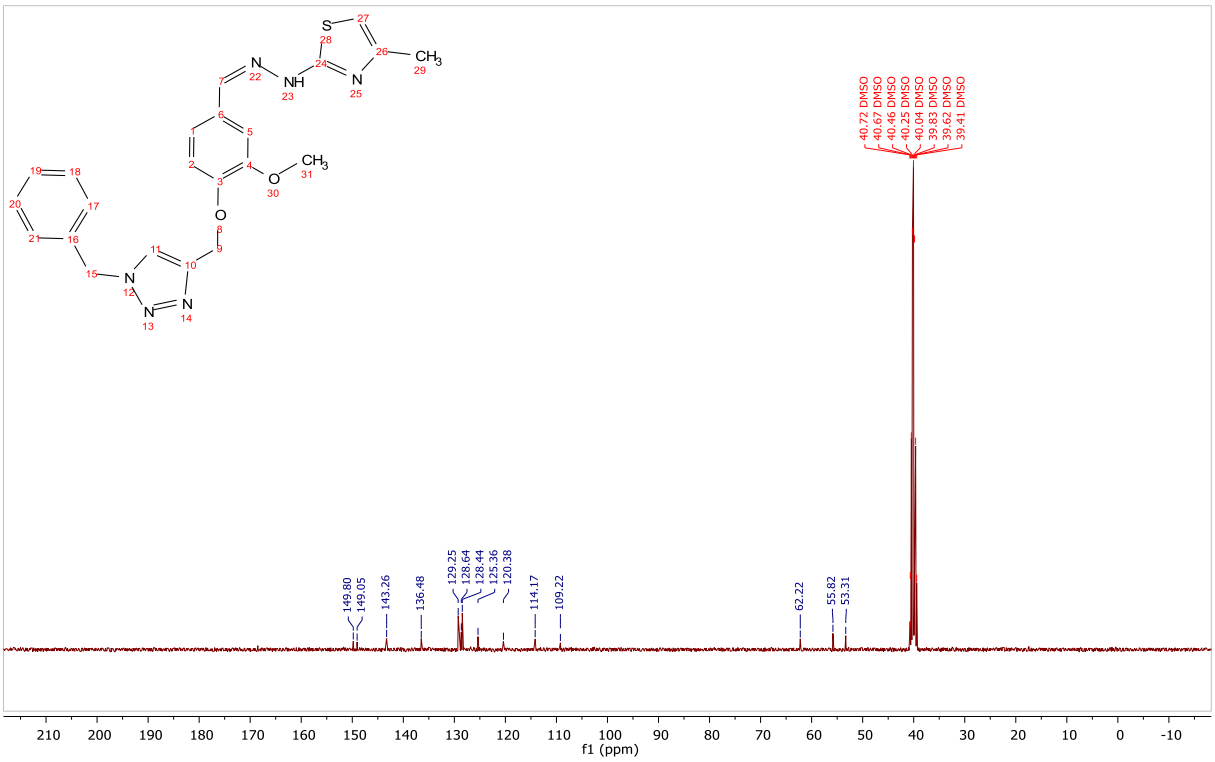
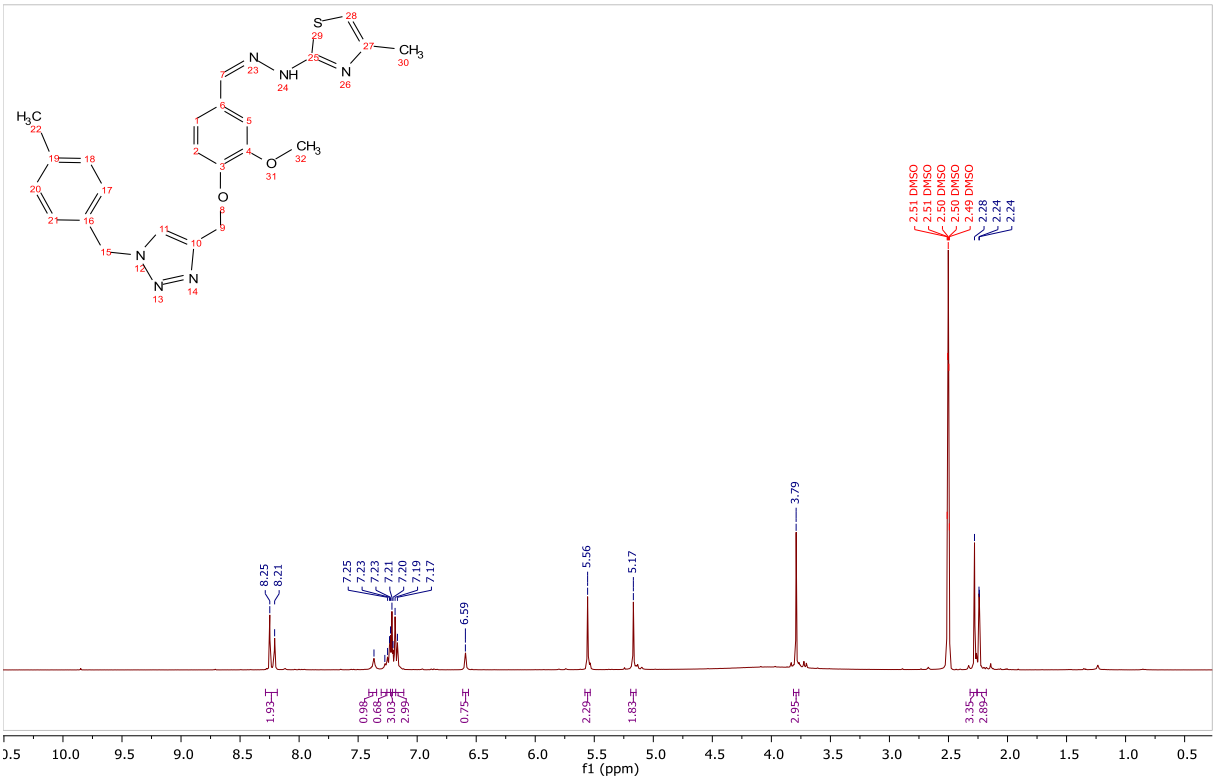


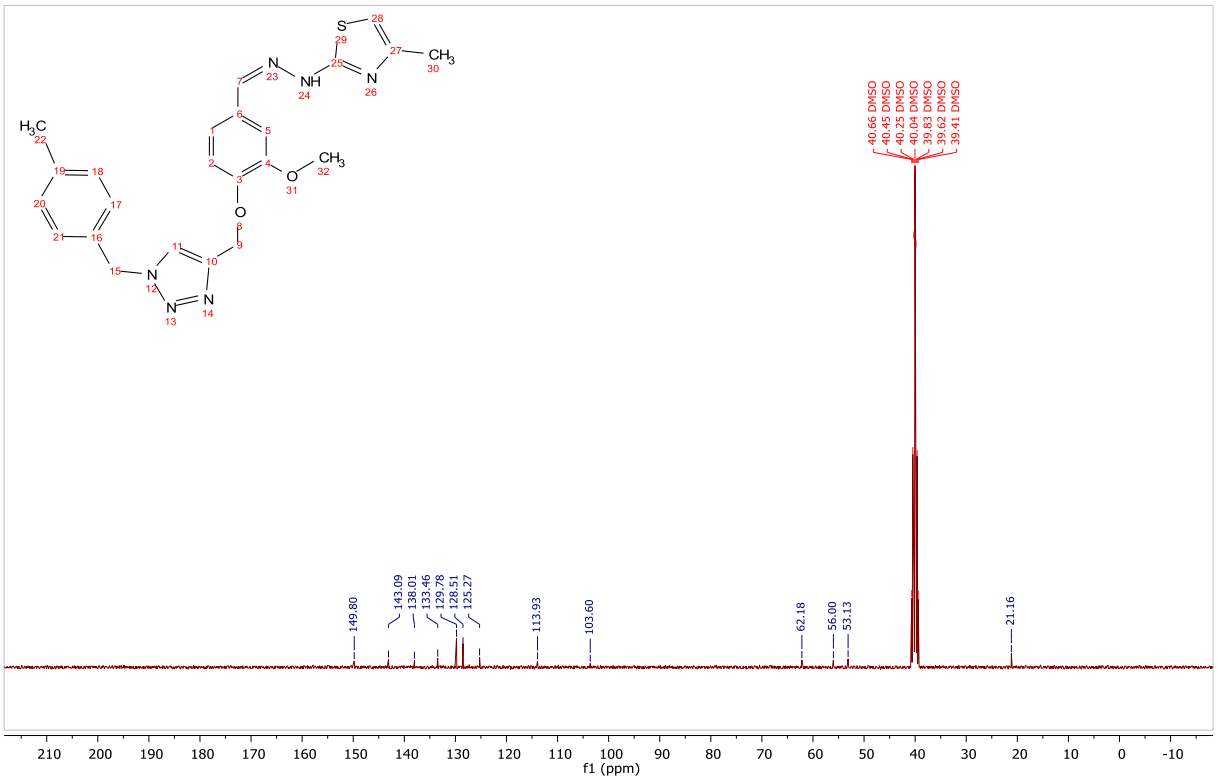

**$^1$H NMR (400 MHz, DMSO-$d_6$) δ** 8.27 (s, 1H), 7.93 (s, 1H), 7.42 – 7.28 (m, 6H), 7.24 (d, 1H), 7.22 – 7.10 (m, 2H), 6.35 (s, 1H), 5.61 (s, 2 5.15 (s, 2H), 3.77 (s, 3H), 2.16 (s, 3H).



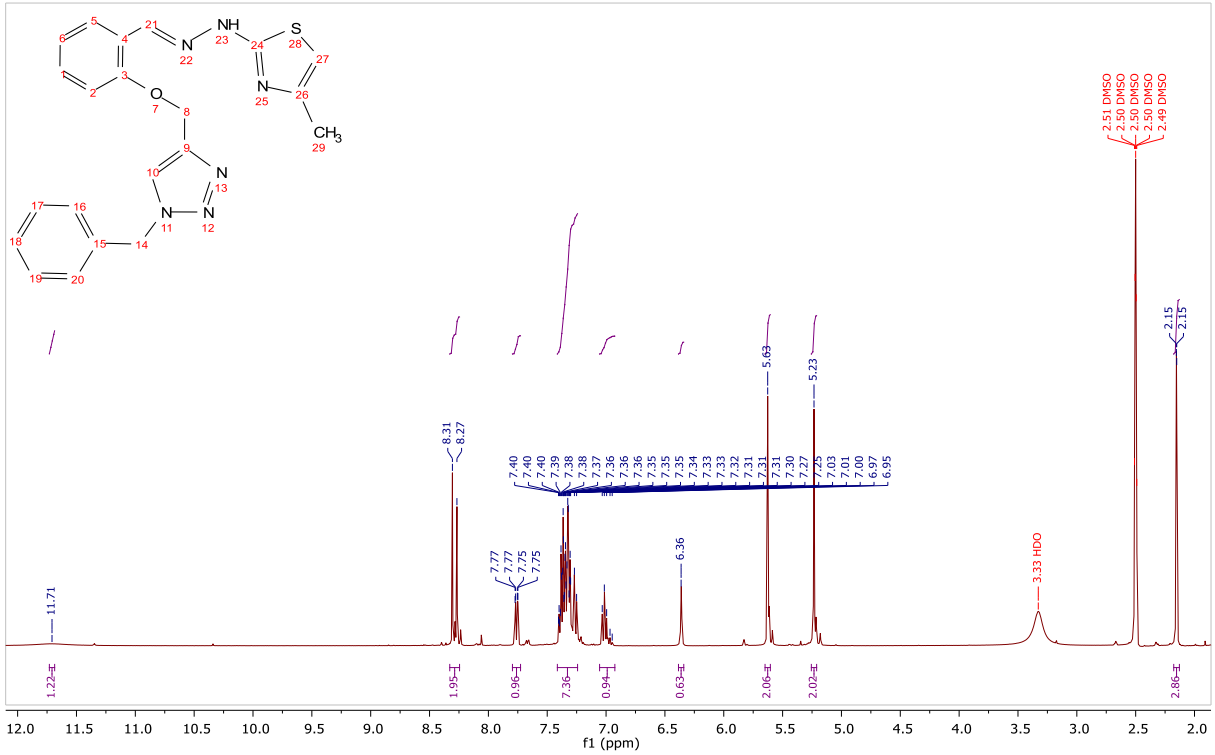

**$^{13}$C NMR (101 MHz, DMSO) δ** 149.801, 149.05, 143.26, 136.48, 129.25, 128.64, 128.44, 125.36, 120.38, 114.17, 109.22, 62.22, 55.82, 53



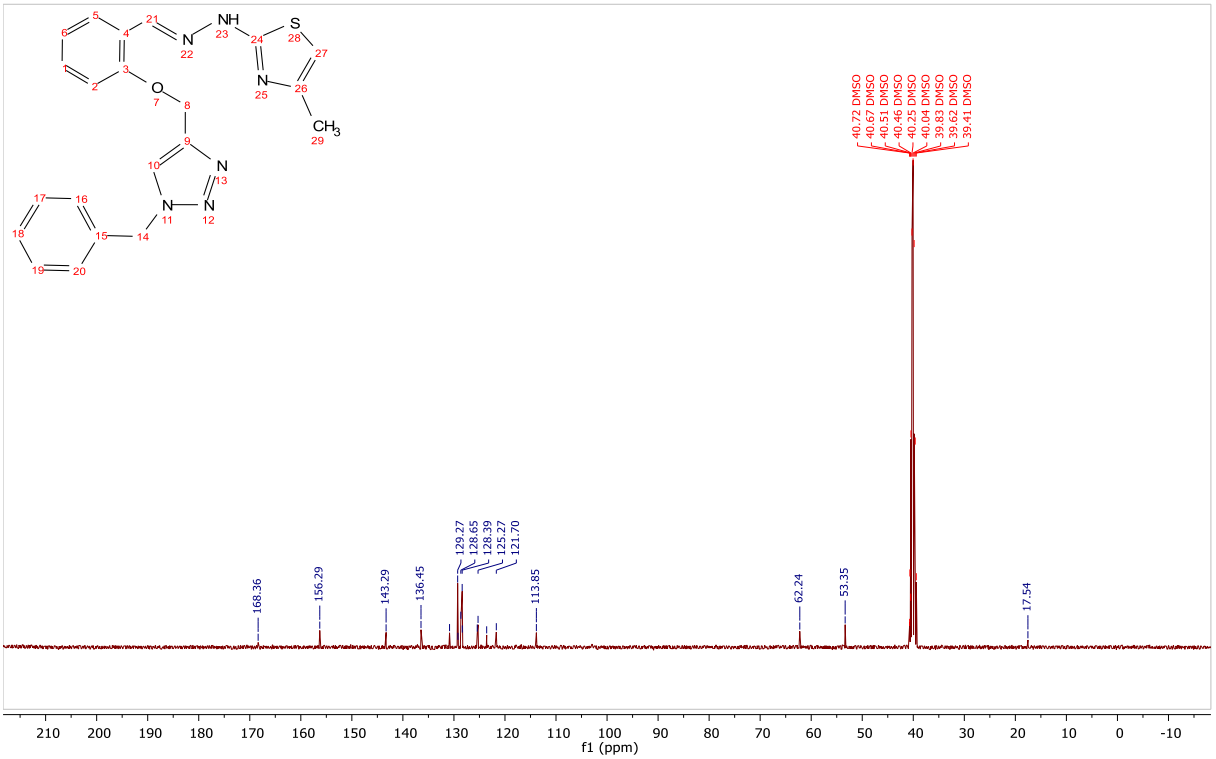

**$^1$H NMR (400 MHz, DMSO-$d_6$) δ** 8.23 (d, 2H), 7.37 (s, 1H), 7.26 (d, 1H), 7.22 (q, 3H), 7.18 (d, 3H), 6.59 (s, 1H), 5.56 (s, 2H), 5.17 (s, 2H 3.79 (s, 3H), 2.28 (s, 3H), 2.24 (d, 3H).



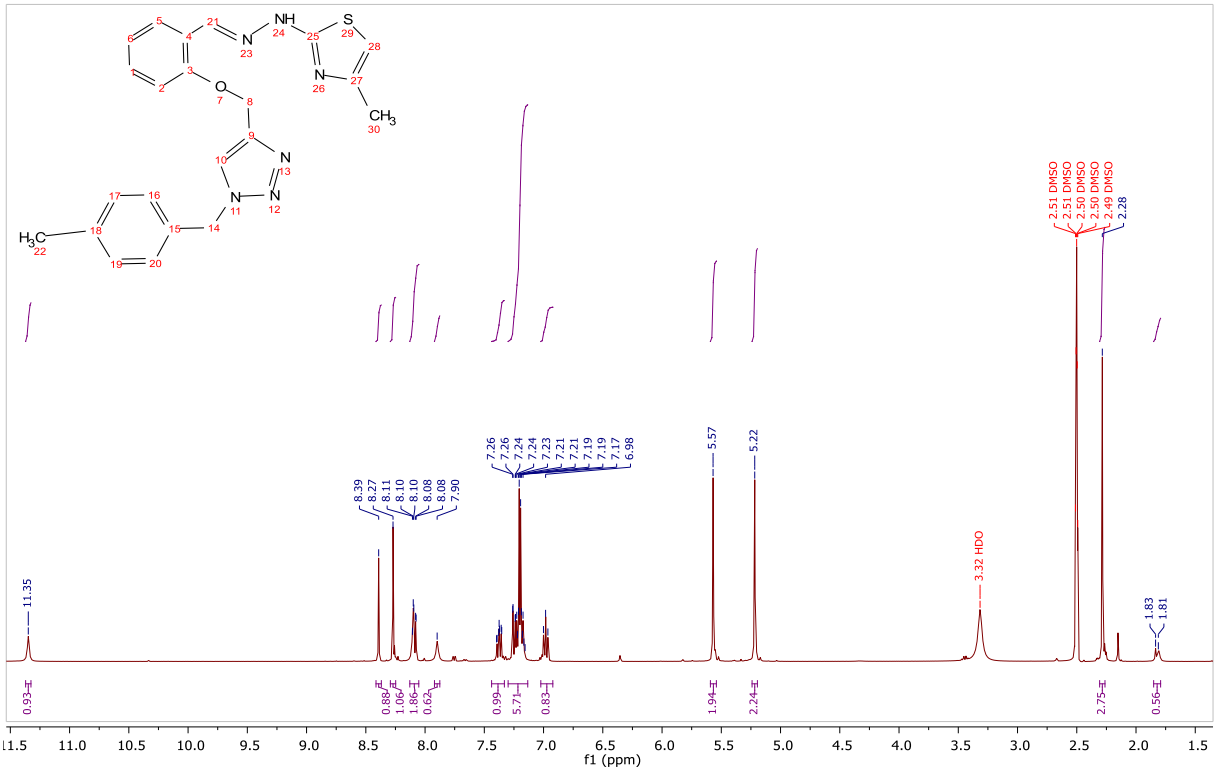

**$^{13}$C NMR (101 MHz, DMSO) δ** 149.80, 143.09, 138.01, 133.46, 129.78, 128.51, 125.27, 113.93, 103.60, 62.18, 56.00, 53.13, 21.16.



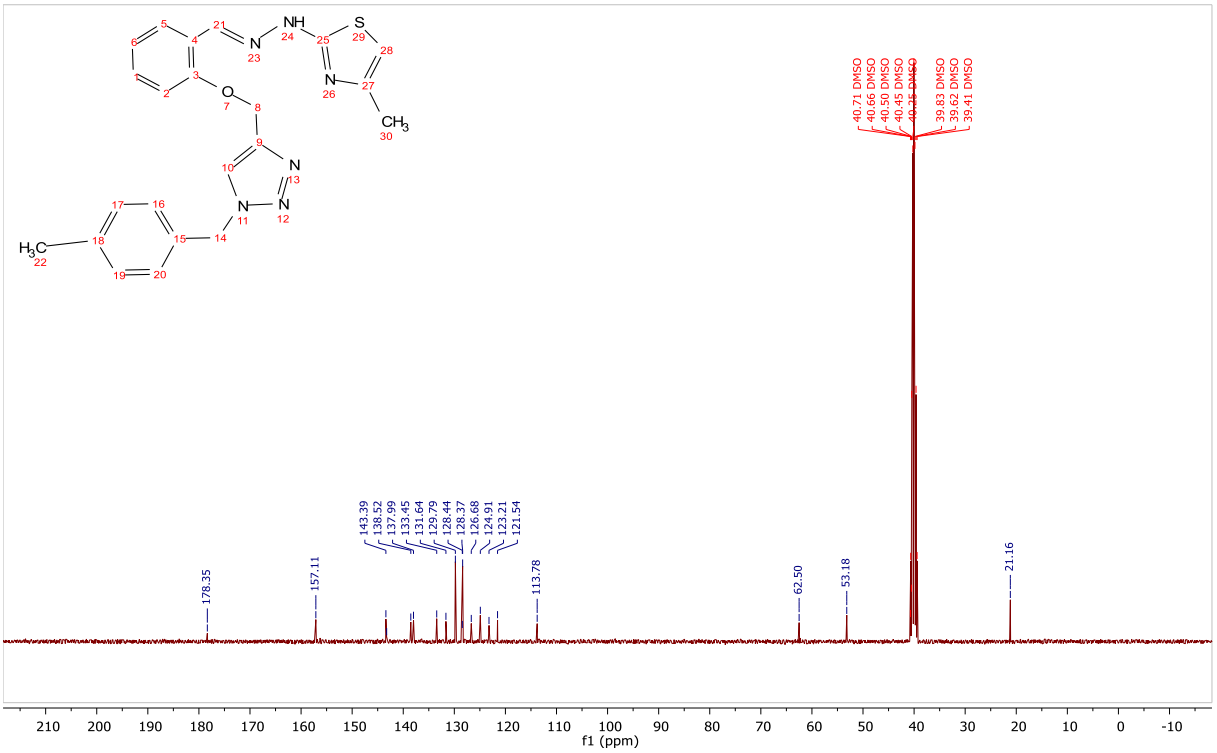

**$^1$H NMR (400 MHz, DMSO-$d_6$) δ** 11.71 (s, 1H), 8.29 (d, 2H), 7.76 (dd, 1H), 7.41 – 7.24 (m, 7H), 7.06 – 6.93 (m, 1H), 6.36 (s, 1H), 5.63 (s 2H), 5.23 (s, 2H), 2.15 (s, 3H).




**$^{13}$C NMR (101 MHz, DMSO) δ** 168.36, 156.29, 143.29, 136.45, 130.86, 129.27, 129.22, 128.65, 128.39, 128.36, 125.43, 125.27, 123.58, 121.70, 113.85, 62.24, 53.35, 17.54.




**$^1$H NMR (400 MHz, DMSO-$d_6$) δ** 11.35 (s, 1H), 8.39 (s, 1H), 8.27 (s, 1H), 8.13 – 8.05 (m, 2H), 7.90 (s, 1H), 7.37 (m, 1H), 7.30 – 7.13 (m, 6H), 7.02 – 6.92 (m, 1H), 5.57 (s, 2H), 5.22 (s, 2H), 2.28 (s, 3H), 1.82 (d, 1H).




**$^{13}$C NMR (101 MHz, DMSO) δ** 178.35, 157.11, 143.39, 143.25, 138.52, 137.99, 133.45, 131.64, 129.79, 128.44, 128.37, 126.68, 124.91, 123.21, 121.54, 113.78, 62.50, 53.18, 21.16.