ONE POT SYNTHESIS OF FUSED PYRIMIDINES FROM 2-\([N-(METHYLTHIOTHIOCARBONYL)AMINO]ACETATE

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Abstract - A variety of 3-substituted fused pyrimidines (4a-k) are readily obtained from the 2-amino esters (2a-k) with 2-[\([N-(methylthiothiocarbonyl)amino]\)acetate (1). Condensed imidazo[1,2-c]pyrimidine ring system was also constructed in a one-pot process by reacting heteroaromatic 2-amino nitriles (3a-l) with 1, obtaining a number of novel tri- and tetracyclic compounds (5a-l).

Fused pyrimidines are found in a wide variety of natural products [e.g. purines, pyrrolopyrimidines, pyridopyrimidines, pteridines], pharmaceuticals, agrochemicals and veterinary products.1-7 In recent papers,8-11 we reported the reaction of heteroaromatic 2-amino esters or 2-amino nitriles with ethyl isothiocyanatoacetate giving fused pyrimidines or imidazopyrimidines, respectively (Scheme 1).

Scheme 1
As illustrated in Scheme 2, the present work is aiming at the synthesis of similar products, using ethyl 2-[N-[(methylthiothiocarbonyl)amino]acetate (1) in DMF.

![Scheme 2](image)

Utilization of 1 seems promising, since the corresponding isocyanatoacetate as well as 2-chloroethyl isocyanate have already been used for cyclizing anthranilonitrile (3a) in a 2- or 3-step procedure, respectively.\textsuperscript{12,13}

Here, we report a simple, one-pot reaction for the synthesis of 3-substituted pyrimidines and tri- or tetracyclic imidazopyrimidine systems by the reaction of 2-amino esters or 2-amino nitriles with ethyl 2-[N-[(methylthiothiocarbonyl)amino]acetate (1) in DMF.

The reaction of various 2-amino esters (2a-k) with 1 afforded cyclization products (4a-k) (Figure 1) by one-pot reactions in 40-55% yields presumably via an intermediate G.

![Figure 1](image)
The conformity of the structure (4a-k) was proved by several evidences: comparison of chemical shifts between 2-(3,4-dihydro-2-methyl-4-oxoquinazolin-3-yl)acetic acid (from a $^{13}$C NMR spectral data bank$^{14}$) and methylthio derivatives$^{15,16}$ of 4b. Moreover, the NMR values of 4b is also good agreements with the literature values.$^{16}$

The reaction of 2-amino nitriles (3a-l) with 1 gave the fused pyrimidines (5a-l) (Figure 2) by the one-pot reactions in 36-46% yields presumably via a thiourea intermediate (5l), wherein imidazolidinyl derivative (5L) and diazepino derivative (5M) were ruled out by NMR spectroscopy. This method is useful for giving smooth access to tricyclic and tetracyclic hetero systems (5a-l).

![Figure 2](image_url)

Thus, a series of imidazo[1,2-c]quinazoline (5a), imidazo[1,2-c]thiazolo[5,4-e]pyrimidine (5b), (benzo)furo[3,2-e]imidazo[1,2-c]pyrimidine (5c,5d), benzothieno[3,2-e]imidazo[1,2-c]pyrimidine (5e,5f), imidazoo[1,2-c]pyrido[4’,3’:4,5]thieno[3,2-e]pyrimidine (3g,3h), imidazo[1,2-c](thio)pyrano[4’,3’:4,5]thieno[3,2-e]pyrimidine (5i,5j), and cyclo(hepta or penta)[4,5]thieno[3,2-e]imidazo[1,2-c]pyrimidine (5k,5l) were easily accessible from 2-amino nitriles (3a-l) and ethyl 2-[N-(methylthiothiocarbonyl)-amino]acetate (1) in DMF by a one-step reaction (Figure 3).

Annelation to such type of angular tri- and tetracyclic compounds (5a-l) was also established by Sauter$^{15,17}$ and Chowdhury$^{9,10,18}$ from 2-amino nitriles with N-[bis(methylthio)methylene]amino (BMMA) reagents. The structural assignment of compounds (5a-l) was based on the NMR spectral and elemental analytical data. Displacement reactions have been employed to create the middle ring of tricyclic or tetracyclic systems in one-step as described above. So, the concept of creating our desired tricyclic and
tetracyclic condensed systems in one-step via a double displacement process using 1 is demonstrated smoothly.

![Chemical structures](image-url)

**Figure 3**

**EXPERIMENTAL**

Melting points were determined on a Yanaco hot stage apparatus and are uncorrected. $^1$H and $^{13}$C NMR spectra were recorded on a JNM-ALPHA 500 (500 MHz) spectrometer (internal standard TMS, solvents CDCl₃ or DMSO-$d_6$ respectively, δ-values in ppm) at the National Institute for Environmental Studies, Tsukuba, Japan. Elemental analyses were performed on an EA 1108 (Fisons Instruments) Elemental Analyzer.

Ethyl 2-[N-(methylthiothiocarbonyl)amino]acetate (1) was prepared from ethyl glycinate using the method reported.$^{10,15}$ Ethyl 2-amino-4,5,6,7-tetrahydrobenzo[b]thiophene-3-carboxylate (2d) and -3-carbonitrile (3e), ethyl 2-amino-4,5,6,7-tetrahydro-6-methylbenzo[b]thiophene-3-carboxylate (2e) and -3-carbonitrile (3f), ethyl 2-amino-6-benzyl-4,5,6,7-tetrahydrothieno[2,3-c]pyridine-3-carboxylate (2f) and -3-carbonitrile (3g), ethyl 2-amino-4,5,6,7-tetrahydro-6-methylthieno[2,3-c]pyridine-3-carboxylate (2g) and -3-carbonitrile (3h), ethyl 2-amino-4,7-dihydro-5H-thieno[2,3-c]pyran-3-carboxylate (2h) and -3-carbonitrile (3i), ethyl 2-amino-4,7-dihydro-5H-thieno[2,3-c]thiopyran-3-carboxylate (2i) -3-carbonitrile (3j), ethyl 2-amino-5,6,7,8-tetrahydro-4H-cyclohepta[b]thiophene-3-carboxylate (2j) and -3-carbonitrile (3k), and ethyl 2-amino-5,6-dihydro-4H-cyclopenta[b]thiophene-3-carboxylate (2k) and -3-carbonitrile (3j) were obtained according to the literature procedures,$^{19,21}$ respectively. 4-Amino-2-methylthiothiazole-5-carbonitrile (3b),$^{22}$ 2-amino-4,5-dimethylfuran-3-carbonitrile (3c)$^{23}$ and 2-amino-
4,5,6,7-tetrahydrobenzofuran-3-carbonitrile (3d)\textsuperscript{10} were prepared according to the procedures in the literatures. Anthranilonitrile (3a), ethyl anthranilate (2b), methyl 2-amino-1-cyclohexene-1-carboxylate (2a) and methyl 4-amino-1-benzyl-1,2,5,6-tetrahydropyridine-3-carboxylate (2c) were purchased from Kanto Chemicals.

**General Procedure for Cyclization Reactions: Synthesis of Compounds (4a-k and 5a-l).** A solution of appropriate 2-amino ester or 2-amino nitrile (10 mmol) and 2-[N-(methylthiothiocarbonyl)-amino]acetate (1) (10 mmol) in 6 mL of DMF was refluxed for 8-10 h. The reaction mixture was cooled and poured onto the crushed ice. The resulting solids were collected by filtration and recrystallized from an appropriate solvent.

**Ethyl 2-(1,2,3,4,5,6,7,8-octahydro-4-oxo-2-thioxoquinazolin-3-yl)acetate (4a):** Prepared from 2a as white crystals (ethanol), yield 52%, mp 187-189 °C. \( ^1\)H NMR (CDCl\(_3\)): \( \delta \) 1.21 (t, \( J = 7.1 \) Hz, 3H, Me), 1.70 (m, 4H, 6-H and 7-H), 2.30 (t, \( J = 7.6 \) Hz, 4H, 5-H and 8-H), 4.18 (q, \( J = 7.1 \) Hz, 2H, OCH\(_2\)), 4.59 (s, 2H, CH\(_2\)), 10.35 (s, 1H, NH). \( ^{13}\)C NMR (DMSO-\( d_6\)): \( \delta \) 13.96 (q, Me), 20.98 (t, C-6), 21.04 (t, C-7), 21.45 (t, C-5), 26.07 (t, C-8), 41.25 (t, CH\(_2\)), 61.51 (t, OCH\(_2\)), 109.76 (s, C-4a), 147.52 (s, C-8a), 154.55 (s, C=O), 167.23 (s, C=O), 170.79 (s, C=S). Anal. Caled for C\(_{12}\)H\(_{16}\)N\(_2\)O\(_3\)S: C, 53.72; H, 6.01; N, 10.44. Found: C, 53.81; H, 5.94; N, 10.35.

**Ethyl 2-(1,2,3,4-tetrahydro-4-oxo-2-thioxoquinazolin-3-yl)acetate (4b):** Prepared from 2b as colorless crystals (ethanol), yield 47%, mp 223-225 °C. \( ^1\)H NMR (CDCl\(_3\)): \( \delta \) 1.28 (t, \( J = 7.1 \) Hz, 3H, Me), 4.25 (q, \( J = 7.1 \) Hz, 2H, OCH\(_2\)), 5.15 (s, 2H, CH\(_2\)), 8.20 (m, 1H, 8-H), 7.30-7.85 (m, 3H, 5-H, 6-H and 7-H), 8.20 (m, 1H, 8-H), 10.30 (s, 1H, NH). \( ^{13}\)C NMR (CDCl\(_3\)): \( \delta \) 14.52 (q, Me), 45.32 (t, CH\(_2\)), 61.64 (t, OCH\(_2\)), 118.68 (s, C-4a), 125.55 (d, C-6), 125.98 (d, C-7), 126.81 (d, C-5), 134.45 (d, C-8), 147.85 (s, C-8a), 156.24 (s, C=O), 167.25 (s, C=O), 173.13 (s, C=S). Anal. Caled for C\(_{12}\)H\(_{16}\)N\(_2\)O\(_3\)S: C, 54.53; H, 4.57; N, 10.59. Found: C, 54.38; H, 4.61; N, 10.47.

**Ethyl 2-(6-benzyl-1,2,3,4,5,6,7,8-octahydro-4-oxo-2-thioxopyrido[4,3-d]pyrimidin-3-yl)acetate (4c):** Prepared from 2c as brown crystals (ethanol), yield 45%, mp 188-190 °C. \( ^1\)H NMR (CDCl\(_3\)): \( \delta \) 1.20 (t, \( J = 7.1 \) Hz, 3H, Me), 2.46 (t, \( J = 5.2 \) Hz, 2H, 8-H), 2.60 (t, \( J = 5.5 \) Hz, 2H, 7-H), 3.28 (s, 2H, 5-H), 3.60 (s, 2H, Ph-CH\(_2\)), 4.15 (q, \( J = 7.1 \) Hz, 2H, OCH\(_2\)), 5.11 (s, 2H, CH\(_2\)), 7.20-7.38 (m, 5H, Ar-H), 11.05 (s, 1H, NH). \( ^{13}\)C NMR (CDCl\(_3\)): \( \delta \) 14.05 (q, Me), 26.45 (t, C-8), 47.08 (t, C-7), 47.78 (t, C-5), 48.51 (t, CH\(_2\)), 61.65 (t, Ph-CH\(_2\)), 61.88 (t, OCH\(_2\)), 110.85 (s, C-4a), 127.24 (d, C-4'), 128.95 (d, C-3’ and C-5’), 129.69
(d, C-2’ and C-6’), 137.25 (s, C-1’), 146.50 (s, C-8a), 159.23 (s, C=O), 167.12 (s, C=O), 175.50 (s, C=S).

**Anal.** Calcd for C_{18}H_{21}N_{3}O_{3}S:  C, 60.14; H, 5.88; N, 11.69. Found: C, 59.99; H, 5.94; N, 11.75.

**Ethyl 2-(1,2,3,4,5,6,7,8-octahydro-4-oxo-2-thioxo[1]benzothieno[2,3-d]pyrimidin-3-yl)acetate (4d):**
Prepared from 2d as yellow crystals (ethanol), yield 55%, mp 220-222 °C. 1H NMR (CDCl3): δ 1.31 (t, J = 7.1 Hz, 3H, Me), 1.85 (m, 4H, 6-H and 7-H), 2.65 (m, 2H, 5-H), 2.84 (m, 2H, 8-H), 4.24 (q, J = 7.1 Hz, 2H, OCH2), 5.22 (s, 2H, CH2), 11.35 (s, 1H, NH). 13C NMR (CDCl3): δ 13.75 (q, Me), 21.42 (t, C-6), 22.36 (t, C-7), 23.98 (t, C-5), 24.61 (t, C-8), 46.31 (t, CH2), 60.72 (t, OCH2), 115.37 (s, C-4b), 128.35 (s, C-4a), 131.12 (s, C-8a), 148.92 (s, C-9a), 156.41 (s, C=O), 167.12 (s, C=O), 173.60 (s, C=S).  

**Ethyl 2-(1,2,3,4,5,6,7,8-octahydro-7-methyl-4-oxo-2-thioxo[1]benzothieno[2,3-d]pyrimidin-3-yl)acetate (4e):**
Prepared from 2e as white crystals (ethanol), yield 47%, mp 225-227 °C. 1H NMR (CDCl3): δ 1.05 (d, J = 6.4 Hz, 1H, 7-Me), 1.33 (t, J = 7.1 Hz, 3H, Me), 1.82-3.04 (m, 7H, 5-H, 6-H, 7-H and 8-H), 4.26 (q, J = 7.1 Hz, 2H, OCH2), 5.23 (s, 2H, CH2), 10.75 (s, 1H, NH). 13C NMR (CDCl3): δ 13.65 (q, Me), 20.80 (t, 7-Me), 24.21 (t, C-6), 28.65 (d, C-7), 29.51 (t, C-5), 31.85 (t, C-8), 46.22 (t, CH2), 60.65 (t, OCH2), 115.16 (s, C-4b), 127.88 (s, C-4a), 130.71 (s, C-8a), 148.95 (s, C-9a), 156.09 (s, C=O), 166.92 (s, C=O), 173.55 (s, C=S).  

**Ethyl 2-(7-benzyl-1,2,3,4,5,6,7,8-octahydro-4-oxo-2-thioopyrido[4’,3’:4,5]thieno[2,3-d]pyrimidin-3-yl)acetate (4f):**
Prepared from 2f as red crystals (ethanol), yield 46%, mp 124-126 °C. 1H NMR (CDCl3): δ 1.15 (t, J = 7.1 Hz, 3H, Me), 2.90 (t, J = 5.2 Hz, 2H, 5-H), 3.33 (t, J = 5.5 Hz, 2H, 6-H), 3.76 (s, 2H, 8-H), 3.89 (s, 2H, CH2-Ph), 4.20 (q, J = 7.1 Hz, 2H, OCH2), 5.10 (s, 2H, CH2), 7.29-7.54 (m, 5H, Ar-H).  

**Ethyl 2-(7-benzyl-1,2,3,4,5,6,7,8-octahydro-4-oxo-2-thioopyrido[4’,3’:4,5]thieno[2,3-d]pyrimidin-3-yl)acetate (4g):**
Prepared from 2g as brown crystals (ethanol), yield 40%; mp 172-174 °C. 1H NMR (DMSO-d6): δ 1.22 (t, J = 7.1 Hz, 3H, Me), 2.60 (s, 3H, N-Me), 3.25 (m, 4H, 5-H and 6-H), 3.92 (s, 2H,
**Ethyl 2-(1,3,4,5,6,8-hexahydro-4-oxo-2-thioxo-2H-pyrano[4′,3′:4,5]thieno[2,3-d]pyrimidin-3-yl)acetate** (4h): Prepared from 2h as yellow crystals (ethanol), yield 45%, mp 226-227 °C. 1H NMR (DMSO-d6): δ 1.29 (t, J = 7.1 Hz, 3H, Me), 2.81 (t, J = 5.2 Hz, 2H, 5-H), 3.89 (t, J = 5.5 Hz, 2H, 6-H), 4.25 (q, J = 7.1 Hz, 2H, OCH2), 4.65 (s, 2H, CH2), 4.68 (s, 2H, 8-H), 8.67 (s, 1H, NH). 13C NMR (DMSO-d6): δ 14.18 (q, Me), 26.99 (t, C-5), 46.15 (t, CH2), 60.65 (t, OCH2), 64.67 (t, C-6), 64.94 (t, C-8), 112.45 (s, C-4b), 128.62 (s, C-4a), 136.56 (s, C-8a), 150.42 (s, C-9a), 156.45 (s, C=O), 166.84 (s, C=O), 170.77 (s, C=S). Anal. Calcd for C13H14N2O4S2: C, 47.83; H, 4.32; N, 8.58. Found: C, 47.75; H, 4.40; N, 8.47.

**Ethyl 2-(1,3,4,5,6,8-hexahydro-4-oxo-2-thioxo-2H-thiopyrano[4′,3′:4,5]thieno[2,3-d]pyrimidin-3-yl)acetate** (4i): Prepared from 2i as yellow needles (ethanol), yield 49%, mp 215-218 °C. 1H NMR (CDCl3): δ 1.26 (t, J = 7.1 Hz, 3H, Me), 2.84 (t, J = 6.1 Hz, 2H, 6-H), 2.99 (t, J = 5.6 Hz, 2H, 5-H), 4.25 (q, J = 7.1 Hz, 2H, OCH2), 4.48 (s, 2H, CH2), 3.70 (s, 2H, 8-H), 9.85 (s, 1H, NH). 13C NMR (CDCl3): δ 14.05 (q, Me), 25.09 (t, C-6), 25.86 (t, C-5), 26.90 (t, C-8), 46.15 (t, CH2), 60.65 (t, OCH2), 111.05 (s, C-4b), 125.29 (s, C-4a), 132.21 (s, C-8a), 140.14 (s, C-9a), 156.15 (s, C=O), 166.25 (s, C=O), 170.27 (s, C=S). Anal. Calcd for C13H14N2O3S3: C, 45.59; H, 4.12; N, 8.18. Found: C, 45.71; H, 4.18; N, 8.25.

**Ethyl 2-(1,3,4,5,6,7,8,9-octahydro-4-oxo-2-thioxo-2H-cyclohepta[4,5]thieno[2,3-d]pyrimidin-3-yl)acetate** (4j): Prepared from 2j as white crystals (ethanol), yield 48%, mp 202-204 °C. 1H NMR (CDCl3): δ 1.25 (t, J = 7.1 Hz, 3H, Me), 1.68 (m, 4H, 6-H and 7-H), 1.95 (m, 2H, 8-H), 2.75 (m, 2H, 5-H), 3.21 (m, 2H, 9-H), 4.20 (q, J = 7.1 Hz, 2H, OCH2), 5.20 (s, 2H, CH2), 10.25 (s, 1H, NH). 13C NMR (CDCl3): δ 14.05 (q, Me), 26.75 (t, C-7), 27.08 (t, C-6), 27.45 (t, C-8), 29.35 (t, C-5), 32.14 (t, C-9), 47.15 (t, CH2), 61.66 (t, OCH2), 117.12 (s, C-4b), 132.97 (s, C-4a), 137.50 (s, C-9a), 146.76 (s, C-10a), 156.69 (s, C=O), 167.74 (s, C=O), 173.59 (s, C=S). Anal. Calcd for C15H18N2O3S2: C, 53.23; H, 5.36; N, 8.28. Found: C, 53.11; H, 5.40; N, 8.12.

**Ethyl 2-(1,3,4,5,6,7,8,9-octahydro-4-oxo-2-thioxo-2H-cyclopenta[4,5]thieno[2,3-d]pyrimidin-3-yl)acetate** (4k): Prepared from 2k as yellow crystals (ethanol), yield 44%, mp 218-220 °C. 1H NMR (CDCl3): δ 1.25 (t, J = 7.1 Hz, 3H, Me), 2.43 (m, 2H, 6-H), 2.85 (m, 4H, 5-H and 7-H), 4.14 (q, J = 7.1 Hz, 2H,
OCH₂), 5.20 (s, 2H, CH₂), 10.21 (s, 1H, NH). ¹³C NMR (CDCl₃): δ 13.74 (q, Me), 27.60 (t, C-6), 27.95 (t, C-5), 28.34 (t, C-7), 46.31 (t, CH₂), 60.68 (t, OCH₂), 112.45 (s, C-4b), 133.61 (s, C-4a), 140.15 (s, C-7a), 153.38 (s, C-8a), 155.94 (s, C=O), 166.87 (s, C=O), 173.81 (s, C=O). Anal. Calcd for C₁₄H₁₆N₂O₃S₂: C, 51.83; H, 4.97; N, 8.63. Found: C, 51.85; H, 4.92; N, 8.80.

5,6-Dihydro-5-thioximidazo[1,2-c]quinazolin-2(3H)-one (5a): Prepared from 3a as brown crystals (ethanol), yield 41%, mp >320 °C. ¹H NMR (DMSO-d₆): δ 4.59 (s, 2H, 3-H), 7.55 (m, 2H, 8-H and 9-H), 7.76 (m, 1H, 10-H), 8.05 (m, 1H, 7-H), 10.65 (s, 1H, NH). ¹³C NMR (DMSO-d₆): δ 53.45 (t, C-3), 110.81 (t, C-9), 116.05 (d, C-8), 125.11 (d, C-10), 127.35 (d, C-7), 136.94 (s, C-10a), 139.56 (s, C-7a), 168.02 (s, C-10b), 168.18 (s, C=S), 184.65 (s, C=O). Anal. Calcd for C₁₀H₇N₃OS: C, 55.29; H, 3.25; N, 19.34. Found: C, 55.19; H, 3.09; N, 19.08.

4,5-Dihydro-2-methylthio-5-thioxoimidazo[1,2-c]thiazolo[5,4-e]pyrimidin-8(7H)-one (5b): Prepared from 3b as red crystals (ethanol), yield: 39%, mp >320 °C. ¹H NMR (DMSO-d₆): δ 4.42 (s, 2H, 7-H), 2.70 (s, 3H, Me), 10.20 (s, 1H, NH). Anal. Calcd. for C₈H₆N₄OS₃: C, 35.54; H, 2.24; N, 20.70. Found: C, 35.65; H, 2.45; N, 20.91.

5,6-Dihydro-8,9-dimethyl-5-thioxofuro[3,2-e]imidazo[1,2-c]pyrimidin-2(3H)-one (5c): Prepared from 3c as red crystals (ethanol), yield 40%, mp 210-212 °C. ¹H NMR (DMSO-d₆): δ 2.16 (s, 3H, 9-Me), 2.28 (s, 3H, 8-Me), 4.35 (s, 2H, 3-H), 10.42 (s, 1H, NH). ¹³C NMR (DMSO-d₆): δ 14.15 (q, 9-Me), 14.45 (q, 8-Me), 53.32 (t, C-3), 95.48 (s, C-9), 107.55 (s, C-9a), 124.28 (s, C-8), 148.65 (s, C-9b), 166.17 (s, C=S), 170.35 (s, C-6a), 172.85 (s, C=O). Anal. Calcd for C₁₀H₉N₃O₂S: C, 51.05; H, 3.85, N, 17.86. Found: C, 50.91; H, 3.93; N, 17.95.

5,6,8,9,10,11-Hexahydro-5-thioxobenzofuro[3,2-e]imidazo[1,2-c]pyrimidin-2(3H)-one (5d): Prepared from 3d as red crystals (ethanol), yield 42 %, mp 276-278 °C. ¹H NMR (DMSO-d₆): δ 1.65-1.90 (m, 4H, 9-H and 10-H), 2.43-2.70 (m, 4H, 8-H and 11-H), 4.60 (s, 2H, 3-H). ¹³C NMR (DMSO-d₆): δ 20.51 (t, C-10), 21.65 (t, C-11 and C-9), 22.18 (t, C-8), 53.49 (t, C-3), 94.26 (s, C-11a), 110.28 (s, C-11b), 149.65 (s, C-7a), 151.19 (s, C-11c), 166.48 (s, C=S), 170.01 (s, C-6a), 172.24 (s, C=O). Anal. Calcd for C₁₂H₁₁N₃O₂S: C, 55.16; H, 4.24; N, 16.08. Found: C, 55.30; H, 4.42; N, 16.19.
5,6,8,9,10,11-Hexahydro-5-thioxo[1]benzothieno[3,2-e]imidazo[1,2-c]pyrimidin-2(3H)-one (5e): Prepared from 3e as brown crystals (ethanol-DMF), 46%, mp >320 °C. \(^1\)H NMR (DMSO-\(d_6\)): \(\delta 1.85\) (m, 4H, 9-H and 10-H), 2.55-2.80 (m, 4H, 8-H and 11-H), 4.35 (s, 2H, 3-H). \(^{13}\)C NMR (DMSO-\(d_6\)): \(\delta 21.10\) (t, C-10), 22.12 (t, C-9), 24.00 (t, C-11), 24.40 (t, C-8), 51.97 (t, C-3), 111.05 (s, C-11a), 129.52 (s, C-116), 130.35 (s, C-7a), 153.85 (s, C-6a), 162.41 (s, C-11c), 166.51 (s, C=S), 182.11 (s, C=O). \textit{Anal.} Calcd for C\(_{12}\)H\(_{11}\)N\(_3\)O\(_2\): C, 51.96; H, 4.00; N, 15.15. Found: C, 52.21; H, 3.95; N, 14.91.

5,6,8,9,10,11-Hexahydro-9-Methyl-5-thioxo[1]benzothieno[3,2-e]imidazo[1,2-c]pyrimidin-2(3H)-one (5f): Prepared from 3f as yellow crystals (ethanol), yield 39%, mp 299-301 °C. \(^1\)H NMR (DMSO-\(d_6\)): \(\delta 1.15\) (d, \(J = 6.4\) Hz, 3H, 9-Me), 1.82-2.95 (m, 7H, 8-H, 9-H, 10-H and 11-H), 4.45 (s, 2H, 3-H). \textit{Anal.} Calcd for C\(_{13}\)H\(_{13}\)N\(_3\)O\(_2\): C, 55.59; H, 4.50; N, 14.42. Found: C, 55.71; H, 4.39; N, 14.56.

9-Benzyl-5,6,8,9,10,11-octahydro-2-oxo-5-thioxoimidazo[1,2-c]pyrido[4',3:4,5]thieno[3,2-e]pyrimidin-2(3H)-one (5g): Prepared from 3g as red crystals (ethanol-chloroform), yield 44%, mp 250-252 °C. \(^1\)H NMR (CDCl\(_3\)): \(\delta 3.30-3.38\) (m, 4H, 10-H and 11-H), 4.02 (s, 2H, 8-H), 4.13 (s, 2H, CH\(_2\)-Ph), 4.25 (s, 2H, 3-H), 7.30-7.55 (m, 5H, Ar-H). \(^{13}\)C NMR (DMSO-\(d_6\)): \(\delta 23.59\) (t, C-11), 48.65 (t, C-10), 49.68 (t, C-8), 53.25 (t, C-3), 59.45 (t, CH\(_2\)-Ph), 109.31 (s, C-11a), 122.65 (s, C-1’), 126.92 (d, C-4’), 128.51 (d, C-2’ and C-6’), 128.57 (d, C-3’ and C-5’), 130.12 (s, C-11b), 136.56 (s, C-8a), 133.16 (s, C-7a), 162.47 (s, C-6a), 163.38 (s, C-11c), 169.45 (s, C=S), 182.64 (s, C=O). \textit{Anal.} Calcd for C\(_{18}\)H\(_{16}\)N\(_4\)O\(_2\): C, 58.67; H, 4.38; N, 15.20. Found: C, 58.45; H, 4.49; N, 15.03.

5,6,8,9,10,11-Hexahydro-9-methyl-5-thioxoimidazo[1,2-c]pyrido[4',3:4,5]thieno[3,2-e]pyrimidin-2(3H)-one (5h): Prepared from 3h as red crystals (dimethyl sulfoxide), yield 36%, mp 270-272 °C. \(^1\)H NMR (CDCl\(_3\)): \(\delta 2.95\) (s, 3H, N-Me), 3.12 (m, 2H, 11-H), 3.54 (m, 2H, 10-H). 4.15 (s, 2H, 8-H), 4.30 (s, 2H, 3-H). \textit{Anal.} Calcd for C\(_{12}\)H\(_{12}\)N\(_4\)O\(_2\): C, 49.30; H, 4.14; N, 19.16. Found: C, 49.01; H, 4.32; N, 18.99.

6,8,10,11-Tetrahydro-5-thioxo-5\(^H\)-imidazo[1,2-c]pyrano[4',3:4,5]thieno[3,2-e]pyrimidin-2(3H)-one (5i): Prepared from 3i as red crystals (dimethyl sulfoxide), yield 36%, mp 270-272 °C (decomp). \(^1\)H NMR (CDCl\(_3\)): \(\delta 2.95\) (s, 3H, N-Me), 3.12 (m, 2H, 11-H), 3.54 (m, 2H, 10-H). 4.15 (s, 2H, 8-H), 4.30 (s, 2H, 3-H). \textit{Anal.} Calcd for C\(_{12}\)H\(_{12}\)N\(_4\)O\(_2\): C, 49.30; H, 4.14; N, 19.16. Found: C, 49.01; H, 4.32; N, 18.99.
6,8,10,11-Tetrahydro-5-thioxo-5H-imidazo[1,2-c]thiopyrano[4',3':4,5]thieno[3,2-e]pyrimidin-2(3H)-one (5j): Prepared from 3j as red crystals (ethanol), yield 43%, mp >320 °C. $^1$H NMR (DMSO-$d_6$): $\delta$ 2.80-3.15 (m, 4H, 10-H and 11-H), 3.90 (s, 2H, 8-H), 4.35 (s, 2H, 3-H). $^{13}$C NMR (DMSO-$d_6$): $\delta$ 24.11 (t, C-10), 24.30 (t, C-11), 26.83 (t, C-8), 52.41 (t, C-3), 111.25 (s, C-11a), 126.88 (s, C-11b), 129.23 (s, C-7a), 161.51 (s, C-6a), 162.40 (s, C-11c), 166.86 (s, C=S), 182.49 (s, C=O). Anal. Calcd for C$_{11}$H$_9$N$_3$OS$_3$: C, 44.73; H, 3.07; N, 14.22. Found: C, 44.91; H, 3.18; N, 14.05.

6,8,9,10,11,12-Hexahydro-5-thioxo-5H-cyclohepta[4,5]thieno[3,2-e]imidazo[1,2-c]pyrimidin-2(3H)-one (5k): Prepared from 3e as red crystals (ethanol-chloroform), yield 39%, mp >320 °C. $^1$H NMR (DMSO-$d_6$): $\delta$ 1.50-1.90 (m, 6H, 9-H, 10-H and 11-H), 2.85 (m, 2H, 12-H), 3.32 (m, 2H, 8-H), 4.30 (s, 2H, 3-H). Anal. Calcd for C$_{13}$H$_{13}$N$_3$OS$_2$: C, 55.59; H, 4.50; N, 14.42. Found: C, 55.43; H, 4.36; N, 14.27.


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