DBU mediated One Pot Synthesis of Triazolotriazine isomers via Dimroth Type Rearrangement.

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SUPPORTING INFORMATION

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1. **Experiment:**

The reaction was performed in 10 ml glass reaction tube at room temperature. 4,4'-((6-hydradzinyl-1,3,5-triazine-2,4-diyl)dimorpholine and simple benzaldehyde resulted in Schiff base formation in 10mins and was monitored by TLC. Addition of NBS led to spontaneous reaction forming isomer 1 and it took 20 mins for its completion. The spot was isolated and characterised by NMR. Next step was addition of DBU which resulted in formation of isomer 2 in 2-4h. The progress of the reaction was monitored by TLC. The isomer 2 on TLC appeared as bluish rather than its isomer 1.

The equivalents of DBU influenced the reaction rate drastically, the 2 eq. of DBU gave the isomer 2 in about 45 mins. The progress of reaction using different equivalents of DBU was studied for isomer 2 as shown in **Figure S1**.

![Figure S1: Visualisation of isomer-1 and isomer-2 (2a) under UV lamp with 254nm. (A= Authentic spot for 2a)](image)

Addition of water caused precipitation the product (isomer 2) and followed by the filtration. 1.5 eq. of DBU resulted in high yield % as compared to 2.0 eq. of DBU and it saved the super-equivalents of reagent.

2. **General consideration**

All the required chemicals and solvents used in this research work were purchased from commercial suppliers Sigma Aldrich, Alfa Aesar and Merck. For Thin-layered chromatography (TLC) precoated with silica gel plates were used for monitoring the progress of the reaction which was procured from E. Merck and Co. (Darmstadt, Germany) and visualized under UV lamp (254 or 365 nm). Melting point for the synthesized compounds was obtained from digital Stuart SMP10 melting point apparatus. The compounds were characterized by Bruker Alpha FT-IR spectrometer using the ATR technique in the 400-4000cm⁻¹ spectral range. The NMR (¹H & ¹³C) spectra were obtained Bruker AVANCE III 400
MHz spectrometer using deuterated solvents- CDCl₃ and DMSO. Tetramethylsilane (TMS) was used as an internal standard at δ 0.0 parts per million (ppm) and the coupling constants (J) were stated in Hertz. The NMR multiplicities were abbreviated as s for singlet, d for doublet, dd for doublet of doublet, t for triplet, q for quartet and m for multiplet.

3. Synthesis

3.1. Synthesis and spectral characterization of 1a, 3a and 4a.

The starting materials 1a, 3a and 4a were synthesised by the previously reported method.¹

3.2. Synthesis of Schiff base:

In a 10 mL glass reaction tubes equipped with a magnetic stirrer 1a (200mg, 1 eq) was placed in 2ml of methanol. To this solution was added 2,3-dimethoxybenzaldehyde (95.3mg, 1 eq) and allowed to stir at room temperature for 20-30 mins resulting in a Schiff base and the same was monitored by the TLC. Next, addition of water (2-3ml) in reaction vessel and filtration resulted in white solid with 96% yield.

3.2.1(E)-4,4'-(6-(2-(2,3-dimethoxybenzylidene)hydrazinyl)-1,3,5-triazine-2,4-diyl)di

**morpholine (Schiff base):**

![Schiff base structure](image)

White solid, Yield: 96%; ¹H NMR (400 MHz, CDCl₃, δ ppm): 9.39 (s, 1H), 8.13 7.59 (s, 1H), 7.60 (d, J = 7.83 Hz, 1H), 7.00 (t, J = 7.30 Hz, 1H), 6.84 (d, J = 8.08 Hz, 1H), 3.81-3.79 (m, 10H), 3.74-3.73 (m, 4H), 3.69-3.67 (m, 8H) ; ¹³C NMR (100 MHz, CDCl₃, δ ppm): 165.35, 164.91, 164.15, 152.63, 147.94, 138.73, 128.15, 124.12, 118.05, 113.15, 66.78, 61.51, 55.73, 43.69 ; MS m/z (ESI) calcd for C₂₀H₂₉N₇O₄ 429.21, found 430.0 [M + H]⁺.

3.3. A General procedure for synthesis and spectral characterization of 2 (a-o), 5(a-e), 6(a-c) and 7 (a-b);
In a 10 mL glass reaction tubes equipped with a magnetic stirrer 1a, 3a, or 4a (200mg, 1 eq.) was placed in 2ml of methanol. To this solution was added aldehydes (1 eq.) and allowed to stir at room temperature (20-30 mins), resulting in respective Schiff base and the same was monitored by the TLC. To the Schiff base NBS (1eq.) was slowly added to the reaction mixture and allowed to stir at room temperature for 5-30 mins, yielding isomer-1, which when treated with 1.5 eq. of DBU resulted in isomerisation to give isomer-2. After the completion of reaction, 2-3 ml of ice-cold water was added to the crude reaction mixture leading to the Precipitation, which was filtered, washed with pentane and vacuum dried to afford the final products in good to excellent yields 65-95%.

3.3.B General procedure for synthesis and spectral characterization of 1b, 3(b, c) and 4(b-d);

In a 10 mL glass reaction tubes equipped with a magnetic stirrer 1a, 3a, or 4a (200mg, 1 eq.) was placed in 2ml of methanol. To this solution was added aldehydes (1 eq.) and allowed to stir at room temperature for 10-30 mins, resulting in the formation of respective Schiff bases. Further slow addition of NBS (1eq.) to this reaction mixture and stirred at room temperature (5-30 mins) yielded isomer-1. The crude reaction mixture was poured onto an ice-cold water (2-3ml) resulting in a precipitate. The precipitate was then filtered and washed with pentane and vacuum dried to afford the final products with yields ranging 83-89%.

3.3.C General procedure for Gram scale synthesis of 2a.

The gram scale reaction was performed to further validate this synthetic procedure. The reaction was carried out using 1a (1g) with Benzaldehyde (0.38g) and stirred for 30 min. The NBS (1.26g, 1eq) was added slowly and stirred till we get new spot for isomer-1 followed by slow addition of DBU (1.5eq) which results in isomerisation to give 2a. After the completion of reaction, 30-40 ml of ice-cold water was added to the crude reaction mixture leading to the Precipitation, which was filtered, washed with pentane (20ml) and vacuum dried. The product 2a was obtained in good yields (1.1g, 84%).

3.3.1 4,4’-(2-phenyl-[1,2,4]triazolo[1,5-a][1,3,5]triazine-5,7-diyl)dimorpholine (2a);
White solid, Yield: 85% ; $^1$H NMR (400 MHz, CDCl$_3$, $\delta$ ppm): 8.22-8.20 (m, 2H), 7.44-7.43 (m, 3H), 4.33 (s, 4H), 3.87 (t, $J = 4.40$ Hz, 8H), 3.73 (t, $J = 4.43$ Hz, 4H) ; $^{13}$C NMR (100 MHz, CDCl$_3$, $\delta$ ppm): 163.23, 161.52, 152.44, 149.05, 130.52, 130.23, 128.61, 127.42, 66.81, 66.72, 47.20, 44.70. MS $m/z$ calcd for C$_{18}$H$_{21}$N$_7$O$_2$ 367.18 found 368.0 [M + H]$^+$. Anal.Calcd for C$_{18}$H$_{21}$N$_7$O$_2$: C, 58.84; H, 5.76; N, 26.69; Found: C, 57.98; H, 6.03; N, 26.25.

3.3.2 4,4’-(2-(p-tolyl)-[1,2,4]triazolo[1,5-a][1,3,5]triazine-5,7-diyl)dimorpholine (2b):

White solid, Yield: 96% ; $^1$H NMR (400 MHz, CDCl$_3$, $\delta$ ppm): 8.08 (d, $J = 7.56$ Hz, 2H), 7.23 (d, $J = 7.31$ Hz, 2H), 4.32 (s, 4H), 3.85 (s, 8H), 3.72 (s, 4H), 2.38 (s, 3H) ; $^{13}$C NMR (100 MHz, CDCl$_3$, $\delta$ ppm): 163.73, 161.70, 159.57, 149.21, 140.51, 129.25, 127.81, 127.37, 66.79, 66.70, 47.25, 44.73, 21.51 ; MS $m/z$ calcd for C$_{19}$H$_{23}$N$_7$O$_2$ 381.19, found 382.0 [M + H]$^+$. Anal.Calced for C$_{19}$H$_{23}$N$_7$O$_2$: C, 59.83; H, 6.08; N, 25.70; Found: C, 58.31; H, 6.41; N, 25.01.

3.3.3 4,4’-(2-(4-methoxyphenyl)-[1,2,4]triazolo[1,5-a][1,3,5]triazine-5,7-diyl)dimorpholine (2c):

White solid, Yield: 85%; $^1$H NMR (400 MHz, CDCl$_3$, $\delta$ ppm): 8.20 (s, 2H), 6.90 (s, 2H), 4.34 (s, 4H), 3.95-3.85 (m, 11H), 3.75 (s, 4H) ; $^{13}$C NMR (100 MHz, CDCl$_3$, $\delta$ ppm): 161.59,
159.42, 149.10, 128.06, 122.86, 114.03, 66.84, 66.74, 55.45, 47.22, 44.73; MS \textit{m/z} calcd for C$_{19}$H$_{23}$N$_{7}$O$_{3}$ 397.19, found 398.0 [M + H]$^+$. Anal.Calcd for C$_{19}$H$_{23}$N$_{7}$O$_{3}$: C, 57.42; H, 5.83; N, 24.67; Found: C, 56.85; H, 6.08; N, 24.25.

3.3.4 4,4'-\(2-(3\text{-methoxyphenyl})-\text{[1,2,4]triazolo[1,5-a}[1,3,5]\text{triazine-5,7-diyl]}\)dimorpholine (2d);

![Chemical structure of 2d](image1)

White solid, Yield: 81% ; $^1$H NMR (400 MHz, CDCl$_3$, $\delta$ ppm): 7.77-7.75 (m, 2H), 7.32 (t, $J$ = 8.15 Hz, 1H), 6.98-6.95 (m, 1H), 4.31(s, 4H), 3.86-3.83(m, 11H), 3.72 (t, $J$ = 4.75 Hz, 4H) ; $^{13}$C NMR (100 MHz, CDCl$_3$, $\delta$ ppm): 163.52, 161.73, 159.84, 159.43, 149.07, 131.84, 129.60, 119.62, 116.76, 112.32, 66.80, 66.71, 55.53, 47.15, 43.87 ; MS \textit{m/z} calcd for C$_{19}$H$_{23}$N$_{7}$O$_{3}$ 397.19, found 398.0 [M + H]$^+$. Anal.Calcd for C$_{19}$H$_{23}$N$_{7}$O$_{3}$: C, 57.42; H, 5.83; N, 24.67; Found: C, 56.85; H, 6.08; N, 24.25.

3.3.5 4,4'-\(2-(2,3\text{-dimethoxyphenyl})-\text{[1,2,4]triazolo[1,5-a}[1,3,5]\text{triazine-5,7-diyl]}\)dimorpholine (2e);

![Chemical structure of 2e](image2)

White solid, Yield: 85% ; $^1$H NMR (400 MHz, DMSO-$d_6$, $\delta$ ppm): 7.65 (d, $J$ = 8.43 Hz, 1H), 7.59 (s, 1H), 7.06 (d, $J$ = 8.39 Hz, 1H), 4.24 (s, 4H), 3.83 (s, 3H), 3.81 (s, 3H), 3.78-3.76 (m, 4H), 3.75-3.72 (m, 4H), 3.66-3.64 (m, 4H) ; $^{13}$C NMR (100 MHz, DMSO, $\delta$ ppm): 162.24, 161.02, 158.87, 150.65, 148.66, 148.52, 122.83, 119.70, 111.64, 109.96, 65.88, 65.76, 55.54, 55.49, 46.73, 44.05; MS \textit{m/z} calcd for C$_{20}$H$_{25}$N$_{7}$O$_{4}$ 427.20, found 428.0 [M + H]$^+$. Anal.Calcd for C$_{20}$H$_{25}$N$_{7}$O$_{4}$: C, 56.20; H, 5.90; N, 22.94; Found: C, 55.82 ; H, 6.13; N, 22.68.

3.3.6 4,4'-\(2-(2,4\text{-dimethoxyphenyl})-\text{[1,2,4]triazolo[1,5-a}[1,3,5]\text{triazine-5,7-diyl]}\)dimorpholine dimorpholine (2f);
White solid, Yield: 79% ; $^1$H NMR (400 MHz, CDCl$_3$, δ ppm): 8.14 (d, $J = 8.64$ Hz, 1H), 6.59-6.53 (m, 2H), 4.34 (s, 4H), 3.94-3.93 (m, 1H), 3.89 (s, 3H), 3.86-3.84 (m, 10H), 3.73-3.71 (m, 4H); $^{13}$C NMR (100 MHz, CDCl$_3$, δ ppm): 162.58, 159.52, 159.48, 149.06, 132.81, 112.27, 105.00, 99.30, 66.73, 56.11, 55.53, 47.14, 44.61; MS m/z calcd for C$_{20}$H$_{25}$N$_7$O$_4$ 427.20, found 428.0 [M + H]$^+$. Anal.Calcd for C$_{20}$H$_{25}$N$_7$O$_4$: C, 56.20; H, 5.90; N, 22.94; Found: C, 53.88; H, 6.03; N, 21.50.

3.3.7 4,4'-(2-(2-chlorophenyl)-[1,2,4]triazolo[1,5-a][1,3,5]triazine-5,7-diyl)dimorpholine (2g):

White solid, Yield: 96% ; $^1$H NMR (400 MHz, CDCl$_3$, δ ppm): 8.20-8.17 (m, 1H ), 7.48-7.46 (m, 1H ), 7.36-7.32 (m, 2H ), 4.35 (s, 4H ), 3.84 (t, $J = 4.61$ Hz, 8H), 3.72 (t, $J = 4.61$ Hz, 4H); $^{13}$C NMR (100 MHz, CDCl$_3$, δ ppm): 161.95, 160.95, 159.55, 149.02, 132.93, 132.24, 131.06. 130.74, 129.21, 126.84, 66.82, 66.74, 47.18, 44.57; MS m/z calcd for C$_{18}$H$_{20}$ClN$_7$O$_2$ 401,14, found 402.0 [M + H]$^+$. Anal.Calcd for C$_{18}$H$_{20}$ClN$_7$O$_2$: C, 53.80; H, 5.02; N, 24.40; Found: C, 53.49; H, 5.34; N, 24.29.

3.3.8 4,4'-(2-(2-chlorophenyl)-[1,2,4]triazolo[1,5-a][1,3,5]triazine-5,7-diyl)dimorpholine (2h):

White solid, Yield: 96% ; $^1$H NMR (400 MHz, CDCl$_3$, δ ppm): 8.20-8.17 (m, 1H ), 7.48-7.46 (m, 1H ), 7.36-7.32 (m, 2H ), 4.35 (s, 4H ), 3.84 (t, $J = 4.61$ Hz, 8H), 3.72 (t, $J = 4.61$ Hz, 4H); $^{13}$C NMR (100 MHz, CDCl$_3$, δ ppm): 161.95, 160.95, 159.55, 149.02, 132.93, 132.24, 131.06. 130.74, 129.21, 126.84, 66.82, 66.74, 47.18, 44.57; MS m/z calcd for C$_{18}$H$_{20}$ClN$_7$O$_2$ 401,14, found 402.0 [M + H]$^+$. Anal.Calcd for C$_{18}$H$_{20}$ClN$_7$O$_2$: C, 53.80; H, 5.02; N, 24.40; Found: C, 53.49; H, 5.34; N, 24.29.
White solid, Yield: 93% ; $^1$H NMR (400 MHz, CDCl$_3$, $\delta$ ppm): 8.16 (s, 1H), 8.08 (d, $J = 7.11$ Hz, 1H), 7.40-7.33 (m, 2H ), 4.32 (s, 4H ), 3.86 (t, $J = 4.38$ Hz, 8H), 3.72 (t, $J = 4.63$ Hz, 4H); $^{13}$C NMR (100 MHz, CDCl$_3$, $\delta$ ppm): 162.40, 161.77, 159.42, 149.02, 134.58, 132.32, 130.35, 129.92, 127.27, 125.57, 66.79, 66.70, 47.18, 44.43 ; MS m/z calcd for C$_{18}$H$_{20}$ClN$_7$O$_2$ 401.14 found 402.0 [M + H]$^+$. Anal.Calcd for C$_{18}$H$_{20}$ClN$_7$O$_2$: C, 53.80; H, 5.02; N, 24.40; Found: C, 51.50; H, 5.59; N, 23.28.

3.3.9 4,4'-(2-(4-chlorophenyl)-[1,2,4]triazolo[1,5-a][1,3,5]triazine-5,7-diyl)dimorpholine (2i);

White solid, Yield: 95% ; $^1$H NMR (400 MHz, CDCl$_3$, $\delta$ ppm): 8.12 (d, $J = 8.70$ Hz, 2H), 7.39 (d, $J = 8.62$ Hz, 2H), 4.32 (s, 4H ), 3.86 (t, $J = 4.71$ Hz, 8H), 3.73 (t, $J = 4.75$ Hz, 4H); $^{13}$C NMR (100 MHz, CDCl$_3$, $\delta$ ppm): 162.62, 161.74, 159.45, 149.04, 136.46, 128.98, 128.87, 128.69, 66.82, 66.72, 47.22, 44.61 ; MS m/z calcd for C$_{18}$H$_{20}$ClN$_7$O$_2$ 401.14, found 402.0 [M + H]$^+$. Anal.Calcd for C$_{18}$H$_{20}$ClN$_7$O$_2$: C, 53.80; H, 5.02; N, 24.40; Found: C, 53.44; H, 5.30; N, 24.06.

3.3.10 4,4'-(2-(4-bromophenyl)-[1,2,4]triazolo[1,5-a][1,3,5]triazine-5,7-diyl)dimorpholine (2j);

White solid, Yield: 89% ; $^1$H NMR (400 MHz, CDCl$_3$, $\delta$ ppm): 8.04 (d, $J = 8.20$ Hz, 2H), 7.54 (d, $J = 8.24$ Hz, 2H), 4.31 (s, 4H ), 3.86 (t, $J = 4.39$ Hz, 8H), 3.73 (t, $J = 4.39$ Hz, 4H); $^{13}$C NMR (100 MHz, CDCl$_3$, $\delta$ ppm): 162.30, 161.51, 159.41, 148.95, 131.83, 129.18, 128.93, 124.96, 66.80, 66.70, 47.21, 44.65 ; MS m/z calcd for C$_{18}$H$_{20}$BrN$_7$O$_2$ 445.09, found
446 [M + H]⁺. Anal. Calcd for C₁₈H₂₀BrN₇O₂: C, 48.44; H, 4.52; N, 21.97; Found: C, 47.83; H, 4.75; N, 24.49.

3.3.11 4,4’-(2-(3-fluorophenyl)[1,2,4]triazolo[1,5-a][1,3,5]triazine-5,7-diyl)dimorpholine (2k):

White solid, Yield: 84% ; ¹H NMR (400 MHz, CDCl₃, δ ppm): 8.00 (d, J = 7.68 Hz, 1H), 7.87 (d, J = 9.69 Hz, 1H), 7.42-7.37 (m, 1H ), 7.14-7.10 (m, 1H ), 4.32 (s, 4H ), 3.87 (s, 8H ), 3.73 (s, 4H ); ¹³C NMR (100 MHz, CDCl₃, δ ppm): 164.19, 162.05, 161.75, 161.45, 159.42, 148.98, 132.38-132.32 (d, J_C-F = 7.97 Hz, 1C), 130.32-130.24 (d, J_C-F = 8.12 Hz, 1C), 123.24-123.21 (d, J_C-F = 2.81 Hz, 1C), 117.55-117.34 (d, J_C-F = 21.31 Hz, 1C), 114.34-114.11(d, J_C-F = 23.58 Hz, 1C), 66.81, 66.71, 47.24, 44.84; MS m/z calcd for C₁₈H₂₀FN₇O₂ 385.17 found 386.0 [M + H]⁺. Anal. Calcd for C₁₈H₂₀FN₇O₂: C, 56.10; H, 5.23; N, 25.44; Found: C, 55.58; H, 5.39; N, 25.27.

3.3.12 4,4’-(2-(4-fluorophenyl)[1,2,4]triazolo[1,5-a][1,3,5]triazine-5,7-diyl)dimorpholine (2l):

White solid Yield: 90% ; ¹H NMR (400 MHz, CDCl₃, δ ppm): 8.18 (s, 2H ), 7.10 (t, J = 8.05 Hz, 2H), 4.31 (s, 4H ), 3.85 (t, J = 4.53 Hz, 8H), 3.72 (t, J = 4.26 Hz, 4H ); ¹³C NMR (100 MHz, CDCl₃, δ ppm): 165.62, 163.13, 159.37, 129.47-129.38 (d, J_C-F = 8.52 Hz, 1C), 126.47-126.43 (d, J_C-F = 3.31 Hz, 1C), 115.83-115.62 (d, J_C-F = 21.90 Hz, 1C), 66.82, 66.72, 47.24, 44.79 ; MS m/z calcd for C₁₈H₂₀FN₇O₂ 385.17 found 386.0 [M + H]⁺. Anal. Calcd for C₁₈H₂₀FN₇O₂: C, 56.10; H, 5.23; N, 25.44; Found: C, 55.29; H, 5.47; N, 24.77.
3.3.13 4,4'-(2-(3,4-difluorophenyl)-[1,2,4]triazolo[1,5-a][1,3,5]triazine-5,7-diyl)dimorpholine (2m);

White solid, Yield: 86%; \(^1\)H NMR (400 MHz, CDCl\(_3\), \(\delta\) ppm): 8.02-7.97 (m, 2H), 7.24-7.17 (m, 1H), 4.32 (s, 4H), 3.87 (t, \(J = 4.60\) Hz, 8H), 3.73 (t, \(J = 4.60\) Hz, 4H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\), \(\delta\) ppm): 161.55-161.42 (d, \(J_{C-F} = 12.67\) Hz, 1C), 159.42, 153.28-153.16 (d, \(J_{C-F} = 12.92\) Hz, 1C), 151.79-151.66 (d, \(J_{C-F} = 12.92\) Hz, 1C), 150.78-150.65 (d, \(J_{C-F} = 12.92\) Hz, 1C), 149.32-149.20 (d, \(J_{C-F} = 12.06\) Hz, 1C), 148.96, 127.36-127.32 (d, \(J_{C-F} = 4.33\) Hz, 1C), 124.00-123.90 (q, \(J_{C-F} = 3.23\) Hz, 1C), 117.69-117.62 (d, \(J_{C-F} = 17.95\) Hz, 1C), 116.55-116.36 (d, \(J_{C-F} = 19.51\) Hz, 1C), 66.79, 66.69, 47.23, 44.81; MS m/z calcd for C\(_{18}\)H\(_{19}\)F\(_{2}\)N\(_{7}\)O\(_{2}\) 403.16 found 426.0 [M + Na]\(^+\). Anal.Calcd for C\(_{18}\)H\(_{19}\)F\(_{2}\)N\(_{7}\)O\(_{2}\): C, 53.59; H, 4.75; N, 24.31; Found: C, 53.65; H, 4.93; N, 24.33.

3.3.14 4,4'-(2-(pyridin-3-yl)-[1,2,4]triazolo[1,5-a][1,3,5]triazine-5,7-diyl)dimorpholine (2n);

Pale yellow solid, Yield: 70%; \(^1\)H NMR (400 MHz, CDCl\(_3\), \(\delta\) ppm): 9.38 (s, 1H), 8.65 (d, \(J = 3.59\) Hz, 1H), 8.46 (d, \(J = 7.90\) Hz, 1H), 7.40-7.37 (m, 1H), 4.33 (s, 4H), 3.87 (t, \(J = 5.01\) Hz, 8H), 3.73 (t, \(J = 5.01\) Hz, 4H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\), \(\delta\) ppm): 161.91, 161.46, 159.46, 150.77, 149.04, 148.35, 134.98, 126.81, 123.66, 66.78, 66.68, 47.22, 43.76; MS m/z calcd for C\(_{17}\)H\(_{20}\)N\(_{8}\)O\(_{2}\) 368.17 found 369.0 [M + H]\(^+\). Anal.Calcd for C\(_{17}\)H\(_{20}\)N\(_{8}\)O\(_{2}\): C, 55.43; H, 5.47; N, 30.42; Found: C, 54.30; H, 5.72; N, 29.70.

3.3.15 4,4'-(2-(thiophen-2-yl)-[1,2,4]triazolo[1,5-a][1,3,5]triazine-5,7-diyl)dimorpholine (2o);
Light brown solid, Yield: 77% ; $^1$H NMR (400 MHz, CDCl$_3$, $\delta$ ppm): 7.83 (d, $J = 3.46$ Hz, 1H), 7.40 (d, $J = 4.96$ Hz, 1H), 7.10 (t, $J = 4.10$ Hz, 1H), 4.30 (s, 4H), 3.86 (t, $J = 4.50$ Hz, 8H), 3.72 (t, $J = 4.64$ Hz, 4H); $^{13}$C NMR (100 MHz, CDCl$_3$, $\delta$ ppm): 161.61, 159.89, 159.50, 148.99, 133.52, 128.60, 128.18, 127.91, 66.82, 66.73, 47.17, 44.06 ; MS m/z calcd for C$_{16}$H$_{19}$N$_7$O$_2$S 373.13 found 374.0 [M + H]$^+$.

Anal.Calcd for C$_{16}$H$_{19}$N$_7$O$_2$: C, 51.46; H, 5.13; N, 26.26; Found: C, 48.80; H, 5.19; N, 24.71.

3.3.16 4,4'-(3-(4-bromophenyl)-[1,2,4]triazolo[4,3-a][1,3,5]triazine-5,7-diyl)dimorpholine (1b);

White solid, Yield: 89% ; $^1$H NMR (400 MHz, DMSO-$d_6$, $\delta$ ppm): 7.86 (d, $J = 8.46$ Hz, 2H), 7.71 (d, $J = 8.46$ Hz, 2H), 3.93 (s, 2H), 3.87 (s, 2H), 3.72 (s, 4H), 3.36-3.34 (m, 4H), 3.20-3.18 (m, 4H); $^{13}$C NMR (100 MHz, DMSO, $\delta$ ppm): 158.68, 155.07, 150.85, 142.71, 132.17, 130.69, 125.15, 124.78, 65.91, 65.70, 64.66, 49.37, 44.49 ; MS m/z (ESI) calcd for C$_{18}$H$_{20}$BrN$_7$O$_2$ 445.09, found 446.0 [M + H]$^+$.

Anal.Calcd for C$_{18}$H$_{20}$BrN$_7$O$_2$: C, 48.44; H, 4.52; N, 21.97; Found: C, 48.23; H, 4.43; N, 21.63.

3.3.17 3-(4-bromophenyl)-5,7-di(piperidin-1-yl)-[1,2,4]triazolo[4,3-a][1,3,5]triazine (3b);
White solid, Yield: 84% ; $^1$H NMR (400 MHz, CDCl$_3$, δ ppm): 7.59-7.52 (m, 4H), 3.83 (s, 4H), 3.11 (t, $J = 5.27$ Hz, 4H), 1.66-1.60 (m, 6H), 1.49-1.43 (m, 2H), 1.31-1.26 (m, 4H) ; $^{13}$C NMR (100 MHz, CDCl$_3$, δ ppm): 159.23, 158.03, 152.34, 142.80, 131.73, 129.94, 127.18, 124.01, 50.21, 24.65, 24.34, 23.76 ; MS m/z (ESI) calcd for C$_{20}$H$_{24}$BrN$_7$ 441.13, found 442.0 [M + H]$^+$. Anal.Calcd for C$_{20}$H$_{24}$BrN$_7$: C, 54.30; H, 5.47; N, 22.16; Found: C, 52.85; H, 5.43; N, 21.25.

3.3.18 5,7-di(piperidin-1-yl)-3-(thiophen-2-yl)-[1,2,4]triazolo[4,3-a][1,3,5]triazine (3c);

![Chemical Structure of 3c]

White solid, Yield: 83% ; $^1$H NMR (400 MHz, CDCl$_3$, δ ppm): 7.83 (d, $J = 3.13$ Hz, 1H), 7.36 (d, $J = 5.07$ Hz, 1H), 7.09-7.06 (m, 1H), 4.17 (s, 4H), 3.80 (s, 4H), 1.71 (s, 6H), 1.64-1.63 (m, 2H), 1.58-1.57 (m, 4H) ; $^{13}$C NMR (100 MHz, CDCl$_3$, δ ppm): 161.82, 159.31, 159.09, 148.79, 133.97, 128.17, 127.74, 127.69, 48.08, 25.98, 24.81, 24.56 ; MS m/z (ESI) calcd for C$_{18}$H$_{23}$N$_7$S 369.17 found 370.0 [M + H]$^+$. Anal.Calcd for C$_{18}$H$_{23}$N$_7$S : C, 58.51; H, 6.27; N, 26.54; Found: C, 58.09; H, 6.87; N, 26.34.

3.3.19 3-(4-bromophenyl)-5,7-bis(4-methylpiperidin-1-yl)-[1,2,4]triazolo[4,3-a][1,3,5]triazine (4b);

![Chemical Structure of 4b]

White solid, Yield: 87% ; $^1$H NMR (400 MHz, CDCl$_3$, δ ppm): 7.59-7.52 (m, 4H), 4.82-4.70 (m, 3H), 3.62-3.59 (m, 2H), 2.96-2.88 (m, 2H), 2.63 (t, $J = 12.47$ Hz, 2H), 1.72-1.65 (m, 3H), 1.43 (d, $J = 10.94$ Hz, 3H), 1.16-1.14 (m, 2H), 0.94 (d, $J = 6.12$ Hz, 3H), 0.81 (d, $J = 5.76$ Hz, 4H) ; $^{13}$C NMR (100 MHz, CDCl$_3$, δ ppm): 159.03, 158.06, 152.17, 142.78, 131.74, 130.01, 127.09, 124.10, 49.59, 33.49, 31.15, 30.35, 21.80, 21.56 ; MS m/z (ESI) calcd for
C_{22}H_{28}BrN_{7} \text{ found } 470.0 \text{ [M + H]}^+\text{. Anal.Calcd for C}_{22}H_{28}BrN_{7} : C, 56.17; H, 6.00; N, 20.84; Found: C, 54.23; H, 5.90; N, 20.11.

3.3.20 3-(4-(benzyloxy)phenyl)-5,7-bis(4-methylpiperidin-1-yl)-[1,2,4]triazolo[4,3-a][1,3,5]triazine (4c);

White solid, Yield: 88% ; \textsuperscript{1}H NMR (400 MHz, CDCl\textsubscript{3}, \delta ppm): 7.57 (d, J = 8.60 Hz, 2H), 7.43-7.35 (m, 4H), 7.32 (d, J = 7.05 Hz, 1H), 7.04 (d, J = 8.68 Hz, 2H), 5.11 (s, 2H), 4.82-4.60 (m, 2H), 4.60-4.33 (m, 1H), 3.64 (d, J = 12.59 Hz, 2H), 2.92 (s, 2H), 2.62 (t, J = 12.22 Hz, 2H), 1.73-1.63 (m, 3H), 1.42 (d, J = 10.87 Hz, 3H), 1.21-1.15 (m, 2H), 0.95 (d, J = 6.28 Hz, 3H), 0.81 (d, J = 6.05 Hz, 4H) ; \textsuperscript{13}C NMR (100 MHz, CDCl\textsubscript{3}, \delta ppm): 160.10, 158.12, 158.07, 152.21, 143.49, 136.45, 130.11, 128.73, 128.23, 127.51, 120.60, 115.03, 70.26, 49.67, 32.54, 31.14, 30.33, 21.80, 21.61 ; MS m/z (ESI) calcd for C_{29}H_{35}N_{7}O 497.29, found 498.0 [M + H]^+\text{. Anal.Calcd for C}_{29}H_{35}N_{7}O : C, 69.99; H, 7.09; N, 19.70; Found: C, 67.22; H, 7.20; N, 18.89.

3.3.21 5,7-bis(4-methylpiperidin-1-yl)-3-(p-tolyl)-[1,2,4]triazolo[4,3-a][1,3,5]triazine (4d);

White solid, Yield: 89% ; \textsuperscript{1}H NMR (400 MHz, CDCl\textsubscript{3}, \delta ppm): 7.53 (d, J = 7.90 Hz, 2H), 7.27 (d, J = 7.64 Hz, 2H), 4.86-4.73 (m, 2H), 4.52-4.29 (m, 1H), 3.67-3.64 (m, 2H), 2.99-2.90 (m, 2H), 2.64 (t, J = 12.48 Hz, 2H), 1.42 (s, 3H), 1.76-1.64 (m, 3H), 1.43 (d, J = 11.76 Hz, 3H), 1.23-1.14 (m, 2H), 0.98 (d, J = 6.41 Hz, 3H), 0.81 (d, J = 6.00 Hz, 4H) ; \textsuperscript{13}C NMR (100 MHz, CDCl\textsubscript{3}, \delta ppm): 158.31, 128.12, 152.18, 149.77, 140.19, 129.28, 128.49, 125.08, 49.64, 32.46, 31.15, 30.30, 21.80, 21.57, 21.51 ; MS m/z (ESI) calcd for C_{23}H_{31}N_{7} 405.26,
3.3.22 2-phenyl-5,7-di(piperidin-1-yl)-[1,2,4]triazolo[1,5-a][1,3,5]triazine (5a);

![Structure of 2-phenyl-5,7-di(piperidin-1-yl)-[1,2,4]triazolo[1,5-a][1,3,5]triazine (5a)](attachment)

White solid, Yield: 89% ; $^1$H NMR (400 MHz, CDCl$_3$, δ ppm): 8.26-8.24 (m, 2H), 7.44-7.43 (m, 3H), 4.23 (s, 4H), 3.83(s, 4H), 1.75 (s, 6H), 1.67-1.66 (m, 2H), 1.61-1.60 (m, 4H) ; $^{13}$C NMR (100 MHz, CDCl$_3$, δ ppm): 161.85, 159.31, 148.91, 130.71, 130.15, 128.50, 127.36, 48.15, 45.26, 26.04, 25.93, 24.85, 24.60; MS m/z (ESI) calcd for C$_{20}$H$_{25}$N$_7$ 363.22, found 364.0 [M + H]$^+$. Anal.Calcd for C$_{20}$H$_{25}$N$_7$: C, 66.09; H, 6.93; N, 26.98; Found: C, 65.16; H, 7.23; N, 26.76.

3.3.23 2-(2-chlorophenyl)-5,7-di(piperidin-1-yl)-[1,2,4]triazolo[1,5-a][1,3,5]triazine (5b);

![Structure of 2-(2-chlorophenyl)-5,7-di(piperidin-1-yl)-[1,2,4]triazolo[1,5-a][1,3,5]triazine (5b)](attachment)

White solid, Yield: 92% ; $^1$H NMR (400 MHz, CDCl$_3$, δ ppm): 8.23-8.21 (m, 1H ), 7.47-7.46 (m, 1H ), 7.33-7.31 (m, 2H ), 4.24 (s, 4H ), 3.82 (s, 4H ), 1.73 (s, 6H ), 1.67-1.64 (m, 2H ), 1.60-1.59 (m, 4H ); $^{13}$C NMR (100 MHz, CDCl$_3$, δ ppm): 161.35, 161.30, 159.35, 148.79, 132.85, 132.13, 130.90, 130.29, 126.66, 126.62, 48.07, 45.25, 26.03, 25.87, 24.79, 24.53; MS m/z (ESI) calcd for C$_{20}$H$_{24}$ClN$_7$ 397.18, found 398.0 [M + H]$^+$. Anal.Calcd for C$_{20}$H$_{24}$ClN$_7$: C, 60.37; H, 6.08; N, 24.64; Found: C, 65.16; H, 6.72; N, 26.58.

3.3.24 2-(4-chlorophenyl)-5,7-di(piperidin-1-yl)-[1,2,4]triazolo[1,5-a][1,3,5]triazine (5c);
White solid, Yield: 91% ; \( ^1\text{H} \text{NMR} \) (400 MHz, CDCl\(_3\), \( \delta \) ppm): 8.17 (d, \( J = 8.41 \) Hz, 2H), 7.40 (d, \( J = 8.33 \) Hz, 2H), 4.21 (s, 4H ), 3.83 (s, 4H ), 1.75 (s, 6H ), 1.67-1.66 (m, 2H ), 1.60-1.59 (m, 4H ); \( ^{13}\text{C} \text{NMR} \) (100 MHz, CDCl\(_3\), \( \delta \) ppm): 162.12, 161.99, 159.26, 148.84, 135.90, 129.55, 128.66, 128.55, 48.07, 45.21, 25.99, 25.89, 24.80, 24.54; MS \( m/z \) (ESI) calcd for C\(_{20}\)H\(_{24}\)ClN\(_7\) 397.18, found 398.0 \([M + H]^+\). Anal.Calcd for C\(_{20}\)H\(_{24}\)ClN\(_7\) : C, 60.37; H, 6.08; N, 24.64; Found: C, 59.89; H, 6.27; N, 24.47.

3.3.25 2-(4-bromophenyl)-5,7-di(piperidin-1-yl)-[1,2,4]triazolo[1,5-a][1,3,5]triazine (5d);

White solid, Yield: 87% ; \( ^1\text{H} \text{NMR} \) (400 MHz, CDCl\(_3\), \( \delta \) ppm): 8.11 (d, \( J = 8.38 \) Hz, 2H), 7.56 (d, \( J = 8.43 \) Hz, 2H), 4.21 (s, 4H ), 3.83 (s, 4H ), 1.75 (s, 6H ), 1.67-1.66 (m, 2H ), 1.60-1.59 (m, 4H ); \( ^{13}\text{C} \text{NMR} \) (100 MHz, CDCl\(_3\), \( \delta \) ppm): 161.93, 161.77, 159.27, 148.83, 131.70, 129.78, 128.87, 124.48, 48.15, 45.35, 26.02, 25.92, 24.83, 24.57 ; MS \( m/z \) (ESI) calcd for C\(_{20}\)H\(_{24}\)BrN\(_7\) 441.13, found 442.0 \([M + H]^+\). Anal.Calcd for C\(_{20}\)H\(_{24}\)BrN\(_7\) : C, 54.30; H, 5.47; N, 22.16; Found: C, 54.40; H, 5.77; N, 21.95.

3.3.26 2-(3-fluorophenyl)-5,7-di(piperidin-1-yl)-[1,2,4]triazolo[1,5-a][1,3,5]triazine (5e);

White solid, Yield: 86% ; \( ^1\text{H} \text{NMR} \) (400 MHz, CDCl\(_3\), \( \delta \) ppm): 8.04 (s, 1H ), 7.72 (d, \( J = 9.34 \) Hz, 1H), 7.42-7.37 (m, 1H ), 7.11 (t, \( J = 8.33 \) Hz, 1H), 4.21 (s, 4H ), 3.83 (s, 4H ), 1.75 (s, 6H ), 1.67-1.66 (m, 2H ), 1.60-1.59 (m, 4H ); \( ^{13}\text{C} \text{NMR} \) (100 MHz, CDCl\(_3\), \( \delta \) ppm): 164.17, 161.74, 159.26, 148.89, 133.16-133.07 (d, \( J_{CF} = 8.87 \) Hz, 1C), 130.12-130.04 (d, \( J_{CF} = 8.20 \) Hz, 1C).
Hz, 1C), 123.06-123.04 (d, $J_{C-F} = 2.82$ Hz, 1C), 117.02-116.80 (d, $J_{C-F} = 21.59$ Hz, 1C),
114.20-113.97 (d, $J_{C-F} = 23.27$ Hz, 1C), 48.15, 45.23, 26.02, 25.91, 24.82, 24.56 ; MS m/z
(ESI) calcd for C$_{20}$H$_{24}$FN$_{7}$ 381.21, found 382.0 [M + H]$^+$. Anal. Calcd for C$_{20}$H$_{24}$FN$_{7}$:
C, 62.97; H, 6.34; N, 25.70; Found: C, 62.68; H, 6.47; N, 25.56.

3.3.27 5,7-bis(4-methylpiperidin-1-yl)-2-phenyl-[1,2,4]triazolo[1,5-a][1,3,5]triazine (6a);

White solid, Yield: 88% ; $^1$H NMR (400 MHz, CDCl$_3$, $\delta$ ppm): 8.23-8.21 (m, 2H), 7.43-7.41
(m, 3H), 5.34 (s, 2H), 4.80-4.61 (m, 2H), 3.10 (t, $J = 12.44$ Hz, 2H), 2.86 (t, $J = 12.44$ Hz,
2H), 1.82-1.59 (m, 6H), 1.38-1.28 (m, 2H), 1.20-1.10 (m, 2H), 0.99 (d, $J = 6.24$ Hz, 3H),
0.95 (d, $J = 6.44$ Hz, 3H) ; $^{13}$C NMR (100 MHz, CDCl$_3$, $\delta$ ppm): 162.97, 162.10, 159.30,
148.94, 130.99, 130.02, 128.45, 127.28, 47.39, 44.62, 34.21, 31.31, 31.13, 21.94, 21.78; MS
m/z (ESI) calcd for C$_{24}$H$_{29}$N$_{7}$ 391.25, found 392.0 [M + H]$^+$. Anal.Calcd for C$_{24}$H$_{29}$N$_{7}$: C,
67.49; H, 7.47; N, 25.04; Found: C, 66.13; H, 7.88; N, 24.51.

3.3.28 2-(4-fluorophenyl)-5,7-bis(4-methylpiperidin-1-yl)-[1,2,4]triazolo[1,5-a][1,3,5]triazine (6b);

White solid, Yield: 86% ; $^1$H NMR (400 MHz, CDCl$_3$, $\delta$ ppm): 8.23-8.20 (m, 2H), 7.13-7.08
(m, 2H), 5.32 (s, 2H), 4.83-4.59 (m, 2H), 3.11 (t, $J = 12.63$ Hz, 2H), 2.87 (t, $J = 12.63$ Hz,
2H), 1.82-1.60 (m, 6H), 1.38-1.28 (m, 2H), 1.20-1.10 (m, 2H), 0.99 (d, $J = 6.34$ Hz, 3H),
0.95 (d, $J = 6.34$ Hz, 3H) ; $^{13}$C NMR (100 MHz, CDCl$_3$, $\delta$ ppm): 165.33, 162.85, 162.08,
159.27, 148.87, 129.29-129.21 (d, $J_{C-F} = 8.63$ Hz, 1C), 127.20-127.17 (d, $J_{C-F} = 3.05$ Hz, 1C),
115.56-115.34 (d, $J_{C-F} = 21.93$ Hz, 1C), 47.38, 44.67, 34.18, 31.28, 31.10, 21.92, 21.75 ; MS
m/z (ESI) calcd for C_{22}H_{28}FN_{7}, 409.24, found 410.0 [M + H]^+. Anal. Calcd for C_{22}H_{28}FN_{7}: C, 64.53; H, 6.89; N, 23.94; Found: C, 63.64; H, 6.93; N, 23.50.

3.3.29 2-(4-chlorophenyl)-5,7-bis(4-methylpiperidin-1-yl)-[1,2,4]triazolo[1,5-a][1,3,5]triazine (6c);

White solid, Yield: 90%; FTIR (ATR, V_{max}, cm^{-1}): 3470.65 (Amide N-H Str.), 2919.78 (Alkyl C-H Str.), 1628.03 (Amide C=O Str.); ¹H NMR (400 MHz, CDCl₃, δ ppm): 8.16 (d, J = 8.54 Hz, 2H), 7.39 (d, J = 8.42 Hz, 2H), 5.31 (s, 2H), 4.84-4.73 (m, 2H), 3.11 (t, J = 12.57 Hz, 2H), 2.87 (t, J = 12.26 Hz, 2H), 1.83-1.60 (m, 6H), 1.38-1.28 (m, 2H), 0.99 (d, J = 6.38 Hz, 3H), 0.95 (d, J = 6.31 Hz, 3H); ¹³C NMR (100 MHz, CDCl₃, δ ppm): 161.73, 159.27, 138.82, 136.23, 129.11, 128.82, 128.71, 147.50, 47.50, 44.75, 34.23, 31.31, 31.14, 21.95, 21.79; MS m/z (ESI) calcd for C_{22}H_{28}ClN_{7}, 425.21, found 426.0 [M + H]^+. Anal. Calcd for C_{22}H_{28}ClN_{7}: C, 62.03; H, 6.63; N, 23.02; Found: C, 61.78; H, 6.67; N, 22.87.

3.3.30 (E)-4,4’-(2-styryl-[1,2,4]triazolo[1,5-a][1,3,5]triazine-5,7-diyl)dimorpholine (7a);

White solid, Yield: 84%; ¹H NMR (400 MHz, CDCl₃, δ ppm): 7.83 (d, J = 16.15 Hz, 1H), 7.54 (d, J = 7.18 Hz, 2H), 7.37-7.34 (m, 2H), 7.30 (d, J = 7.15 Hz, 1H), 6.98 (d, J = 16.12 Hz, 1H), 4.28 (s, 4H), 3.84 (t, J = 4.74 Hz, 8H), 3.72 (t, J = 4.99 Hz, 4H); ¹³C NMR (100 MHz, CDCl₃, δ ppm): 163.28, 161.19, 159.53, 149.03, 138.04, 136.21, 128.96, 128.84, 127.40, 117.21, 66.81, 66.72, 47011, 44.60; MS m/z (ESI) calcd for C_{20}H_{23}N_{7}O_{2}, 393.19, found 394.0 [M + H]^+. Anal. Calcd for C_{20}H_{23}N_{7}O_{2}: C, 61.05; H, 5.89; N, 24.92; Found: C, 59.83; H, 6.18; N, 23.93.

3.3.31 (E)-4,4’-(2-(2-phenylprop-1-en-1-yl)-[1,2,4]triazolo[1,5-a][1,3,5]triazine-5,7-diyl)dimorpholine (7a)
**dimorpholine (7b):**

![dimorpholine structure](image)

White solid, Yield: 82%; \(^1\)H NMR (400 MHz, CDCl\(_3\), \(\delta\) ppm): 7.90 (s, 1H), 7.44-7.43 (m, 2H), 7.36 (t, \(J = 7.56\) Hz, 2H), 7.27-7.24 (m, 1H), 4.30 (s, 4H), 3.84 (t, \(J = 4.61\) Hz, 8H), 3.72 (t, \(J = 4.80\) Hz, 4H), 2.32 (s, 3H); \(^1^3\)C NMR (100 MHz, CDCl\(_3\), \(\delta\) ppm): 166.25, 161.24, 159.50, 149.05, 137.19, 133.52, 129.65, 128.31, 127.40, 127.20, 66.79, 66.69, 47.10, 44.60, 14.51; MS \(m/z\) (ESI) calcd for C\(_{21}\)H\(_{25}\)N\(_7\)O\(_2\) 407.21, found 408.0 [M + H]\(^{+}\). Anal. Calcd for C\(_{21}\)H\(_{25}\)N\(_7\)O\(_2\): C, 61.90; H, 6.18; N, 24.06; Found: C, 59.25; H, 6.63; N, 22.84.

4. **References:**

1. El-faham A, Soliman SM, Ghabbour HA, Albericio F. Ultrasonic promoted synthesis of novel s-triazine-Schiff base derivatives; molecular structure, spectroscopic studies and their preliminary anti-proliferative activities. *J Mol Struct.* 2016;1125:121-135. doi:10.1016/j.molstruc.2016.06.061
5. X-ray crystallographic structures of 2e.

**Method of crystallization:** The compound 2e was dissolved in isopropanol in a conical flask and heated till the solution was reduced to half. The hot solution was then closed using aluminium foil and kept in dark for slow evaporation. The slow evaporation of the solutions leads to the formation of crystals which were further taken for the X-ray crystallographic studies.

![Crystal structure of 2e](image-url)

**Figure S2.** Crystal structure of 2e (CCDC No. 2053179)
**Table S1:** X-ray crystallographic data and structure refinement.

| Identification code  | **2e**  |
|----------------------|---------|
| Empirical formula    | C_{20}H_{25}N_{7}O_{4} |
| Formula weight       | 427.47  |
| Temperature/K        | 150.0   |
| Crystal system       | monoclinic |
| Space group          | P2_1/n  |
| a/Å                  | 11.320(3) |
| b/Å                  | 12.339(3) |
| c/Å                  | 15.403(4) |
| α/°                  | 90      |
| β/°                  | 109.964(14) |
| γ/°                  | 90      |
| Volume/Å³            | 2022.3(9) |
| Z                    | 4       |
| ρ_{calc} g/cm³       | 1.404   |
| μ/mm⁻¹               | 0.101   |
| F(000)               | 904.0   |
| Crystal size/mm³     | 0.23 × 0.17 × 0.08 |
| Radiation            | MoKα (λ = 0.71073) |
| 2Θ range for data collection/° | 3.9 to 52.346 |
| Index ranges         | -8 ≤ h ≤ 14, -15 ≤ k ≤ 12, -19 ≤ l ≤ 19 |
| Reflections collected| 13314   |
| Independent reflections| 3995 [R_{int} = 0.0206, R_{sigma} = 0.0228] |
| Data/restraints/parameters | 3995/0/282 |
| Goodness-of-fit on F² | 1.031   |
| Final R indexes [I≥2σ (I)] | R₁ = 0.0384, wR₂ = 0.0979 |
| Final R indexes [all data] | R₁ = 0.0507, wR₂ = 0.1064 |
| Largest diff. peak/hole / e Å⁻³ | 0.33/-0.21 |
8. NMR Spectra: $^1$H NMR, $^{13}$C NMR and Mass spectra

$^1$H NMR spectrum for schiff base (CDCl$_3$, 400 MHz)

$^{13}$C NMR spectrum for schiff base (CDCl$_3$, 100 MHz)
Mass spectrum for schiff base

$^1$H NMR spectrum for compound 2a (CDCl$_3$, 400 MHz)
$^{13}$C NMR spectrum for compound 2a (CDCl$_3$, 100 MHz)

Mass spectrum for 2a
$^1$H NMR spectrum for compound $2b$ (CDCl$_3$, 400 MHz)

$^{13}$C NMR spectrum for compound $2b$ (CDCl$_3$, 100 MHz)
Mass spectrum for 2b

$^1$H NMR spectrum for compound 2c (CDCl$_3$, 400 MHz)
$^{13}$C NMR spectrum for compound 2c (CDCl$_3$, 100 MHz)

Mass spectrum for 2c
$^1$H NMR spectrum for compound 2d (CDCl$_3$, 400 MHz)

$^{13}$C NMR spectrum for compound 2d (CDCl$_3$, 100 MHz)
Mass spectrum for 2d

$^{1}H$ NMR spectrum for compound 2e (DMSO-d6, 400 MHz)
$^{13}$C NMR spectrum for compound 2e (DMSO-d$_6$, 100 MHz)

Mass spectrum for 2e
$^1$H NMR spectrum for compound 2f (CDCl$_3$, 400 MHz)

$^{13}$C NMR spectrum for compound 2f (CDCl$_3$, 100 MHz)
Mass spectrum for \( 2^f \)

\(^1\)H NMR spectrum for compound \( 2^g \) (CDCl\(_3\), 400 MHz)
$^{13}$C NMR spectrum for compound 2g (CDCl$_3$, 100 MHz)

Mass spectrum for 2g
$\text{H NMR spectrum for compound } 2h \text{ (CDCl}_3\text{, 400 MHz)}$

$\text{13C NMR spectrum for compound } 2h \text{ (CDCl}_3\text{, 100 MHz)}$
Mass spectrum for 2h

$^{1}$H NMR spectrum for compound 2i (CDCl$_3$, 400 MHz)
$^{13}$C NMR spectrum for compound 2i (CDCl$_3$, 100 MHz)

Mass spectrum for 2i
$^{1}H$ NMR spectrum for compound 2j (CDCl$_3$, 400 MHz)

$^{13}C$ NMR spectrum for compound 2j (CDCl$_3$, 100 MHz)
Mass spectrum for 2j

$^1$H NMR spectrum for compound 2k (CDCl$_3$, 400 MHz)
$^{13}$C NMR spectrum for compound 2k (CDCl$_3$, 100 MHz)

Mass spectrum for 2k
**1H NMR spectrum for compound 2l (CDCl₃, 400 MHz)**

**13C NMR spectrum for compound 2l (CDCl₃, 100 MHz)**
Mass spectrum for 2i

NMR spectrum for compound 2m (CDCl₃, 400 MHz)
$^{13}$C NMR spectrum for compound 2m (CDCl$_3$, 100 MHz)

Mass spectrum for 2m
S42

H NMR spectrum for compound 2n (CDCl₃, 400 MHz)

C NMR spectrum for compound 2n (CDCl₃, 100 MHz)
Mass spectrum for 2n

\(^1\)H NMR spectrum for compound 2o (CDCl\(_3\), 400 MHz)
$^{13}$C NMR spectrum for compound 2o (CDCl$_3$, 100 MHz)

Mass spectrum for 2o
$^1$H NMR spectrum for compound 1b (DMSO-$d_6$, 400 MHz)

$^{13}$C NMR spectrum for compound 1b (DMSO-$d_6$, 100 MHz)
Mass spectrum for 1b

\[ 1^1H \text{ NMR spectrum for compound } 3b \text{ (CDCl}_3, \text{ 400 MHz}) \]
$^{13}$C NMR spectrum for compound 3b (CDCl$_3$, 100 MHz)

Mass spectrum for 3b
H NMR spectrum for compound 3c (CDCl₃, 400 MHz)

C NMR spectrum for compound 3c (CDCl₃, 100 MHz)

^13^C NMR spectrum for compound 3e (CDCl₃, 100 MHz)
Mass spectrum for 3c

$^1$H NMR spectrum for compound 4b (CDCl$_3$, 400 MHz)
$^{13}$C NMR spectrum for compound 4b (CDCl$_3$, 100 MHz)

Mass spectrum for 4b
$^1$H NMR spectrum for compound 4c (CDCl$_3$, 400 MHz)

$^{13}$C NMR spectrum for compound 4c (CDCl$_3$, 100 MHz)
Mass spectrum for 4c

NMR spectrum for compound 4d (CDCl₃, 400 MHz)
C NMR spectrum for compound 4d (CDCl$_3$, 100 MHz)

Mass spectrum for 4d
$^{1}H$ NMR spectrum for compound 5a (CDCl$_3$, 400 MHz)

$^{13}C$ NMR spectrum for compound 5a (CDCl$_3$, 100 MHz)
Mass spectrum for 5a

$^1$H NMR spectrum for compound 5b (CDCl$_3$, 400 MHz)
$^{13}$C NMR spectrum for compound 5b (CDCl$_3$, 100 MHz)

Mass spectrum for 5b
$^1$H NMR spectrum for compound 5c (CDCl$_3$, 400 MHz)

$^{13}$C NMR spectrum for compound 5c (CDCl$_3$, 100 MHz)
Mass spectrum for 5c

$^1$H NMR spectrum for compound 5d (CDCl$_3$, 400 MHz)
$^{13}$C NMR spectrum for compound 5d (CDCl$_3$, 100 MHz)

Mass spectrum for 5d
$^1$H NMR spectrum for compound 5e (CDCl$_3$, 400 MHz)

$^{13}$C NMR spectrum for compound 5e (CDCl$_3$, 100 MHz)
Mass spectrum for 5e

$^1$H NMR spectrum for compound 6a (CDCl$_3$, 400 MHz)
$^{13}$C NMR spectrum for compound 6a (CDCl$_3$, 100 MHz)

Mas spectrum for 6a
$^1$H NMR spectrum for compound 6b (CDCl$_3$, 400 MHz)

$^1$C NMR spectrum for compound 6b (CDCl$_3$, 100 MHz)
Mass spectrum for 6b

$^1$H NMR spectrum for compound 6c (CDCl$_3$, 400 MHz)
$^{13}$C NMR spectrum for compound 6c (CDCl$_3$, 100 MHz)

Mass spectrum for 6c
$^1$H NMR spectrum for compound 7a (CDCl$_3$, 400 MHz)

$^{13}$C NMR spectrum for compound 7a (CDCl$_3$, 100 MHz)
Mass spectrum for 7a

H NMR spectrum for compound 7b (CDCl₃, 400 MHz)
$^3$C NMR spectrum for compound 7b (CDCl$_3$, 100 MHz)

Mass spectrum for 7b
INSTALLATION TEST - 25_03_2019

varioELcube serial number: 19181072

Text report

| No | Name   | Manuscript Compound ID | C [%] | H [%] | N [%] | S [%] |
|----|--------|------------------------|-------|-------|-------|-------|
| 01 | DIM_109| 5d                     | 54.40 | 5.771 | 21.95 | 0.719 |
| 02 | DIM_110| 5c                     | 59.89 | 6.273 | 24.47 | 0.442 |
| 03 | DIM_140| 5b                     | 65.02 | 6.722 | 26.58 | 0.332 |
| 04 | DIM_401| 6c                     | 61.78 | 6.674 | 22.87 | 0.219 |
| 05 | DS_02/06| 1b                     | 39.90 | 4.282 | 18.30 | 0.195 |
| 06 | DS_101 | 3b                     | 52.85 | 5.437 | 21.25 | 0.122 |
| 07 | DS_201 | 4b                     | 54.23 | 5.904 | 20.11 | 0.109 |
| 08 | DIM_18 | 2k                     | 55.58 | 5.398 | 25.27 | 0.131 |
| 09 | DIM_25 | 2l                     | 55.29 | 5.471 | 24.77 | 0.115 |
| 10 | DIM_27 | 2m                     | 53.65 | 4.930 | 24.33 | 0.146 |
| 11 | DIM_106| 5e                     | 62.68 | 6.475 | 25.56 | 0.170 |
| 12 | DIM_403| 6b                     | 63.64 | 6.931 | 23.50 | 0.214 |

Name: eassuperuser, Access: varioELcube superuser  
Mon May 10 18:34:43 2021 varioEL cube V4.0.16 (366251fb2)2018-07-25, CHNS Mode, Ser. No.: 19181072

Elementar Analysensysteme GmbH

INSTALLATION TEST - 25_03_2019

varioELcube serial number: 19181072

Text report

| No | Name   | Manuscript Compound ID | C [%] | H [%] | N [%] | S [%] |
|----|--------|------------------------|-------|-------|-------|-------|
| 14 | DIM_01 | 2a                     | 57.98 | 6.031 | 26.25 | 0.441 |
| 15 | DIM_02 | 2h                     | 51.50 | 5.592 | 23.28 | 0.126 |
| 16 | DIM_03 | 2g                     | 53.49 | 5.348 | 24.29 | 0.089 |
| 17 | DIM_04 | 2i                     | 53.44 | 5.300 | 24.06 | 0.088 |
| 18 | DIM_06 | 2n                     | 54.30 | 5.720 | 29.70 | 0.062 |
| 19 | DIM_10 | 2o                     | 48.80 | 5.195 | 24.71 | 0.731 |
|   |      |   |   |   |   |
|---|------|---|---|---|---|
| 20 | DIM_11 | 2j | 47.83 | 4.752 | 21.49 | 0.125 |
| 21 | DIM_15 | 2e | 55.82 | 6.134 | 22.68 | 0.052 |
| 22 | DIM_17 | 2f | 53.88 | 6.034 | 21.50 | 0.041 |
| 23 | DIM_19 | 2c | 56.85 | 6.081 | 24.25 | 0.026 |
| 24 | DIM_20 | 2d | 56.57 | 6.152 | 24.28 | 0.020 |
| 25 | DIM_16 | 2b | 58.31 | 6.417 | 25.01 | 0.015 |
| 26 | CN_01  | 7a | 59.83 | 6.184 | 23.93 | 0.017 |
| 27 | CN_02  | 7b | 59.25 | 6.630 | 22.84 | 0.014 |
| 28 | DIM_113 | 5a | 65.16 | 7.236 | 26.76 | 0.009 |
| 29 | DIM_404 | 6a | 66.13 | 7.888 | 24.51 | 0.009 |
| 30 | DS_103 | 3c | 68.09 | 6.875 | 19.84 | 0.013 |
| 31 | DS_203 | 4c | 67.22 | 7.209 | 18.89 | 0.011 |
| 32 | DS_202 | 4d | 64.64 | 7.752 | 22.64 | 0.016 |
| 33 | M_PIPE | 5b | 58.72 | 9.272 | 31.73 | 0.010 |

Parameter report

| Temperatures                  |       |
|-------------------------------|-------|
| Pyrol.tube                    | 1170  |
| CO col.standby                | 40    |
| Desorpt.Mid.                  | 40    |
| Cool temp                     | 60    |

**Figure S2.** Elemental analysis report