Metal-free C(sp³)–H functionalization (C–C and C–N bond formation) of 1,2,3,4-tetrahydroacridines using Deep Eutectic solvent as catalyst and reaction medium

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c Academy of Scientific and Innovative Research (AcSIR), Ghaziabad-201 002, India

1. General: All the solvents and required chemicals were procured from SD-Fine, Sigma-Aldrich, and Spectrochem, and used without purification and distillation. 1H and 13C-NMR spectra were recorded on Bruker Avance 400 MHz spectrometers using CDCl3 and DMSO-d6 as solvents and reported in δ ppm. The mass spectra of all the compounds were record using Agilent Technologies-6530.

2. Experimental section:

Synthesis of 1,2,3,4- tetrahydroacridine derivatives (1a-1p, 1r, 1s,1u)

General procedure for synthesis of compound (1a):1

In a round bottom flask equipped with a magnetic stir bar, 2-nitrobenzaldehyde (5.0 mmol) was dissolved in EtOH (15 mL). Iron powder (4.0 equiv) and 0.1 N HCl (5.0 mol %, 2.5 mL) were added and the mixture was stirred at 95 °C for 40 min. The contents were cooled to room temperature and cyclohexanone (1.0 equiv) was added followed by addition of powdered KOH (1.2 equiv). Heating was continued at 95 °C for another 30 min. The reaction mixture was then filtered through celite pad. The resulting filtrate was diluted with water and extracted using dichloromethane (310 mL). The combined organic layers were further washed with brine, dried over Na2SO4 and concentrated under reduced pressure. Purification by silica gel chromatography (hexane/EtOAc) afforded 1a as yellow solid in 90% yield.

General procedure for synthesis of compound (1b-1f, 1n,1o,1q,1r):2

1.53g of Deep Eutectic Solvent (DES) was prepared by heating N,N'-dimethyl urea (0.975g) + L-tartaric acid (0.555g) at 80 °C for 30 min. To this melt, 2- aminoacetophenone/2-aminobenzophenone derivatives (0.231g, 1 mmol) and cyclohexanone/1,3-cyclohexadione/1,3-diketone was added and heating continued for another 1-2 h at 80 °C to give the (1b-1f,1n,1o,1q,1r)

General procedure for synthesis of compound (1g-1i):3

POCl3 (25 mL) was added dropwise using a constant pressure dropping funnel to an ice-cooled mixture of anthranilic acid (3.2 g, 23.3 mmol) and cyclohexanone (2.65 mL, 27 mmol). Then, the reaction mixture was heated at 100 °C for 3 h. After the reaction was completed, the reaction mixture was cold to rt. Then the solvent was reduced in a vacuum and the ethyl acetate was...
added to residue and neutralized with 1 N K$_2$CO$_3$ solution, and brine, and the organic layer was dried over anhydrous Na$_2$SO$_4$. The residue was purified by silica gel chromatography to yield the desired product (4) as a yellow solid.

**General procedure for synthesis of compound (1j-1l):**

1,2,3,4-tetrahydroacridine-9-carboxylic acid (0.98 g, 3 mmol) and potassium carbonate (2.07 g, 15 mmol) were weighed into a round-bottom flask. Methyl iodide / propargylbromide/ benzylbromide (3 equiv) and acetone (4 mL) were added. The reaction mixture was stirred at room temperature. The progress of the reaction was monitored by TLC. The reaction was completed after 5 h. The solvent was evaporated in vacuo and water was added to the remaining mixture. The product was collected by suction filtration and air-dried. The crude product was separated on a silica gel column to obtain desired product (1j-1l).

**General procedure for synthesis of compound (1m):**

To a solution of 1,2,3,4-tetrahydroacridine-9-carboxylic acid (3.2 mmol) in DMF (10 mL) DMAP (9.7 mmol) was added and cooled to 0 °C. Then EDC·HCl (6.5 mmol), HOBt (6.5 mmol) and toluidine (4.9 mmol) were added and resulting mixture was stirred at room temperature for 30 minutes.

**General procedure for synthesis of compound (1p):**

In a 25-mL round-bottom flask, the mixture of isatins (1.0 g, 6.8 mmol), cyclohexanone (2.15 g, 13.6 mmol), conc.H$_2$SO$_4$ (1.0 mL, 18.4 mmol), and EtOH (10 mL) was stirred at 80 °C for 1.5 h, and monitored by thin-layer chromatography (TLC) until the staring material to show complete consumption. The mixture was cooled to room temperature, the alcohols were evaporated in vacuo, and then water was added. The mixture was extracted with ethyl acetate (EtOAc). The organic phase was washed with brine, dried with sodium sulfate (Na$_2$SO$_4$), and concentrated. The residue was purified by column chromatography on silica gel (5–25% ethyl acetate in petroleum ether) to get the desired product.

**General procedure for synthesis of compound (3):**

Deep eutectic solvent was prepared by heating Cholinechloride + L-tartaric acid (1:2 ratio) at 80 °C for 30 min. To this, 1,2,3,4- tetrahydro acridine 1 (0.545 mmol) and dialkylazodicarboxylate 2 (0.545 mmol) were added and heating continued for another 30 min to 2 hours at 80 °C. The completion of reaction was monitored by TLC. After completion of reaction the crude products obtained were purified by column chromatography on silica gel using petroleum ether-ethyl acetate as eluent to give the compound 3.

**General procedure for synthesis of compound (5):**

Deep eutectic solvent was prepared by heating N, N'-dimethyl urea + L-tartaric acid (3:1 ratio) at 80 °C for 30 min. To this, compound 1 (0.545 mmol) and N- phenyl maleimide (0.545 mmol) were added and heating continued 2 hours at 80 °C. The completion of reaction was monitored by TLC. After completion of reaction the crude products obtained were purified by column chromatography on silica gel using petroleum ether-ethyl acetate as eluent to give the compound 5.
3. Recycling experiments

To check the recyclability of DES [i.e., ChCl/L- (+)-TA (1:2) or DMU/ L- (+)-TA (3:1)], experiments were conducted to extract DES from the reaction mixture using liquid-to-liquid extraction method and this was followed by evaporation of aqueous layer. The recovered DES was then vacuum-dried and utilized to conduct the model reaction in the subsequent run. Interestingly it was noted that DES was stable even after four consecutive runs to give the desired products 3e or 5e with relatively good yields.

General procedure for the recycling the DES:

After completion of the reaction [monitored by the TLC (both C-N and C-C bond formations)], water (5 mL) was added and the mixture was stirred for 5 minutes at room temperature. Then EtOAc (10 mL) was added the round bottom flask. The mixture was transferred to the separating funnel and organic layer was separated (Two times). The aqueous layer concentrated under vacuum (to remove the water). The thick liquid (DES) obtained was reused for the next cycle of reaction.

![Fig.1 Bar graph showing the recyclability of ChCl/L- (+)-TA for the synthesis of compound 3e.](image-url)
Fig. 2 Bar graph showing the recyclability of DMU/L-(+)-TA for the synthesis of compound 5e.
4. Green metrics calculations

![Chemical reaction diagram]

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<th>S. No.</th>
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<td>E-factor signifies the total amount of waste generated in a chemical reaction.</td>
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| 2     | Atom economy (AE %)                 | MW of product / Sum of MW of reactants × 100                            | Atom economy signifies the percentage of atoms wasted in chemical reaction. Higher the value of AE, greener is the reaction. | 100%                 | \[
\frac{[357.41/(183.25+174.156)]}{100} = 100
\]                   |
| 3     | Mass intensity (MI)                 | \[\sum (mass of stoichiometric reactants) / [mass of stoichiometry product]\] | Mass intensity (MI), defined as the mass ratio of total input of materials (excluding water) to final product. MI takes into account reaction efficiency. | 1                    | (0.1+0.095)/0.179 = 1.09          |
| 4     | Reaction mass efficiency (RME %)    | \[\frac{mass of product}{\sum (mass of stoichiometric reactants)} \times 100\] | RME accounts into atom economy, chemical yield and stoichiometry.              | 100%                 | \[
\frac{0.179}{(0.1+0.095)} \times 100 = 91.79
\]                   |
| 5     | Carbon efficiency (CE %)            | \[\frac{Amount of carbon in product}{Total carbon present in reactants} \times 100\] | CE signifies the percentage of carbons in the reactants that is remain in the product. | 100%                 | \[
\frac{0.5 \times 19}{(0.545 \times 13 + 0.545 \times 6)} \times 100
= \frac{3.401}{7.085+3.27} = 91.74\%
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![Chemical Reaction](image)
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5. Characterization Data for synthesized compounds

**Diethyl 1-(1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3a):** Yield = 92%, white solid; M. P: 99.2 - 99.8 °C; IR (KBr, cm\(^{-1}\)): 3055, 2928, 2862, 1757, 1623, 1545, 1247, 1141, 1056, 945, 742; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.94 (d, \(J = 10.6\) Hz, 1H), 7.86 (d, \(J = 9.0\) Hz, 1H), 7.73 (dd, \(J = 13.6, 7.5\) Hz, 1H), 7.64 – 7.58 (m, 1H), 7.51 – 7.42 (m, 1H), 6.61 (m, 1H), 4.24 (d, \(J = 7.1\) Hz, 2H), 4.21 – 4.02 (m, 2H), 3.04 – 2.87 (m, 2H), 2.44 (d, \(J = 33.5\) Hz, 1H), 2.04 (d, \(J = 32.4\) Hz, 2H), 1.72 (s, 1H), 1.39 – 1.25 (m, 6H). \(^{13}\)C NMR (101 MHz, DMSO) \(\delta\) 156.85, 156.30, 152.37, 146.60, 135.32, 132.02, 129.21, 128.81, 127.37, 127.09, 126.53, 63.65, 62.02, 61.14, 28.64, 27.69, 21.24, 14.74, 14.35. HRMS (ESI-MS): m/z Calculated for C\(_{19}\)H\(_{23}\)N\(_3\)O\(_4\) [M+H]\(^+\): 358.1761; Observed: 358.1766.

**Diethyl 1-(9-methyl-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3b):** Yield = 90%, White solid; M. P: 119-119.9 °C; IR (KBr, cm\(^{-1}\)): 3025, 2948, 2884, 1753, 1645, 1510, 1275, 1112, 1071, 954, 798; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.96 (d, \(J = 8.4\) Hz, 1H), 7.93 (d, \(J = 8.0\) Hz, 1H), 7.60 (t, \(J = 8.4\) Hz, 1H), 7.49 (t, \(J = 8.4\) Hz, 1H), 6.73 – 6.38 (m, 1H), 5.51 (m, 1H), 4.30 (q, \(J = 7.2\) Hz, 4H), 2.99 (d, \(J = 16.8\) Hz, 1H), 2.84 – 2.75 (m, 1H), 2.54 (s, 3H), 2.51 – 2.41 (m, 1H), 2.17 (s, 1H), 1.96 (d, \(J = 6.0\) Hz, 2H), 1.32 (t, \(J = 7.2\) Hz, 6H). \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 158.43, 157.66, 156.90, 155.23, 152.23, 145.85, 142.02, 129.88, 129.25, 128.20, 127.20, 126.03, 123.28, 64.08, 62.61, 62.48, 61.66, 26.99, 26.58, 21.43, 14.58, 14.40, 14.13, 13.77. HRMS (ESI-MS): m/z Calculated for C\(_{20}\)H\(_{25}\)N\(_3\)O\(_4\) [M+H]\(^+\): 372.1918; Observed: 372.1920.

**Diethyl 1-(9-phenyl-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3c):**

Yield = 93%, white solid; M. P: 121.9 – 121.5 °C; IR (KBr, cm\(^{-1}\)): 3055, 2928, 2873, 1756, 1672, 1531, 1274, 1142, 1049, 959, 763; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.99 (d, \(J = 8.8\) Hz, 1H), 7.59 (d, \(J = 5.6\) Hz, 1H), 7.54 – 7.50 (m, 2H), 7.49 – 7.46 (m, 1H), 7.34 (d, \(J = 5.6\) Hz, 2H), 7.22 (d, \(J = 6.8\) Hz, 2H), 6.87 – 6.50 (m, 1H), 5.58 (m, 1H), 4.35 (s, 2H), 4.20 (q, \(J = 7.2\) Hz, 2H), 2.62 (d, \(J = 8.4\) Hz, 2H), 2.46 (s, 1H), 1.97 (s, 3H), 1.43 – 1.25 (m, 6H). \(^{13}\)C NMR (101 MHz, DMSO) \(\delta\) 156.88, 156.18, 146.59, 146.23, 136.84, 130.62, 129.59, 129.40, 129.34, 129.27, 129.17, 129.07, 128.72, 128.39, 126.90, 126.64, 125.58, 62.05,
61.15, 27.52, 27.18, 21.16, 14.85, 14.79. **HRMS (ESI-MS):** m/z Calculated for C_{25}H_{27}N_{5}O_{4} [M+H]^+: 434.2075; Observed: 434.2068.

**Diethyl 1-(7-chloro-9-phenyl-2,3-dihydro-1H-cyclopenta[b]quinolin-3-yl)hydrazine-1,2-dicarboxylate (3d):**

Yield = 91%, White solid; M. P: 198.1-198.4 °C; **IR (KBr, cm⁻¹):** 3255, 2978, 2928, 2852, 1743, 1682, 1522, 1228, 1159, 1060, 942, 759; **^1H NMR (400 MHz, CDCl₃+DMSO)** δ 8.04 (d, J = 8.8 Hz, 1H), 7.73 (s, 1H), 7.59 (dd, J = 6.4, 2.3 Hz, 2H), 7.56 (d, J = 2.4 Hz, 2H), 7.52 (d, J = 7.1 Hz, 1H), 7.35 (q, J = 7.5 Hz, 2H), 5.84 (s, 1H), 4.31 – 4.22 (m, 2H), 4.18 – 4.07 (m, 2H), 2.84 (t, J = 7.3 Hz, 2H), 2.55 – 2.48 (m, 1H), 2.26 (s, 1H), 1.31 (t, J = 6.8 Hz, 3H), 1.21 (t, J = 7.0 Hz, 3H). **^13C NMR (101 MHz, CDCl₃+DMSO)** δ 163.73, 156.85, 156.00, 152.31, 146.91, 142.39, 135.51, 134.21, 131.68, 131.46, 129.35, 129.13, 129.05, 128.81, 127.60, 124.21, 63.49, 62.12, 61.16, 27.81, 27.40, 14.68, 14.29. **HRMS (ESI-MS):** m/z Calculated for C_{24}H_{24}ClN_{3}O_{4} [M+H]^+: 454.1528; Observed: 454.1529.

**Diethyl 1-(7-chloro-9-phenyl-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3e):**

Yield = 96%, White solid; M. P: 186.9 – 187.3 °C; **IR (KBr, cm⁻¹):** 3367, 2979, 1801, 1759, 156.00, 152.31, 146.91, 142.39, 135.51, 134.21, 131.68, 131.46, 129.35, 129.13, 129.05, 128.81, 127.60, 124.21, 63.49, 62.12, 61.16, 27.81, 27.40, 14.68, 14.29. **HRMS (ESI-MS):** m/z Calculated for C_{25}H_{26}ClN_{4}O_{4} [M+H]^+: 468.1685; Observed: 468.1686.

**Diisopropyl 1-(7-chloro-9-phenyl-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3f) **

Yield = 92%, White solid; M. P: 150.9-151.3 °C; **IR (KBr, cm⁻¹):** 3304, 2981, 2934, 1730, 1674, 1469, 1262, 1097, 831, 762; **^1H NMR (400 MHz, CDCl₃+DMSO)** δ 8.04 (d, J = 8.8 Hz, 1H), 7.73 (s, 1H), 7.59 (dd, J = 6.4, 2.3 Hz, 2H), 7.56 (d, J = 2.4 Hz, 2H), 7.52 (d, J = 7.1 Hz, 1H), 7.35 (q, J = 7.5 Hz, 2H), 5.84 (s, 1H), 4.31 – 4.22 (m, 2H), 4.18 – 4.07 (m, 2H), 2.84 (t, J = 7.3 Hz, 2H), 2.55 – 2.48 (m, 1H), 2.26 (s, 1H), 1.31 (t, J = 6.8 Hz, 3H), 1.21 (t, J = 7.0 Hz, 3H). **^13C NMR (101 MHz, CDCl₃+DMSO)** δ 157.03, 156.91, 145.71, 144.75, 136.11, 131.98, 131.28, 130.54, 129.38, 129.32, 129.23, 128.73, 127.68, 124.07, 62.06, 61.14, 27.60, 27.07, 21.01, 14.85, 14.80. **HRMS (ESI-MS):** m/z Calculated for C_{26}H_{26}ClN_{5}O_{4} [M+H]^+: 468.1685; Observed: 468.1686.
MHz, CDCl\textsubscript{3}) \ \delta \ 8.19 \ (d, J = 9.2 \ Hz, 1H), 7.90 \ (d, J = 9.2 \ Hz, 1H), 7.71 – 7.65 \ (m, 1H), 7.62 \ (m, 1H), 7.55 – 7.50 \ (m, 2H), 7.49 – 7.41 \ (m, 1H), 7.20 \ (d, J = 6.6 \ Hz, 1H), 6.78 – 6.24 \ (m, 1H), 5.52 \ (m, 1H), 5.11 – 5.03 \ (m, 1H), 4.99 \ (q, J = 6.0 \ Hz, 1H), 2.52 \ (m, 2H), 2.19 \ (m, 1H), 2.02 – 1.72 \ (m, 3H), 1.30 \ (dd, J = 16.4, 6.0 \ Hz, 12H). ^{13}C \ NMR \ (101 \ MHz, DMSO) \ \delta \ 157.18, 156.54, 155.67, 152.01, 145.68, 144.75, 136.11, 135.02, 132.68, 131.84, 131.56, 131.28, 130.56, 128.68, 127.67, 124.78, 124.09, 71.64, 69.59, 27.60, 27.12, 22.27, 22.21, 22.15, 21.86, 21.06. HRMS (ESI-MS): m/z Calculated for C\textsubscript{27}H\textsubscript{30}ClN\textsubscript{3}O\textsubscript{4} [M+H]\textsuperscript{+}: 496.1998; Observed: 496.1999.

**Diethyl 1-(7-nitro-9-phenyl-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3g):**

Yield = 88%, Yellow solid; M. P: 176.2 – 177.0 °C; IR (KBr, cm\textsuperscript{-1}): 3420, 2924, 2853, 1751, 1715, 1545, 1374, 1292, 1054, 706; ^{1}H NMR (400 MHz, CDCl\textsubscript{3}) \ \delta \ 8.37 \ (dd, J = 9.2, 2.4 \ Hz, 1H), 8.29 \ (d, J = 2.4 \ Hz, 1H), 8.10 \ (d, J = 9.0 \ Hz, 1H), 7.59 \ (d, J = 2.4 \ Hz, 1H), 7.58 – 7.55 \ (m, 2H), 7.25 – 7.23 \ (m, 1H), 7.22 \ (m, 1H), 6.81 – 6.47 \ (m, 1H), 5.57 \ (m, 1H), 4.34 \ (s, 2H), 4.27 – 4.19 \ (m, 2H), 2.66 \ (m, 2H), 2.50 \ (s, 1H), 2.03 \ (m, 3H), 1.40 \ (s, 2H), 1.32 – 1.26 \ (m, 4H). ^{13}C \ NMR (101 MHz, CDCl\textsubscript{3}) \ \delta \ 156.70, 150.96, 148.76, 148.10, 146.94, 135.28, 134.44, 133.37, 130.97, 130.30, 129.32, 129.18, 129.00, 128.86, 127.76, 122.83, 62.89, 62.28, 61.97, 40.08, 28.02, 22.25, 14.42. HRMS (ESI-MS): m/z Calculated for C\textsubscript{25}H\textsubscript{26}N\textsubscript{4}O\textsubscript{6} [M+H]\textsuperscript{+}: 479.1925; Observed: 479.1930.

**Diethyl 1-(9-chloro-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3h):**

Yield = 93%, White solid; M. P: 153.8 – 154.9 °C; IR (KBr, cm\textsuperscript{-1}): 3251, 2979, 2934, 2868, 1749, 1682, 1512, 1317, 1217, 1132, 1056, 915,753; ^{1}H NMR (400 MHz, CDCl\textsubscript{3}) \ \delta \ 8.19 \ (dd, J = 8.8, 1.8 \ Hz, 1H), 7.97 \ (d, J = 8.8 \ Hz, 1H), 7.69 \ (dd, J = 8.4, 6.8, 1.6 \ Hz, 1H), 7.60 \ (dd, J = 8.4, 6.8, 1.6 \ Hz, 1H), 6.68 – 6.33 \ (m, 1H), 5.54 \ (m, 1H), 4.34 \ (s, 2H), 4.25 – 4.11 \ (m, 2H), 3.20 \ (d, J = 16.0 \ Hz, 1H), 2.90 \ (m, 1H), 2.49 \ (s, 1H), 2.22 \ (s, 1H), 2.01 \ (s, 2H), 1.40 – 1.23 \ (m, 6H). ^{13}C \ NMR (101 MHz, DMSO) \ \delta \ 158.38, 156.87, 156.78, 147.19, 140.59, 131.97, 130.95, 130.75, 125.61, 124.35, 123.00, 62.08, 61.09, 27.28, 26.87, 20.42, 14.82, 14.78. HRMS (ESI-MS): m/z Calculated for C\textsubscript{19}H\textsubscript{22}ClN\textsubscript{3}O\textsubscript{4} [M+H]\textsuperscript{+}: 392.1372; Observed: 392.1372.
Diethyl 1-(6-bromo-9-chloro-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3i):

Yield = 95%, white solid; M. P: 169.4-169.9 °C; IR (KBr, cm$^{-1}$): 3253, 3062, 2977, 2933, 2869, 1750, 1682, 1509, 12290, 1094, 805; $^1$H NMR (400 MHz, CDCl$_3$) δ 8.11 (s, 1H), 7.98 (d, J = 8.8 Hz, 1H), 7.62 (d, J = 7.2 Hz, 1H), 6.76 – 6.30 (m, 1H), 5.48 (m, 1H), 4.38 – 4.26 (m, 2H), 4.23 – 4.10 (m, 2H), 3.19 – 3.13 (m, 1H), 2.89 – 2.77 (m, 1H), 2.46 (s, 1H), 2.20 (s, 1H), 2.01 – 1.94 (m, 2H), 1.40 – 1.21 (m, 6H). $^{13}$C NMR (101 MHz, DMSO) δ 156.82, 146.72, 140.43, 130.03, 129.98, 129.82, 128.01, 125.42, 123.49, 62.06, 61.13, 27.30, 27.00, 20.48, 14.81, 14.76. HRMS (ESI-MS): m/z Calculated for C$_{19}$H$_{21}$BrClN$_3$O$_4$ [M+H]$^+$: 470.0477; Observed: 470.0477.

Diethyl 1-(9-chloro-6-nitro-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3j):

Yield = 96%, light Yellow solid; M. P: 158.2 – 158.9 °C; IR (KBr, cm$^{-1}$): 3246, 3021, 2931, 1749, 1677, 1528, 1346, 1226, 1163, 1068, 901, 885; $^1$H NMR (400 MHz, CDCl$_3$) δ 8.83 (s, 1H), 8.32 (s, 2H), 6.70 – 6.25 (m, 1H), 5.53 (m, 1H), 4.39 – 4.26 (m, 2H), 4.25 – 4.09 (m, 2H), 3.23 (m, 1H), 2.93 (m, 1H), 2.51 (s, 1H), 2.25 (s, 1H), 2.04 (d, J = 6.4 Hz, 2H), 1.25 (d, J = 6.0 Hz, 6H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 159.54, 157.13, 156.31, 148.05, 145.39, 141.86, 133.25, 128.85, 125.76, 125.58, 120.59, 62.97, 62.01, 27.46, 26.46, 20.74, 14.55, 14.42. HRMS (ESI-MS): m/z Calculated for C$_{19}$H$_{21}$ClN$_4$O$_6$ [M+H]$^+$: 437.1223; Observed: 437.1228.

Diethyl 1-(9-(methoxycarbonyl)-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3k):

Yield = 95%, white solid; M. P: 147.8 - 148.6 °C; IR (KBr, cm$^{-1}$): 3253, 3078, 2933, 1744, 1683, 1435, 1316, 1194, 1059, 957, 758; $^1$H NMR (400 MHz, CDCl$_3$) δ 7.98 (d, J = 8.4 Hz, 1H), 7.70 – 7.63 (m, 2H), 7.55 – 7.49 (m, 1H), 6.60 (m, 1H), 5.52 (m, 1H), 4.32 (s, 2H), 4.24 – 4.11 (m, 2H), 4.06 (s, 3H), 2.94 (q, J = 5.2 Hz, 2H), 2.30 (m, 2H), 2.02 (m, 2H), 1.41 – 1.21 (m, 6H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 172.56, 161.67, 161.57, 161.22, 151.00, 142.81, 134.66, 134.21, 132.92, 132.55, 129.13, 127.94, 66.78, 65.85, 57.81, 31.96, 31.31, 25.47, 19.57, 19.53. HRMS (ESI-MS): m/z Calculated for C$_{21}$H$_{25}$N$_3$O$_6$ [M+H]$^+$: 416.1816; Observed: 416.1839.
Diisopropyl 1-(9-(methoxycarbonyl)-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3l):

Yield = 91%, White solid; M. P: 119.2 -119.9 °C; IR (KBr, cm\(^{-1}\))): 3273, 2977, 2938, 1728, 1671, 1231, 1026, 962, 761; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.96 (d, \(J = 8.4\) Hz, 1H), 7.66 (m, 2H), 7.55 – 7.49 (m, 1H), 6.47 (s, 1H), 5.50 (m, 1H), 5.02 (m, 2H), 4.05 (s, 3H), 2.98 – 2.92 (m, 2H), 2.53 – 1.95 (m, 4H), 1.44 – 1.18 (m, 12H). \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 172.56, 161.37, 161.29, 161.15, 151.00, 142.76, 134.60, 134.21, 132.89, 132.52, 129.14, 74.27, 73.32, 57.82, 31.99, 31.33, 27.01, 26.99, 26.96, 26.93, 25.48. HRMS (ESI-MS): m/z Calculated for C\(_{23}\)H\(_{29}\)N\(_3\)O\(_6\) [M+H]\(^+\): 444.2129; Observed: 444.2127.

Diethyl 1-(9-((prop-2-yn-1-yloxy)carbonyl)-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3m):

Yield = 92%, White solid; M. P: 110.1-110.5 °C; IR (KBr, cm\(^{-1}\)):3273, 2977, 2938, 1728, 1671, 1231, 1026, 962, 761; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.98 (d, \(J = 8.8\) Hz, 1H), 7.73 (d, \(J = 8.4\) Hz, 1H), 7.69 – 7.64 (m, 1H), 7.56 – 7.52 (m, 1H), 6.55 (s, 1H), 5.53 (m, 1H), 5.06 (s, 2H), 4.31 (dd, \(J = 6.8, 2.0\) Hz, 2H), 4.20 (dd, \(J = 6.8, 2.4\) Hz, 2H), 3.02 – 2.95 (m, 2H), 2.62 (t, \(J = 2.4\) Hz, 1H), 2.49 (s, 1H), 2.06 (m, 3H), 1.35 – 1.25 (m, 6H). \(^{13}\)C NMR (101 MHz, DMSO) \(\delta\) 166.65, 156.95, 156.88, 156.80, 156.55, 146.26, 136.99, 129.96, 129.56, 128.40, 127.89, 124.09, 123.14, 78.68, 78.26, 62.03, 61.11, 60.91, 53.69, 27.18, 26.45, 20.66, 14.89, 14.77. HRMS (ESI-MS): m/z Calculated for C\(_{23}\)H\(_{25}\)N\(_3\)O\(_6\) [M+H]\(^+\): 440.1816; Observed: 440.1816.

Diisopropyl 1-(9-((prop-2-yn-1-yloxy)carbonyl)-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3n):

Yield = 90%, White solid; M. P: 94.8-95.2 °C; IR (KBr, cm\(^{-1}\)):3273, 2977, 2938, 1728, 1671, 1231, 1026, 962, 761; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.97 (d, \(J = 8.4\) Hz, 1H), 7.73 (d, \(J = 8.4\) Hz, 1H), 7.69 – 7.64 (m, 1H), 7.56 – 7.52 (m, 1H), 6.55 (s, 1H), 5.62 (s, 1H), 5.06 (d, \(J = 2.4\) Hz, 2H), 5.03 – 4.89 (m, 2H), 3.01 – 2.95 (m, 2H), 2.62 (t, \(J = 2.4\) Hz, 1H), 2.49 (s, 1H), 2.08 (m, 3H), 1.31 – 1.23 (m, 12H). \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 166.80, 166.21,
156.14, 146.19, 137.11, 132.46, 131.83, 129.58, 127.47, 124.05, 123.97, 123.33, 76.85, 75.97, 70.24, 69.51, 52.99, 29.69, 27.19, 26.29, 21.98, 21.95. **HRMS (ESI-MS):** m/z Calculated for C_{25}H_{29}N_{3}O_{6} [M+H]^+: 468.2129; Observed: 468.2126.

*Diethyl 1-(9-((benzyloxy)carbonyl)-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3o):*

Yield = 89%, white solid; M. P: 145.5 – 146.3 °C; **IR (KBr, cm\(^{-1}\)):** 3250, 2979, 2933, 1745, 1683, 1513, 1093, 956; **\(^1\)H NMR (400 MHz, DMSO)** \(\delta\) 8.54 (s, 1H), 7.71 (s, 1H), 7.48 (t, \(J = 8.4\) Hz, 1H), 7.44 (d, \(J = 7.0\) Hz, 1H), 7.33 (t, \(J = 8.4\) Hz, 1H), 7.30 – 7.24 (m, 2H), 7.21 – 7.11 (m, 3H), 5.29 (s, 2H), 5.15 (s, 1H), 4.03 – 3.70 (m, 4H), 3.13 (s, 3H), 2.57 (t, \(J = 6.4\) Hz, 2H), 1.86 (m, 2H), 1.67 (m, 2H), 1.02 – 0.84 (m, 6H). **\(^13\)C NMR (101 MHz, DMSO)** \(\delta\) 167.22, 156.87, 156.81, 156.53, 146.27, 137.80, 135.81, 129.94, 129.46, 129.14, 129.00, 128.94, 128.16, 127.78, 124.19, 123.20, 67.87, 62.03, 61.11, 27.16, 26.47, 20.69, 14.80, 14.76. **HRMS (ESI-MS):** m/z Calculated for C_{27}H_{29}N_{3}O_{6} [M+H]^+: 492.2129; Observed: 492.2129.

*Diisopropyl 1-(9-(p-tolylcarbamoyl)-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3p):*

Yield = 83%, White solid; M. P: 238.4- 238.9 °C; **\(^1\)H NMR (400 MHz, DMSO)** \(\delta\) 10.98 (s, 1H), 10.13 (s, 1H), 8.21 (s, 1H), 8.12 (s, 1H), 8.01 (d, \(J = 8.0\) Hz, 1H), 7.92 (t, \(J = 7.6\) Hz, 2H), 7.71 (d, \(J = 8.8\) Hz, 2H), 7.24 (d, \(J = 8.8\) Hz, 2H), 4.94 – 4.88 (m, 2H), 4.88 – 4.75 (m, 2H), 4.35 (s, 1H), 2.33 (s, 3H), 1.79 (m, 2H), 1.54 (s, 1H), 1.22 (d, \(J = 6.4\) Hz, 12H). **\(^13\)C NMR (101 MHz, DMSO)** \(\delta\) 164.91, 155.41, 153.92, 147.94, 142.07, 140.13, 139.90, 136.58, 134.05, 130.97, 130.31, 129.67, 127.89, 125.59, 122.75, 122.48, 120.74, 71.12, 70.22, 69.04, 22.27, 22.14, 22.01, 20.91. **HRMS (ESI-MS):** m/z Calculated for C_{29}H_{34}N_{5}O_{5} [M+H]^+: 519.2602; Observed: 519.2596.

*Diethyl 1-(1-oxo-9-phenyl-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3q):*
Yield = 87%, light Yellow solid; M. P: 121.3 – 122.1 °C; IR (KBr, cm⁻¹): 3275, 2988, 1750, 1682, 1610, 1505, 1387, 1221, 1061, 952, 757; ¹H NMR (400 MHz, DMSO) δ 8.89 (s, 1H), 8.08 (d, J = 8.4 Hz, 1H), 7.87 (dd, J = 8.4, 6.8, 1.6 Hz, 1H), 7.55 (t, J = 6.8 Hz, 1H), 7.52 – 7.46 (m, 3H), 7.36 (d, J = 6.8 Hz, 1H), 7.18 (d, J = 5.6 Hz, 2H), 5.79 (s, 1H), 4.13 (m, 4H), 2.99 – 2.64 (m, 2H), 2.32 (m, 2H), 1.29 – 1.16 (m, 6H). ¹³C NMR (101 MHz, DMSO) δ 196.32, 158.79, 156.91, 150.78, 148.41, 137.62, 131.89, 129.81, 128.82, 128.30, 127.81, 127.65, 127.57, 124.40, 62.25, 61.24, 38.30, 29.36, 25.62, 14.85, 14.78. HRMS (ESI-MS): m/z Calculated for C₂₅H₂₅N₃O₅[M+H]⁺: 448.1867; Observed: 448.1869.

Diethyl 1-(7-chloro-1-oxo-9-phenyl-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3r):

Yield = 90%, light Yellow solid; M. P: 181.2 – 181.6 °C; IR (KBr, cm⁻¹): 3309, 2982 1750, 1678, 1548, 1482.1312, 1284, 1024, 945.856; ¹H NMR (400 MHz, CDCl₃) δ 8.00 (s, 1H), 7.71 (dd, J = 8.8, 2.0 Hz, 1H), 7.52 (m, 3H), 7.44 (d, J = 2.0 Hz, 1H), 7.22 – 7.16 (m, 1H), 7.14 – 7.09 (m, 1H), 6.56 (s, 1H), 5.74 (m, 1H), 4.43 – 4.31 (m, 2H), 4.22 (m, 2H), 2.83 (m, 2H), 2.62 (s, 1H), 2.39 (s, 1H), 1.42 (m, 2H), 1.28 (m, 4H). ¹³C NMR (101 MHz, CDCl₃) δ 195.82, 158.70, 156.75, 151.58, 146.73, 136.27, 133.26, 132.83, 130.86, 128.65, 128.46, 128.35, 128.21, 128.13, 127.73, 126.74, 63.05, 62.22, 38.92, 25.63, 14.59, 14.43. HRMS (ESI-MS): m/z Calculated for C₂₅H₂₄ClN₃O₅[M+H]⁺: 482.1477; Observed: 482.1479.

Diethyl 1-(9-(ethoxycarbonyl)-1-oxo-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3s):

Yield = 82%, white solid; M. P: 170.3 – 170.9 °C; IR (KBr, cm⁻¹): 3350, 2924, 1725, 1689, 1356, 1227, 1024, 759; ¹H NMR (400 MHz, DMSO) δ 8.93 (s, 1H), 8.11 (d, J = 8.8 Hz, 1H), 7.98 (ddd, J = 8.4, 6.8, 1.4 Hz, 1H), 7.83 (d, J = 6.8 Hz, 1H), 7.76 (ddd, J = 8.4, 6.8, 1.2 Hz, 1H), 5.89 (s, 1H), 4.53 (q, J = 7.2 Hz, 2H), 4.20 (q, J = 7.0 Hz, 2H), 4.09 – 3.98 (m, 2H), 3.15 – 2.79 (m, 2H), 2.46 – 2.19 (m, 2H), 1.38 (t, J = 7.2 Hz, 3H), 1.28 – 1.20 (m, 3H), 1.12 (t, J = 7.0 Hz, 3H). ¹³C NMR (101 MHz, DMSO) δ 195.89, 167.26, 158.78, 156.88, 156.74, 149.12, 141.55, 132.99, 130.08, 128.83, 126.14, 123.28, 121.91, 62.25, 62.22, 61.22, 36.89, 25.70.
14.80, 14.74, 14.24. **HRMS (ESI-MS):** m/z Calculated for C_{22}H_{25}N_{3}O_{7}[M+H]^+: 444.1766; Observed: 444.1764.

**Diethyl 1-(quinolin-2-ylmethyl)hydrazine-1,2-dicarboxylate (3t):**

Yield = 85%, white solid; M. P: 77.9 - 78.2 °C; **IR (KBr, cm\(^{-1}\)):** 3263, 2978, 2874, 1754, 1645, 1502, 1325, 1219, 1132, 1058, 915; **\(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 8.18 – 8.04 (m, 1H), 7.99 (s, 1H), 7.74 (s, 2H), 7.65 (s, 1H), 7.51 – 7.47 (m, 1H), 7.33 (d, \(J = 8.4\) Hz, 1H), 5.01 (s, 2H), 4.24 – 4.15 (m, 4H), 1.23 (t, \(J = 7.2\) Hz, 6H). **\(^{13}\)C NMR (101 MHz, DMSO) \(\delta\) 157.88, 156.57, 156.19, 147.61, 132.90, 129.85, 129.08, 128.12, 127.58, 126.62, 120.47, 62.35, 61.23, 56.81, 14.75, 14.46. **HRMS (ESI-MS):** m/z Calculated for C\(_{16}\)H\(_{19}\)N\(_3\)O\(_4\)[M+H]^+: 318.1449; Observed: 318.1454.

**Diethyl 1-(1-(4-phenyl-3-propionylquinolin-2-yl)ethyl)hydrazine-1,2-dicarboxylate (3u):**

Yield = 83%, white solid; M. P: 127.1 – 127.6 °C; **IR (KBr, cm\(^{-1}\)):** 3351, 2978, 2934, 1744, 1707, 1559, 1314, 1257, 1140, 1028, 954, 755; **\(^1\)H NMR (400 MHz, DMSO) \(\delta\) 8.86 (s, 1H), 7.94 (s, 1H), 7.57 (t, \(J = 7.2\) Hz, 1H), 7.39 (s, 1H), 7.33 (d, \(J = 8.8\) Hz, 2H), 7.31 – 7.28 (m, 2H), 7.23 (s, 1H), 6.92 (s, 1H), 5.52 – 5.13 (m, 1H), 3.81 (m, 4H), 1.84 (s, 2H), 1.27 (s, 3H), 0.90 (m, 6H), 0.42 – 0.38 (m, 3H). **\(^{13}\)C NMR (101 MHz, DMSO) \(\delta\) 207.81, 156.60, 155.93, 147.03, 135.35, 130.45, 130.34, 129.90, 129.31, 129.22, 128.90, 127.84, 126.00, 125.68, 62.18, 61.08, 37.74, 16.84, 14.70, 7.51. **HRMS (ESI-MS):** m/z Calculated for C\(_{26}\)H\(_{29}\)N\(_3\)O\(_5\)[M+H]^+: 464.218; Observed: 464.2183.

**Diethyl 1-(1-(6-chloro-4-phenyl-3-propionylquinolin-2-yl)ethyl)hydrazine-1,2-dicarboxylate (3v):**

Yield = 84%, white solid; M. P: 129.2 - 130 °C; **IR (KBr, cm\(^{-1}\)):** 3274, 2981, 2929, 1749, 1731, 1702, 1682, 1226, 1058, 768; **\(^1\)H NMR (400 MHz, DMSO) \(\delta\) 9.15 (s, 1H), 8.23 (s, 1H), 7.83 (dd, \(J = 8.8, 2.4\) Hz, 1H), 7.66 – 7.62 (m, 1H), 7.56 (td, \(J = 4.0, 2.0\) Hz, 2H), 7.49 – 7.43 (m, 2H), 7.16 (s, 1H), 5.56 (m, 1H), 4.02 (s, 4H), 2.08 (s, 1H), 1.50 (m, 3H), 1.22 – 1.07 (m, 6H), 0.64 (m, 4H). **\(^{13}\)C NMR (101 MHz, DMSO) \(\delta\) 207.41, 156.62, 155.88, 145.49, 143.51, 134.63, 132.61, 132.10, 131.01, 130.40, 130.18, 129.62, 129.39, 129.09.
126.64, 124.57, 62.22, 61.08, 37.67, 16.70, 14.71, 14.68, 7.43. **HRMS (ESI-MS):** m/z Calculated for C_{26}H_{28}ClN_{3}O_{5}[M+H]^+: 498.179; Observed: 498.1799.

**Diethyl 1-(5,6,7,8-tetrahydroquinolin-8-yl)hydrazine-1,2-dicarboxylate (3w):**

Yield = 70%, colourless oil; **IR (KBr, cm^{-1}):** 3274, 2981, 2929, 1749, 1731, 1702, 1682, 1226, 1058, 768 **\(^1\)H NMR (400 MHz, CDCl\(_3\))\:** 8.38 (d, J = 5.2 Hz, 1H), 7.40 (d, J = 7.6 Hz, 1H), 7.09 (dd, J = 7.8, 4.8 Hz, 1H), 6.53 (s, 1H), 5.58 – 5.26 (m, 1H), 4.23 (q, J = 7.2 Hz, 4H), 2.83 – 2.71 (m, 2H), 2.04 – 1.81 (m, 4H), 1.28 (m, 6H). **\(^{13}\)C NMR (101 MHz, CDCl\(_3\))\:** 156.36, 154.24, 147.18, 137.27, 122.21, 63.10, 62.61, 61.77, 31.88, 28.32, 21.32, 14.45. **HRMS (ESI-MS):** m/z Calculated for C_{15}H_{21}N_{3}O_{4}[M+H]^+: 308.1605; Observed: 308.1605.

**Diethyl 1-((3-hydroxyquinoxalin-2-yl)methyl)hydrazine-1,2-dicarboxylate (3x):**

Yield = 82%, white solid; M. P: 128.5 – 128.9 °C; **IR (KBr, cm^{-1}):** 3274, 2982, 2929, 1728, 1481, 1380, 1236, 1060, 763; **\(^1\)H NMR (400 MHz, DMSO)\:** 12.39 (s, 1H), 8.99 (m, 1H), 7.85 – 7.58 (m, 1H), 7.55 – 7.48 (m, 1H), 7.36 – 7.21 (m, 2H), 4.15 – 3.98 (m, 4H), 1.23 – 1.08 (m, 6H). **\(^{13}\)C NMR (101 MHz, DMSO)\:** 155.99, 155.46, 154.04, 132.79, 131.54, 130.95, 129.26, 123.43, 115.71, 62.61, 61.32, 14.56, 14.53. **HRMS (ESI-MS):** m/z Calculated for C_{15}H_{18}N_{4}O_{5}[M+H]^+: 335.135; Observed: 335.1349.

**1-Phenyl-3-(1,2,3,4-tetrahydroacridin-4-yl)pyrrolidine-2,5-dione (5a):**

Yield = 90%, white solid; M. P: 128.5 – 155.1 °C; **IR (KBr, cm^{-1}):** 3034, 2982, 2855, 1759, 1699, 1454, 1392, 1132, 758; **\(^1\)H NMR (400 MHz, CDCl\(_3\))\:** 7.83 (s, 1H), 7.70 – 7.63 (m, 2H), 7.63 – 7.51 (m, 4H), 7.50 – 7.28 (m, 3H), 4.04 (m, 1H), 3.26 (s, 1H), 3.00 (m, 2H), 2.84 (m, 1H), 2.51 – 2.40 (m, 1H), 2.24 (m, 1H), 2.03 (m, 2H), 1.74 (m, 1H). **\(^{13}\)C NMR (101 MHz, CDCl\(_3\))\:** 179.33, 176.53, 157.47, 146.13, 135.19, 132.95, 131.20, 129.07, 128.75, 128.70, 128.09, 127.33, 126.80, 126.31, 126.15, 44.02, 43.16, 31.23, 29.32, 28.75, 22.56. **HRMS (ESI-MS):** m/z Calculated for C_{23}H_{20}N_{2}O_{2}[M+H]^+: 357.1598; Observed: 357.1597.

**3-(9-Methyl-1,2,3,4-tetrahydroacridin-4-yl)-1-phenylpyrrolidine-2,5-dione (5b):**
Yield = 87%, white solid; M. P: 180.9 – 181.9 °C; IR (KBr, cm\(^{-1}\)): 3068, 2924, 2858, 1770, 1498, 1181, 785; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.96 (dd, \(J = 8.4, 2.0\) Hz, 1H), 7.83 (dd, \(J = 8.4, 2.0\) Hz, 1H), 7.56 (ddd, \(J = 8.4, 6.8, 1.6\) Hz, 1H), 7.47 (ddd, \(J = 8.3, 6.8, 1.6\) Hz, 1H), 7.41 – 7.33 (m, 2H), 7.33 – 7.28 (m, 1H), 7.17 – 7.08 (m, 2H), 3.96 – 3.86 (m, 1H), 3.69 – 3.60 (m, 1H), 3.16 – 3.06 (m, 2H), 3.06 – 2.99 (m, 1H), 2.90 – 2.80 (m, 1H), 2.55 (s, 3H), 2.22 – 2.15 (m, 2H), 2.11 (m, 1H), 1.90 – 1.82 (m, 1H). \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 179.31, 176.99, 157.85, 145.52, 141.40, 132.36, 129.58, 128.98, 128.85, 128.29, 128.17, 127.04, 126.64, 125.82, 123.30, 44.75, 43.89, 35.15, 29.72, 27.10, 22.80, 13.74. HRMS (ESI-MS): m/z Calculated for C\(_{24}\)H\(_{22}\)N\(_2\)O\(_2\)[M+H]\(^+\): 371.1754; Observed: 371.1754.

1-Phenyl-3-(9-phenyl-1,2,3,4-tetrahydroacridin-4-yl)pyrrolidine-2,5-dione (5c):

Yield = 91%, white solid; M. P: 208.4 - 209.2 °C; IR (KBr, cm\(^{-1}\)): 3060, 2927, 2861, 1702, 1577, 145.5, 132.36, 129.58, 128.98, 128.85, 128.29, 128.17, 127.04, 126.64, 125.82, 123.30, 44.75, 43.89, 35.15, 29.72, 27.10, 22.80, 13.74. HRMS (ESI-MS): m/z Calculated for C\(_{24}\)H\(_{22}\)N\(_2\)O\(_2\)[M+H]\(^+\): 371.1754; Observed: 371.1754.

3-(7-Chloro-9-phenyl-2,3-dihydro-1H-cyclopenta[b]quinolin-3-yl)-1-phenylpyrrolidine-2,5-dione (5d):

Yield = 90%, white solid; M. P: 198.9 -199.4 °C; IR (KBr, cm\(^{-1}\)): 3072, 2954, 1706, 1556, 1475, 1150, 945, 762; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.81 (d, \(J = 8.8\) Hz, 1H), 7.59 (d, \(J = 3.5\) Hz, 3H), 7.58 (d, \(J = 1.6\) Hz, 2H), 7.54 (dd, \(J = 8.8, 4.4\) Hz, 2H), 7.51 (d, \(J = 1.6\) Hz, 1H), 7.50 – 7.44 (m, 2H), 7.37 – 7.32 (m, 2H), 4.24 (m, 1H), 3.47 – 3.41 (m, 1H), 2.99 – 2.79 (m, 3H), 2.51 (m, 2H), 1.94 – 1.85 (m, 1H). \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 178.65, 176.01, 164.98, 146.46, 142.55, 135.53, 134.38, 132.68, 131.96, 130.86, 129.32,
129.20, 128.51, 127.18, 126.58, 124.54, 46.74, 41.72, 31.30, 29.43, 28.74. **HRMS (ESI-MS):**
m/z Calculated for C_{28}H_{21}ClN_{2}O_{2}[M+H]^+: 453.1359; Observed: 453.1359.

3-(7-Chloro-9-phenyl-1,2,3,4-tetrahydroacridin-4-yl)-1-phenylpyrrolidine-2,5-dione (5e):

Yield = 94%, white solid; M. P: 200 – 200.8 °C; **IR (KBr, cm⁻¹):**
3065, 2957, 2874, 1734, 1589, 1498, 1167, 860, 770; **¹H NMR (400 MHz, CDCl₃) δ:**
7.63 (d, J = 8.8 Hz, 1H), 7.60 (s, 1H), 7.58 (s, 2H), 7.56 (s, 1H), 7.55 – 7.49 (m, 3H), 7.48 – 7.44 (m, 1H), 7.42 (dd, J = 8.8, 2.0 Hz, 1H), 7.26 (s, 1H), 7.20 (dt, J = 6.4, 2.0 Hz, 2H), 4.08 (m, 1H), 3.34 – 3.28 (m, 1H), 2.91 (m, 1H), 2.69 – 2.64 (m, 1H), 2.64 – 2.59 (m, 1H), 2.59 – 2.52 (m, 1H), 2.27 – 2.20 (m, 1H), 1.98 – 1.94 (m, 1H), 1.94 – 1.69 (m, 2H). **¹³C NMR (101 MHz, CDCl₃) δ:**
179.32, 176.59, 157.77, 146.08, 144.07, 136.10, 132.87, 131.89, 130.40, 129.86, 129.53, 129.14, 128.98, 128.94, 128.24, 128.18, 127.51, 126.21, 124.56, 43.94, 43.51, 31.31, 28.70, 27.45, 22.38. **HRMS (ESI-MS):** m/z Calculated for C_{29}H_{23}ClN_{2}O_{2}[M+H]^+: 467.1521; Observed: 467.1527.

tert-Butyl 8-chloro-4-(2,5-dioxo-1-phenylpyrrolidin-3-yl)-10-phenyl-3,4-dihydrobenzo[b][1,6]naphthyridine-2(1H)-carboxylate (5f):

Yield = 84%, white solid; M. P: 202.1 - 202.7 °C; **IR (KBr, cm⁻¹):**
3065, 2957, 2874, 1734, 1589, 1498, 1167, 860, 770; **¹H NMR (400 MHz, CDCl₃) δ:**
7.70 (d, J = 8.8 Hz, 1H), 7.60 (s, 2H), 7.58 (s, 3H), 7.56 (s, 1H), 7.54 (s, 1H), 7.53 – 7.47 (m, 2H), 7.45 (t, J = 8.4 Hz, 1H), 7.36 (s, 1H), 7.23 (d, J = 7.6 Hz, 2H), 4.54 (m, 2H), 4.30 – 4.19 (m, 2H), 3.32 (m, 2H), 2.99 – 2.82 (m, 1H), 2.74 – 2.53 (m, 1H), 1.43 (m, 9H). **¹³C NMR (101 MHz, CDCl₃) δ:**
178.33, 176.05, 154.37, 144.64, 134.40, 132.68, 132.61, 130.53, 130.38, 129.20, 128.87, 128.38, 127.34, 126.27, 124.73, 80.73, 44.04, 41.21, 31.13, 29.71, 28.35. **HRMS (ESI-MS):** m/z Calculated for C_{33}H_{30}ClN_{3}O_{4}[M+H]^+: 568.1998; Observed: 568.1995.

3-(7-Nitro-9-phenyl-1,2,3,4-tetrahydroacridin-4-yl)-1-phenylpyrrolidine-2,5-dione (5g):

Yield = 95%, light Yellow solid; M. P: 201.4 - 202.2 °C; **IR (KBr, cm⁻¹):**
3032, 1770, 1704, 1596, 1344, 1283, 1182, 1092, 781; **¹H
NMR (400 MHz, CDCl$_3$) δ 8.30 – 8.21 (m, 2H), 7.81 (d, J = 8.8 Hz, 1H), 7.58 (d, J = 4.0 Hz, 5H), 7.57 – 7.50 (m, 2H), 7.46 (dt, J = 8.8, 4.0 Hz, 1H), 7.23 (m, 2H), 4.14 – 4.08 (m, 1H), 3.36 (m, 1H), 2.96 (m, 1H), 2.76 – 2.63 (m, 2H), 2.58 (m, 1H), 2.27 (m, 1H), 1.98 (m, 2H), 1.81 – 1.74 (m, 1H). 13C NMR (101 MHz, CDCl$_3$) δ 179.07, 176.38, 161.82, 148.79, 147.58, 145.32, 135.08, 132.76, 131.28, 130.46, 129.21, 129.15, 128.92, 128.85, 128.83, 128.30, 126.10, 122.91, 122.18, 43.81, 43.76, 31.35, 28.36, 27.41, 22.15. HRMS (ESI-MS): m/z Calculated for C$_{29}$H$_{23}$N$_3$O$_4$[M+H]$^+$: 478.1762; Observed: 478.1689.

3-(9-Chloro-1,2,3,4-tetrahydroacridin-4-yl)-1-phenylpyrrolidine-2,5-dione (5h):

Yield = 90%, White solid; M. P: 166.2 – 167.0 °C; IR (KBr, cm$^{-1}$): 3063, 2923, 2854, 1770, 1705, 1595, 1480, 1158, 919, 857; $^1$H NMR (400 MHz, CDCl$_3$) δ 8.14 (dd, J = 8.0, 3.2 Hz, 1H), 7.67 (dd, J = 7.2, 1.6 Hz, 1H), 7.60 (dd, J = 8.8, 1.6 Hz, 2H), 7.58 – 7.55 (m, 2H), 7.55 – 7.50 (m, 2H), 7.47 – 7.40 (m, 1H), 4.06 (m, 1H), 3.30 – 3.26 (m, 1H), 3.26 – 3.19 (m, 1H), 2.96 – 2.80 (m, 2H), 2.38 (m, 1H), 2.23 (m, 2H), 2.05 – 1.95 (m, 1H), 1.73 (td, J = 12.8, 9.4 Hz, 1H). 13C NMR (101 MHz, CDCl$_3$) δ 179.09, 176.31, 157.60, 146.13, 141.86, 132.85, 129.54, 129.10, 128.12, 127.17, 126.18, 125.45, 123.66, 44.04, 43.69, 31.09, 28.97, 27.34, 22.30. HRMS (ESI-MS): m/z Calculated for C$_{23}$H$_{19}$ClN$_2$O$_2$[M+H]$^+$: 391.1208; Observed: 391.1214.

3-(6-Bromo-9-chloro-1,2,3,4-tetrahydroacridin-4-yl)-1-phenylpyrrolidine-2,5-dione (5i):

Yield = 91%, white solid; M. P: 186.5 – 187.2 °C; IR (KBr, cm$^{-1}$) : 3054, 2924, 2853, 1710, 1599, 1458, 1382, 1179, 821, 816; $^1$H NMR (400 MHz, CDCl$_3$) δ 8.00 (d, J = 8.8 Hz, 1H), 7.88 (d, J = 2.0 Hz, 1H), 7.63 – 7.59 (m, 1H), 7.58 (d, J = 6.0 Hz, 4H), 7.49 – 7.41 (m, 1H), 4.06 – 4.01 (m, 1H), 3.30 (m, 1H), 3.25 – 3.17 (m, 1H), 2.86 (m, 2H), 2.38 – 2.32 (m, 1H), 2.27 – 2.21 (m, 1H), 2.01 – 1.95 (m, 1H), 1.77 – 1.71 (m, 1H). 13C NMR (101 MHz, CDCl$_3$) δ 178.82, 176.03, 158.87, 146.53, 142.00, 132.68, 131.28, 130.68, 129.71, 129.15, 128.27, 126.06, 125.19, 124.23, 123.80, 43.89, 43.64, 31.11, 28.72, 27.39, 22.14. HRMS (ESI-MS): m/z Calculated for C$_{23}$H$_{18}$BrClN$_2$O$_2$[M+H]$^+$: 469.0313; Observed: 469.0317.

3-(9-Chloro-6-nitro-1,2,3,4-tetrahydroacridin-4-yl)-1-phenylpyrrolidine-2,5-dione (5j):

Yield = 91%, White solid; M. P: 166.2 – 167.0 °C; IR (KBr, cm$^{-1}$): 3063, 2924, 2853, 1710, 1599, 1458, 1382, 1179, 821, 816; $^1$H NMR (400 MHz, CDCl$_3$) δ 8.00 (d, J = 8.8 Hz, 1H), 7.88 (d, J = 2.0 Hz, 1H), 7.63 – 7.59 (m, 1H), 7.58 (d, J = 6.0 Hz, 4H), 7.49 – 7.41 (m, 1H), 4.06 – 4.01 (m, 1H), 3.30 (m, 1H), 3.25 – 3.17 (m, 1H), 2.86 (m, 2H), 2.38 – 2.32 (m, 1H), 2.27 – 2.21 (m, 1H), 2.01 – 1.95 (m, 1H), 1.77 – 1.71 (m, 1H). 13C NMR (101 MHz, CDCl$_3$) δ 178.82, 176.03, 158.87, 146.53, 142.00, 132.68, 131.28, 130.68, 129.71, 129.15, 128.27, 126.06, 125.19, 124.23, 123.80, 43.89, 43.64, 31.11, 28.72, 27.39, 22.14. HRMS (ESI-MS): m/z Calculated for C$_{23}$H$_{18}$BrClN$_2$O$_2$[M+H]$^+$: 469.0313; Observed: 469.0317.
Yield = 96%, white solid; M. P: 184.2 – 185.2 °C; **IR (KBr, cm⁻¹):** 3069, 2953, 2824, 1732, 1549, 1452, 1361, 1182, 825; **¹H NMR (400 MHz, CDCl₃) δ** 8.63 (s, 1H), 8.30 (s, 2H), 7.63 (s, 1H), 7.62 (d, J = 2.6 Hz, 3H), 7.48 (dd, J = 6.2, 3.4 Hz, 1H), 4.08 (m, 1H), 3.40 – 3.36 (m, 1H), 3.33 – 3.27 (m, 1H), 2.90 (m, 2H), 2.32 (d, J = 5.6 Hz, 1H), 2.28 (t, J = 5.6 Hz, 2H), 2.04 – 1.99 (m, 1H), 1.78 (m, 1H). **¹⁳C NMR (101 MHz, CDCl₃) δ** 178.67, 175.80, 160.71, 148.13, 144.86, 142.04, 132.86, 132.49, 129.37, 128.57, 128.45, 125.93, 125.76, 125.17, 120.59, 43.77, 31.14, 29.71, 28.45, 27.78, 21.97. **HRMS (ESI-MS):** m/z Calculated for C₂₃H₁₈ClN₃O₄ [M+H]⁺: 436.1059; Observed: 436.1056.  

*Methyl-4-(2,5-dioxo-1-phenylpyrrolidin-3-yl)-1,2,3,4-tetrahydroacridine-9-carboxylate (5k):*

Yield = 95%, White solid; M. P: 134.6-135.2 °C; **IR (KBr, cm⁻¹):** 3045, 2937, 1770, 1736, 1596, 1440, 1384, 1228, 1182, 1092, 985, 781; **¹H NMR (400 MHz, CDCl₃) δ** 7.88 (d, J = 8.0 Hz, 1H), 7.67 (d, J = 9.2 Hz, 1H), 7.62 (ddd, J = 8.0, 6.8, 1.6 Hz, 1H), 7.51 (ddd, J = 8.0, 6.8, 1.6 Hz, 1H), 7.41 – 7.36 (m, 2H), 7.34 (d, J = 1.6 Hz, 1H), 7.16 (d, J = 1.6 Hz, 1H), 7.14 (s, 1H), 4.05 (s, 3H), 3.94 (d, J = 8.0 Hz, 1H), 3.70 – 3.64 (m, 1H), 3.13 (m, 1H), 3.01 (m, 2H), 2.97 (d, J = 4.8 Hz, 1H), 2.22 – 2.14 (m, 2H), 2.14 – 2.08 (m, 1H), 1.95 – 1.85 (m, 1H). **¹³C NMR (101 MHz, CDCl₃) δ** 178.91, 176.68, 168.13, 158.43, 145.83, 137.88, 132.25, 129.26, 129.20, 129.04, 128.40, 127.54, 127.20, 126.57, 124.13, 123.12, 52.58, 44.37, 43.51, 34.77, 29.70, 26.71, 22.17. **HRMS (ESI-MS):** m/z Calculated for C₂₅H₂₂N₂O₄ [M+H]⁺: 415.1653; Observed: 415.1654.  

*Prop-2-yn-1-yl 4-(2,5-dioxo-1-phenylpyrrolidin-3-yl)-1,2,3,4-tetrahydroacridine-9-carboxylate (5l):*

Yield = 82%, white solid; M. P: 170.1-171 °C; **IR (KBr, cm⁻¹):** 3229, 2932, 2865, 1741, 1701, 1498, 1397, 1206, 1026, 947, 769; **¹H NMR (400 MHz, CDCl₃) δ** 7.71 (m, 1H), 7.69 (m, 1H), 7.59 – 7.56 (m, 3H), 7.54 (dd, J = 7.2, 1.6 Hz, 2H), 7.51 – 7.47 (m, 1H), 7.45 – 7.41 (m, 1H), 5.05 (s, 2H),
4.09 – 4.04 (m, 1H), 3.30 – 3.26 (m, 1H), 3.04 – 2.98 (m, 2H), 2.86 (m, 1H), 2.61 (s, 1H), 2.44 (m, 1H), 2.28 – 2.22 (m, 1H), 2.16 – 2.10 (m, 1H), 2.05 – 1.97 (m, 1H), 1.81 – 1.74 (m, 1H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 179.03, 176.27, 166.82, 157.43, 145.68, 137.05, 132.84, 129.41, 129.09, 128.13, 127.86, 126.20, 123.95, 123.01, 76.89, 75.95, 52.99, 43.98, 43.41, 31.12, 28.79, 26.38, 22.13.

HRMS (ESI-MS): m/z Calculated for C$_{27}$H$_{22}$N$_2$O$_4$[M+H]$^+$: 439.1653; Observed: 439.1658.

**Benzyl 4-(2,5-dioxo-1-phenylpyrrolidin-3-yl)-1,2,3,4-tetrahydroacridine-9-carboxylate (5m):**

Yield = 91%, white solid; M. P: 138.7-139.3 °C; IR (KBr, cm$^{-1}$): 3060, 2935, 2852, 1730, 1705, 1498, 1337, 1178, 1023, 766; $^1$H NMR (400 MHz, CDCl$_3$) δ 7.68 (d, $J = 8.0$ Hz, 1H), 7.59 (d, $J = 2.0$ Hz, 1H), 7.57 (d, $J = 2.0$ Hz, 3H), 7.55 – 7.53 (m, 1H), 7.53 – 7.50 (m, 1H), 7.47 (dd, $J = 8.0$, 2.0 Hz, 2H), 7.45 – 7.42 (m, 2H), 7.41 – 7.37 (m, 3H), 5.50 (s, 2H), 4.04 (dd, $J = 5.2$, 2.4 Hz, 1H), 3.26 (dd, $J = 5.2$, 2.4 Hz, 1H), 2.96 – 2.88 (m, 2H), 2.84 (m, 1H), 2.42 (m, 1H), 2.26 – 2.19 (m, 1H), 2.08 (m, 1H), 2.01 – 1.92 (m, 1H), 1.75 (m, 1H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 179.06, 176.30, 167.47, 157.39, 145.69, 137.97, 135.00, 132.84, 129.29, 129.09, 128.79, 128.12, 127.52, 127.23, 126.20, 124.01, 123.06, 67.67, 43.98, 43.41, 31.12, 28.80, 26.35, 22.14. HRMS (ESI-MS): m/z Calculated for C$_{31}$H$_{26}$N$_2$O$_4$[M+H]$^+$: 491.1966; Observed: 491.1966.

4-(2,5-Dioxo-1-phenylpyrrolidin-3-yl)-N-(p-tolyl)-1,2,3,4-tetrahydroacridine-9-carboxamide (5n):

Yield = 80%, white solid; M. P: 227.9 – 228.3 °C; IR (KBr, cm$^{-1}$): 3441, 3296, 2926, 2858, 1706, 1670, 1534, 1392, 1185, 819, 763; $^1$H NMR (400 MHz, CDCl$_3$) δ 8.66 (s, 1H), 7.80 (q, $J = 8.4$ Hz, 2H), 7.59 (d, $J = 7.6$ Hz, 1H), 7.54 (m, 3H), 7.52 (d, $J = 2.4$ Hz, 2H), 7.50 (m, 2H), 7.42 (t, $J = 7.2$ Hz, 2H), 7.15 (d, $J = 8.4$ Hz, 2H), 3.05 (m, 1H), 2.82 (s, 1H), 2.62 (s, 2H), 2.35 (s, 3H), 2.06 (m, 2H), 1.84 (s, 1H), 1.58 (s, 1H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 176.43, 165.52, 157.49, 145.66, 141.56, 135.17, 134.73, 132.71, 129.69, 129.56, 129.29, 129.10, 128.87, 128.26, 127.13, 126.19, 124.39, 123.40, 120.00, 43.85, 43.23, 30.88, 28.64, 26.04, 22.03, 20.96. HRMS (ESI-MS): m/z Calculated for C$_{31}$H$_{27}$N$_3$O$_3$[M+H]$^+$: 490.2125; Observed: 490.2124.
3-(7-Chloro-1-oxo-9-phenyl-1,2,3,4-tetrahydroacridin-4-yl)-1-phenylpyrrolidine-2,5-dione (5o):

Yield = 88%, white solid; M. P: 241.2-241.9 °C; IR (KBr, cm\(^{-1}\)):
3072, 2954, 1706, 1556, 1475, 1386, 1150, 945, 762; \( ^1\)H NMR (400 MHz, CDCl\(_3\)) \( \delta \)
7.85 (d, \( J = 8.8 \) Hz, 1H), 7.67 (dd, \( J = 8.8, 2.4 \) Hz, 1H), 7.58 – 7.51 (m, 3H), 7.49 – 7.45 (m, 2H), 7.45 – 7.38 (m, 2H), 7.26 (s, 1H), 7.25 – 7.19 (m, 2H), 7.19 – 7.13 (m, 1H), 3.85 – 3.74 (m, 2H), 3.36 – 3.20 (m, 2H), 2.88 (m, 1H), 2.82 – 2.70 (m, 2H), 2.35 (m, 1H).

\( ^{13}\)C NMR (101 MHz, CDCl\(_3\)) \( \delta \)
196.55, 178.51, 176.47, 161.04, 151.09, 146.15, 136.37, 133.14, 132.80, 132.24, 130.50, 129.15, 128.55, 128.53, 128.47, 128.37, 128.26, 128.10, 127.71, 126.81, 126.47, 124.38, 44.62, 43.28, 40.31, 35.15, 26.59.

HRMS (ESI-MS): m/z Calculated for C\(_{29}\)H\(_{21}\)ClN\(_2\)O\(_3\) [M+H]\(^+\): 481.1314; Observed: 481.1312.

Ethyl 4-(2,5-dioxo-1-phenylpyrrolidin-3-yl)-1-oxo-1,2,3,4-tetrahydroacridine-9-carboxylate (5p):

Yield = 80%, light yellow solid; M. P: 204.1-204.5 °C; IR (KBr, cm\(^{-1}\)):
3084, 2924, 1731, 1708, 1691, 1571, 1498, 1287, 1181, 784, 755; \( ^1\)H NMR (400 MHz, CDCl\(_3\)) \( \delta \)
7.94 (d, \( J = 8.0 \) Hz, 1H), 7.87 – 7.80 (m, 2H), 7.65 (t, \( J = 7.2 \) Hz, 1H), 7.46 – 7.41 (m, 2H), 7.39 (d, \( J = 7.2 \) Hz, 1H), 7.24 – 7.18 (m, 2H), 4.66 (q, \( J = 7.2 \) Hz, 2H), 3.87 (d, \( J = 2.4 \) Hz, 1H), 3.87 – 3.82 (m, 1H), 3.29 (m, 1H), 3.13 (m, 1H), 3.07 – 3.00 (m, 1H), 2.90 – 2.81 (m, 1H), 2.77 – 2.67 (m, 1H), 2.41 – 2.35 (m, 1H), 1.50 (t, \( J = 7.2 \) Hz, 3H). \( ^{13}\)C NMR (101 MHz, CDCl\(_3\)) \( \delta \)
195.79, 178.27, 176.30, 167.64, 160.42, 148.66, 142.40, 132.89, 132.15, 129.31, 129.11, 128.52, 128.22, 126.49, 126.37, 123.35, 121.44, 62.54, 44.01, 43.07, 39.11, 34.78, 29.70, 26.40, 14.08.

HRMS (ESI-MS): m/z Calculated for C\(_{26}\)H\(_{22}\)N\(_2\)O\(_5\) [M+H]\(^+\): 443.1602; Observed: 443.1603.

I-Phenyl-3-(quinolin-2-ylmethyl)pyrrolidine-2,5-dione (5q):

Yield = 89%, white solid; M. P: 123.4 - 124 °C; IR (KBr, cm\(^{-1}\)):
3084, 2924, 1731, 1708, 1691, 1571, 1498, 1287, 1181, 784, 755; \( ^1\)H NMR (400 MHz, CDCl\(_3\)) \( \delta \)
8.04 (d, \( J = 8.4 \) Hz, 1H), 7.85 (d, \( J = 8.8 \) Hz, 1H), 7.74 (d, \( J = 8.4 \) Hz, 1H), 7.62 (d, \( J = 8.4 \) Hz, 1H),...
Hz, 1H), 7.61 (t, J = 7.6 Hz, 1H), 7.49 – 7.45 (m, 2H), 7.43 (s, 1H), 7.39 – 7.35 (m, 2H), 7.34 (s, 1H), 7.25 (t, J = 2.4 Hz, 1H), 3.69 (m, 1H), 3.53 – 3.44 (m, 2H), 3.05 – 2.90 (m, 2H). 13C NMR (101 MHz, CDCl3) δ 179.24, 176.47, 157.42, 147.47, 136.60, 132.57, 129.69, 129.13, 129.04, 128.39, 127.56, 126.84, 126.55, 126.28, 121.59, 39.34, 37.23, 34.09. HRMS (ESI-MS): m/z Calculated for C20H16N2O2[M+H]+: 317.1285;Observed: 317.1284.

1-Phenyl-3-(1-(4-phenyl-3-propionylquinolin-2-yl)ethyl)pyrrolidine-2,5-dione (5r):

Yield = 76%, white solid; M. P: 172.1-172.8 °C; IR (KBr, cm⁻¹): 3060, 2927, 2861, 1702, 1572, 1498, 1186, 770, 756; ¹H NMR (400 MHz, CDCl3) δ 7.95 (dd, J = 9.0, 1.2 Hz, 1H), 7.67 (ddd, J = 8.4, 6.8, 1.6 Hz, 1H), 7.61 (dd, J = 9.0, 1.6 Hz, 1H), 7.51 – 7.46 (m, 3H), 7.46 – 7.43 (m, 1H), 7.39 – 7.35 (m, 1H), 7.35 – 7.30 (m, 3H), 7.30 – 7.26 (m, 1H), 7.07 – 7.00 (m, 2H), 4.15 – 3.88 (m, 1H), 3.75 – 3.63 (m, 1H), 3.41 (m, 1H), 3.01 (m, 1H), 2.48 (m, 1H), 2.24 – 2.09 (m, 1H), 1.55 (t, J = 7.2 Hz, 3H), 0.83 (t, J = 7.2 Hz, 3H). 13C NMR (101 MHz, CDCl3) δ 208.59, 179.11, 177.20, 158.49, 146.97, 144.65, 135.06, 134.68, 132.30, 130.65, 130.17, 129.99, 129.22, 129.04, 128.92, 128.83, 128.40, 128.37, 126.99, 126.60, 126.12, 125.25, 45.17, 38.59, 38.36, 33.05, 20.08, 7.59. HRMS (ESI-MS): m/z Calculated for C30H26N2O3[M+H]+: 463.2016; Observed: 463.2027.

3-(1-(3-Acetyl-6-chloro-4-phenylquinolin-2-yl)ethyl)-1-phenylpyrrolidine-2,5-dione (5s):

Yield = 79%, White solid; M. P: 162.3-163 °C; IR (KBr, cm⁻¹): 3057, 2973, 2925, 1775, 1705, 1478, 1392, 1184, 1074, 965, 835; ¹H NMR (400 MHz, CDCl3) δ 7.90 (d, J = 8.8 Hz, 1H), 7.64 (dd, J = 8.8, 2.4 Hz, 1H), 7.60 (d, J = 2.4 Hz, 1H), 7.57 – 7.52 (m, 3H), 7.52 – 7.49 (m, 1H), 7.39 – 7.35 (m, 3H), 7.34 (d, J = 7.6 Hz, 1H), 7.33 – 7.30 (m, 1H), 7.04 (dd, J = 4.8, 2.4 Hz, 1H), 3.90 (d, J = 4.8 Hz, 1H), 3.76 – 3.67 (m, 1H), 3.46 – 3.40 (m, 1H), 3.05 (d, J = 8.1 Hz, 1H), 2.50 (m, 1H), 2.15 (m, 1H), 1.57 (d, J = 7.2 Hz, 3H), 0.85 (t, J = 7.2 Hz, 3H). 13C NMR (101 MHz, CDCl3) δ 208.15, 178.95, 177.08, 158.94, 146.97, 144.65, 135.06, 134.68, 132.30, 130.65, 130.17, 129.99, 129.22, 129.04, 128.92, 128.83, 128.40, 128.37, 126.99, 126.60, 126.12, 125.25, 45.17, 38.59, 38.36, 33.05, 20.08, 7.59. HRMS (ESI-MS): m/z Calculated for C30H25ClN2O3[M+H]+: 497.1627; Observed: 497.1627.

1-Phenyl-3-(5,6,7,8-tetrahydroquinolin-8-yl)pyrrolidine-2,5-dione (5t):

Yield = 75%, light Yellow solid; M. P: 129.1-130.2 °C; IR (KBr, cm⁻¹): 3010, 2967, 2903, 2852, 1714, 1665, 1598, 1215, 1177, 1094, 880, 760; ¹H
NMR (400 MHz, CDCl$_3$) $\delta$ 8.34 (dd, $J = 4.6, 1.8$ Hz, 1H), 7.47 – 7.43 (m, 2H), 7.38 (dd, $J = 7.6, 2.3$ Hz, 2H), 7.24 (d, $J = 1.3$ Hz, 1H), 7.23 – 7.21 (m, 1H), 7.07 (ddd, $J = 4.6, 1.0$ Hz, 1H), 4.06 (ddd, $J = 9.7, 4.8, 3.4$ Hz, 1H), 3.67 – 3.60 (m, 1H), 2.93 (dd, $J = 18.5, 9.6$ Hz, 1H), 2.83 – 2.80 (m, 2H), 2.67 (dd, $J = 18.5, 4.7$ Hz, 1H), 2.10 – 2.02 (m, 2H), 1.83 – 1.75 (m, 2H).

$^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 179.12, 176.47, 156.44, 146.76, 136.91, 133.18, 129.11, 128.47, 126.53, 121.75, 43.11, 42.51, 33.28, 28.82, 25.63, 22.06. HRMS (ESI-MS): m/z Calculated for C$_{19}$H$_{18}$N$_2$O$_2$ [M+H]$^+$: 307.1441; Observed: 307.1441.

3-((3-Hydroxyquinoxalin-2-yl)methyl)-1-phenylpyrrolidine-2,5-dione (5u):
Yield = 79%, white solid; M. P: 234.5-234.9 °C; IR (KBr, cm$^{-1}$): 3010, 2967, 2903, 2852, 1714, 1665, 1598, 1215, 1177, 1094, 880, 760; $^1$H NMR (400 MHz, DMSO) $\delta$ 12.41 (s, 1H), 7.57 – 7.52 (m, 2H), 7.49 (d, $J = 8.8$ Hz, 2H), 7.42 (t, $J = 7.6$ Hz, 1H), 7.32 (t, $J = 8.0$ Hz, 3H), 7.27 (t, $J = 7.6$ Hz, 1H), 3.56 (q, $J = 5.0$ Hz, 1H), 3.43 (d, $J = 4.4$ Hz, 1H), 3.30 (m, 1H), 3.04 (m, 1H), 2.77 (m, 1H). $^{13}$C NMR (101 MHz, DMSO) $\delta$ 179.58, 176.79, 159.26, 155.14, 133.36, 132.29, 131.65, 130.17, 129.30, 128.53, 127.33, 123.65, 115.86, 37.02, 34.43, 33.03. HRMS (ESI-MS): m/z Calculated for C$_{19}$H$_{15}$N$_3$O$_3$ [M+H]$^+$: 334.1186; Observed: 334.1188.

6. Spectral Data

Diethyl 1-(1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3a):
Diethyl 1-(9-methyl-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3b):
Chemical Formula: $\text{C}_{20}\text{H}_{25}\text{N}_3\text{O}_4$

Exact Mass: 371.1845
Diethyl 1-(9-phenyl-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3c):
Diethyl 1-(7-Chloro-9-phenyl-2,3-dihydro-1H-cyclopenta[b]quinolin-3-yl)hydrazine-1,2-dicarboxylate (3d):
Chemical Formula: C_{24}H_{24}ClN_{3}O_{4}

Exact Mass: 453.1455
Diethyl 1-(7-chloro-9-phenyl-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3e):
Diisopropyl 1-(7-chloro-9-phenyl-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3f)
Chemical Formula: C_{27}H_{30}ClN_{3}O_{4}

Exact Mass: 495.1925
Diethyl 1-(7-nitro-9-phenyl-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3g):
Diethyl 1-(9-chloro-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3h):
Chemical Formula: $\text{C}_{19}\text{H}_{22}\text{ClN}_3\text{O}_4$

Exact Mass: 391.1299
**Diethyl 1-(6-bromo-9-chloro-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3i):**
Diethyl 1-(9-chloro-6-nitro-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3j):
Chemical Formula: $C_{19}H_{21}ClN_4O_6$

Exact Mass: 436.1150
Diethyl 1-(9-(methoxycarbonyl)-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3k):
Diisopropyl 1-(9-(methoxycarbonyl)-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3l):
Chemical Formula: $C_{23}H_{29}N_3O_6$

Exact Mass: 443.2056
Diethyl 1-(9-((prop-2-yn-1-yl)oxy)carbonyl)-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3m):
Diisopropyl 1-((9-((prop-2-yn-1-yloxy)carbonyl)-1,2,3,4-tetrahydroacridin-4-yl)hydrazyl)-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3n)
Diethyl 1-(9-((benzyloxy)carbonyl)-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3o):
Diisopropyl 1-(9-(p-tolylcarbamoyl)-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3p):
Chemical Formula: $C_{29}H_{34}N_4O_5$

Exact Mass: 518.2529
Diethyl 1-(1-oxo-9-phenyl-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3q):
Diethyl 1-(7-chloro-1-oxo-9-phenyl-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3r):
Chemical Formula: C_{25}H_{24}ClN_{3}O_{5}

Exact Mass: 481.1404
Diethyl 1-(9-(ethoxycarbonyl)-1-oxo-1,2,3,4-tetrahydroacridin-4-yl)hydrazine-1,2-dicarboxylate (3s):
Diethyl 1-(quinolin-2-ylmethyl)hydrazine-1,2-dicarboxylate (3t):
Chemical Formula: C_{16}H_{19}N_{3}O_{4}

Exact Mass: 317.1376
Diethyl 1-(1-(4-phenyl-3-propionylquinolin-2-yl)ethyl)hydrazine-1,2-dicarboxylate (3u):
Diethyl 1-(1-(6-chloro-4-phenyl-3-propionylquinolin-2-yl)ethyl)hydrazine-1,2-dicarboxylate (3v):
Chemical Formula: C_{26}H_{28}ClN_{3}O_{5}

Exact Mass: 497.1717
Diethyl 1-(5,6,7,8-tetrahydroquinolin-8-yl)hydrazine-1,2-dicarboxylate (3w):

![Chemical Structure]

![NMR Spectrogram]
Diethyl 1-((3-hydroxyquinoxalin-2-yl)methyl)hydrazine-1,2-dicarboxylate (3x):
Chemical Formula: \( \text{C}_{15}\text{H}_{18}\text{N}_{4}\text{O}_{5} \)

Exact Mass: 334.1277
1-Phenyl-3-(1,2,3,4-tetrahydroacridin-4-yl)pyrrolidine-2,5-dione (5a):

![Chemical Structure of 1-Phenyl-3-(1,2,3,4-tetrahydroacridin-4-yl)pyrrolidine-2,5-dione (5a)]
3-(9-Methyl-1,2,3,4-tetrahydroacridin-4-yl)-1-phenylpyrrolidine-2,5-dione (5b):

Chemical Formula: $\text{C}_{23}\text{H}_{20}\text{N}_{2}\text{O}_{2}$

Exact Mass: 356.1525
Chemical Formula: \( C_{24}H_{22}N_2O_2 \)

Exact Mass: 370.1681
1-Phenyl-3-(9-phenyl-1,2,3,4-tetrahydroacridin-4-yl)pyrrolidine-2,5-dione (5c):
3-(7-Chloro-9-phenyl-2,3-dihydro-1H-cyclopenta[b]quinolin-3-yl)-1-phenylpyrrolidine-2,5-dione (5d):
Chemical Formula: $\text{C}_{28}\text{H}_{21}\text{ClN}_{2}\text{O}_{2}$

Exact Mass: 452.1292
3-(7-Chloro-9-phenyl-1,2,3,4-tetrahydroacridin-4-yl)-1-phenylpyrrolidine-2,5-dione (5e):
tert-Butyl 8-chloro-4-(2,5-dioxo-1-phenylpyrrolidin-3-yl)-10-phenyl-3,4-dihydrobenzo[b][1,6]naphthyridine-2(1H)-carboxylate (5f):

Chemical Formula: C_{29}H_{23}ClN_{2}O_{2}

Exact Mass: 466.1448
Chemical Formula: C$_{33}$H$_{30}$ClN$_3$O$_4$

Exact Mass: 567.1925
3-(7-Nitro-9-phenyl-1,2,3,4-tetrahydroacridin-4-yl)-1-phenylpyrrolidine-2,5-dione (5g):
3-(9-Chloro-1,2,3,4-tetrahydroacridin-4-yl)-1-phenylpyrrolidine-2,5-dione (5h):

Chemical Formula: C_{29}H_{23}N_{3}O_{4}
Exact Mass: 477.1689
Chemical Formula: C_{23}H_{19}ClN_{2}O_{2}
Exact Mass: 390.1135
3-(6-Bromo-9-chloro-1,2,3,4-tetrahydroacridin-4-yl)-1-phenylpyrrolidine-2,5-dione (5i):
3-(9-Chloro-6-nitro-1,2,3,4-tetrahydroacridin-4-yl)-1-phenylpyrrolidine-2,5-dione (5j):
Chemical Formula: $C_{23}H_{18}ClN_3O_4$

Exact Mass: 435.0986
Methyl 4-(2,5-dioxo-1-phenylpyrrolidin-3-yl)-1,2,3,4-tetrahydroacridine-9-carboxylate (5k):
Prop-2-yn-1-yl 4-(2,5-dioxo-1-phenylpyrrolidin-3-yl)-1,2,3,4-tetrahydroacridine-9-carboxylate (5l)

Chemical Formula: C_{25}H_{22}N_{2}O_{4}

Exact Mass: 414.1580
Chemical Formula: C_{27}H_{22}N_{2}O_{4}

Exact Mass: 438.1580
Benzyl 4-(2,5-dioxo-1-phenylpyrrolidin-3-yl)-1,2,3,4-tetrahydroacridine-9-carboxylate (5m):
4-(2,5-Dioxo-1-phenylpyrrolidin-3-yl)-N-(p-tolyl)-1,2,3,4-tetrahydroacridine-9-carboxamide (5n):
3-(7-Chloro-1-oxo-9-phenyl-1,2,3,4-tetrahydroacridin-4-yl)-1-phenylpyrrolidine-2,5-dione (5o):
Ethyl 4-(2,5-dioxo-1-phenylpyrrolidin-3-yl)-1-oxo-1,2,3,4-tetrahydroacridine-9-carboxylate (5p):
Chemical Formula: $C_{26}H_{22}N_2O_5$

Exact Mass: 442.1529
1-Phenyl-3-(quinolin-2-ylmethyl)pyrrolidine-2,5-dione (5q):
1-Phenyl-3-(1-(4-phenyl-3-propionylquinolin-2-yl)ethyl)pyrrolidine-2,5-dione (5r):

Chemical Formula: C_{20}H_{16}N_{2}O_{2}

Exact Mass: 316.1212
Chemical Formula: C₃₀H₂₆N₂O₃
Exact Mass: 462.1943
3-((1-(3-Acetyl-6-chloro-4-phenylquinolin-2-yl)ethyl)-1-phenylpyrroloidine-2,5-dione (5s):
1-Phenyl-3-(5,6,7,8-tetrahydroquinolin-8-yl)pyrrolidine-2,5-dione (5t):

Chemical Formula: C$_{30}$H$_{25}$ClN$_2$O$_3$

Exact Mass: 496.1554
Chemical Formula: C_{19}H_{18}N_{2}O_{2}

Exact Mass: 306.1368
3-((3-Hydroxyquinoxalin-2-yl)methyl)-1-phenylpyrrolidine-2,5-dione (5u):
7. X-ray Crystallography.

X-ray data for the compound was collected at room temperature on a Bruker D8 QUEST instrument with an IμS Mo microsource (λ = 0.7107 Å) and a PHOTON-III detector. The raw data frames were reduced and corrected for absorption effects using the Bruker Apex 3 software suite programs [1]. The structure was solved using intrinsic phasing method [2] and further refined with the SHELXL [2] program and expanded using Fourier techniques. Anisotropic displacement parameters were included for all non-hydrogen atoms. All C bound H atoms were positioned geometrically and treated as riding on their parent C atoms [C-H = 0.93-0.97 Å, and Uiso(H) = 1.5Ueq(C) for methyl H or 1.2Ueq(C) for other H atoms].

Crystal structure determination of (5i)

Crystal Data for C_{23}H_{18}N_{2}O_{2}ClBr (M = 469.75 g/mol): monoclinic, space group P2_{1}/c (no. 14), a = 12.9798(5) Å, b = 8.3982(3) Å, c = 18.9108(8) Å, β = 104.1125(19)°, V = 1999.19(14) Å³, Z = 4, T = 294.15 K, μ(MoKα) = 2.212 mm⁻¹, Dcalc = 1.561 g/cm³, 30943 reflections measured (4.442° ≤ 2θ ≤ 54.998°), 4574 unique (R_{int} = 0.0730, R_{sigma} = 0.0503) which were used in all calculations. The final R₁ was 0.0392 (I > 2σ(I)) and wR₂ was 0.1040.
(all data). **CCDC 2294878** deposition number contains the supplementary crystallographic data for this paper which can be obtained free of charge at [https://www.ccdc.cam.ac.uk/structures/](https://www.ccdc.cam.ac.uk/structures/)

![Chemical structure diagram](https://via.placeholder.com/150)

**Figure caption**: ORTEP diagram of 5i compound with the atom-numbering. Displacement ellipsoids are drawn at the 30% probability level and H atoms are shown as small spheres of arbitrary radius.