Supplementary Material (ESI) for Green Chemistry

A Highly Efficient and Green Method for the Synthesis of 3,4-Dihydropyrimidin-2-ones and 1,5-Benzodiazepines Catalyzed by Dodecyl Sulfonic Acid in Water

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Supporting Information

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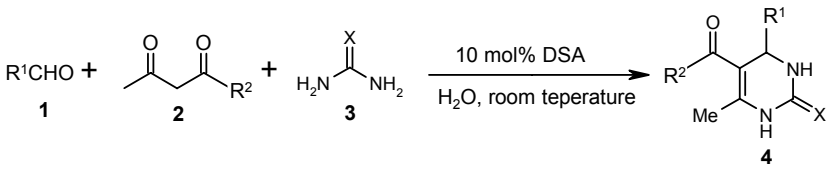
General Information

^{1}H NMR spectra were recorded on 300 MHz. Chemical shifts are expressed in δ units relative to tetramethylsilane (TMS) signal as internal reference in DMSO-d_6 or $CDCl_3$. FT-IR spectra were recorded in $CHCl_3$ or on KBr pellets. Column chromatography was performed on silica gel (60-120 mesh) using ethyl acetate and hexane as eluent.

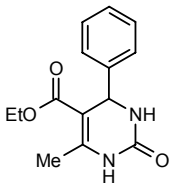
General Procedure for the formation of 3,4-dihydropyrimidin-2-ones:



In a 50 ml round-bottom flask, aldehyde (2 mmol), ethyl aetoaetate (2 mmol) and urea (3 mmol) were stirred in presence of dodecyl sulfonic acid (10 mol %) in H_2O (10 ml) at the room temperature for the stipulated time. The progress of the reaction was monitored by TLC. After completion of the reaction, the solid seperated was filtered, washed with water (5x10 ml), dried under vacuum and recrystallized from ethanol to afford pure product.

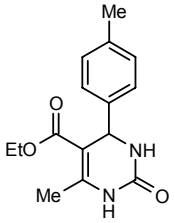
Spectral Data of the 3,4-Dihydropyrimidin-2-ones and thiones Obtained by the Condensation of Aldehydes, 1,3-Dicarbonyls and Urea:

4a. 5-(Ethoxycarbonyl)-6-methyl-4-phenyl-3,4-dihydropyrimidin-2(1H)-one:



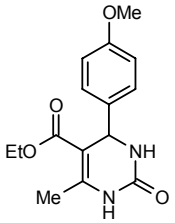
M.P.202-203 ^{o}C; ^{1}H NMR (DMSO, 300MHz): δ 1.08 (t, 3H), 2.23 (s, 3H), 3.98 (q, 2H), 5.13 (d, 1H), 7.10-7.29 (m, 5H), 7.81 (s,1H), 9.15 (s, 1H); FT-IR (KBr, cm^{-1}): 1635.2, 1725.1, 3240.5; MS (m/z): 260.26 (M^+). Anal. Calcd. for $C_{14}H_{16}O_3N_2$: C, 64.60; H, 6.20; N, 10.76. Found: C, 64.56; H, 6.14; N, 10.74.

4b. 5-(Ethoxycarbonyl)-6-methyl-4-(4-methylphenyl)-3,4-dihydropyrimidin-2(1H)-one:



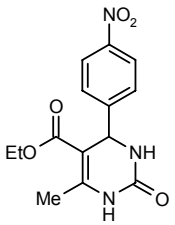
M.P.214-216 ^{o}C; ^{1}H NMR (DMSO, 300MHz): δ 1.07 (t, 3H), 2.22 (s, 3H), 2.29 (s, 3H), 4.00 (q, 2H), 5.10 (s, 1H), 7.15-7.19 (m, 4H), 7.80 (s, 1H), 9.18 (s, 1H); FT-IR (KBr, cm^{-1}): 1633.8, 1715.9, 3241.5; MS (m/z): 274.37 (M^{+}). Anal. Calcd. for $C_{15}H_{18}O_3N_2$: C, 65.68; H, 6.61; N, 10.21. Found: C, 65.61; H, 6.65; N, 10.17.

4c. 5-(Ethoxycarbonyl)-4-(4-methoxyphenyl)- 6-methyl-3,4-dihydropyrimidin-2(1H)-one:



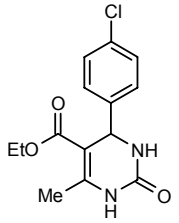
M.P.200-201 ^{o}C; ^{1}H NMR (DMSO, 300MHz): δ 1.10 (t, 3H), 2.25 (s, 3H), 3.73 (s, 3H), 3.98 (q, 2H), 5.16 (s, 1H), 7.01-7.21 (m, 4H), 7.73 (s, 1H), 9.19 (s, 1H); FT-IR (KBr, cm^{-1}): 1635.7, 1717.5, 3242.1; MS (m/z): 290.39 (M^{+}). Anal. Calcd. for $C_{15}H_{18}O_4N_2$: C, 62.06; H, 6.25; N, 9.65. Found: C, 62.11; H, 6.16; N, 9.72.

4d. 5-(Ethoxycarbonyl)-6-methyl-4-(4-nitrophenyl)-3,4-dihydropyrimidin-2(1H)-one:



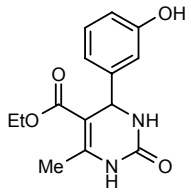
M.P.208-209 ^{o}C; ^{1}H NMR (DMSO, 300MHz): δ 1.09 (t, 3H), 2.24 (s, 3H), 3.76 (q, 2H), 5.19 (d, 1H), 7.62-8.10 (m, 4H), 7.92 (s, 1H), 9.28 (s, 1H); FT-IR (KBr, cm^{-1}): 1644.2, 1723.6, 3240.0; MS (m/z): 305.20 (M^{+}). Anal. Calcd. for $C_{14}H_{15}O_5N_3$: C, 55.08; H, 4.95; N, 13.76. Found: C, 55.17; H, 4.88; N, 13.62.

4e. 4-(4-Chlorophenyl)-5-(ethoxycarbonyl)-6-methyl-3,4-dihydropyrimidin-2(1H)-one:



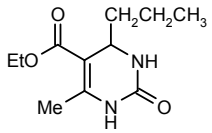
M.P. 210-211 ^{o}C; ^{1}H NMR (DMSO, 300MHz): δ 1.10 (t, 3H), 2.25 (s, 3H), 3.89 (q, 2H), 5.16 (s, 1H), 7.31-7.50 (m, 4H), 7.80 (s, 1H), 9.25 (s, 1H); FT-IR (KBr, cm^{-1}): 1644.0, 1723.1, 3239.7; MS (m/z): 294.79 (M^{+}). Anal. Calcd. for $C_{14}H_{15}O_3N_2Cl$: C, 57.05; H, 5.13; N, 9.50. Found: C, 57.12; H, 5.04; N, 9.45.

4f. 5-(Ethoxycarbonyl)-4-(3-hydroxyphenyl)-6-methyl-3,4-dihydropyrimidin-2(1H)-one:



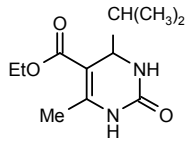
M.P. 163-164 ^{o}C; ^{1}H NMR (DMSO, 300MHz): δ 1.09 (t, 3H), 2.22 (s, 3H), 4.01 (q, 2H), 5.05 (d, 1H), 6.6 (s, 1H), 6.51-7.06 (m, 4H), 7.71 (s, 1H), 9.17 (s, 1H), 9.36 (s, 1H); FT-IR (KBr, cm^{-1}): 1644.2, 1723.6, 3240.0; MS (m/z): 276.23 (M^{+}). Anal. Calcd. for $C_{14}H_{16}O_4N_2$: C, 60.86; H, 5.84; N, 10.14. Found: C, 60.79; H, 5.88; N, 10.10.

4g. 5-(Ethoxycarbonyl)-6-methyl-4-(*n*-propyl)-3,4-dihydropyrimidin-2(1H)-one:



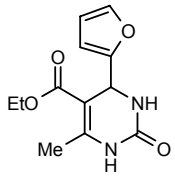
M.P. 152-153 ^{o}C; ^{1}H NMR (DMSO, 300MHz): δ 0.90 (t, 3H), 1.27 (t, 3H), 1.41-1.58 (m, 4H), 2.29 (s, 3H), 4.14 (q, 2H), 4.91 (s, 1H), 7.53 (s, 1H), 9.04 (s, 1H); FT-IR (KBr, cm^{-1}): 1646.2, 1705.8, 3246.6; MS (m/z):226.22 (M^{+}). Anal. Calcd. for $C_{11}H_{18}O_3N_2$: C, 58.39; H, 8.02; N, 12.38. Found: C, 58.31; H, 8.10; N, 12.30.

4h. 5-(Ethoxycarbonyl)-4-(*iso*-propyl)-6-methyl-3,4-dihydropyrimidin-2(1H)-one:



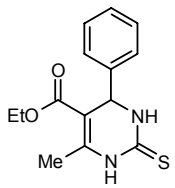
M.P. 170-171 ^{o}C; ^{1}H NMR (DMSO, 300MHz): δ 0.76-0.81 (m, 6H), 1.07 (t, 3H), 1.69 (m,1H), 2.19 (s, 3H), 4.02 (q, 2H), 4.89 (s, 1H), 7.54 (s,1H), 9.00 (s, 1H); FT-IR (KBr, cm^{-1}): 1642.0, 1709.5, 3235.0; MS (m/z):226.21 (M^{+}). Anal. Calcd. for $C_{11}H_{18}O_3N_2$: C, 58.39; H, 8.02; N, 12.38. Found: C, 58.33; H, 8.08; N, 12.30.

4i. 5-(Ethoxycarbonyl)-4-(2-furyl)-6-methyl-3,4-dihydropyrimidin-2(1H)-one:



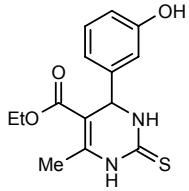
M.P. 203-204 ^{o}C; ^{1}H NMR (DMSO, 300MHz): δ 1.12 (t, 3H), 2.21 (s, 3H), 4.02 (q, 2H), 5.18 (d, 1H), 6.4-7.5 (m, 3H), 7.76 (s, 1H), 9.20 (s, 1H); FT-IR (KBr, cm^{-1}): 1644.0, 1706.1, 3240.2; MS (m/z):250.29 (M^{+}). Anal. Calcd. for $C_{12}H_{14}O_4N_2$: C, 57.59; H, 5.64; N, 11.19. Found: C, 57.65; H, 5.70; N, 11.27.

4j. 5-(Ethoxycarbonyl)-6-methyl-4-phenyl-3,4-dihydropyrimidin-2(1H)-thione:



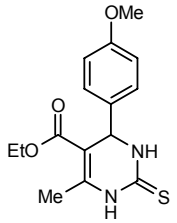
M.P. 207-209 ^{o}C; ^{1}H NMR (DMSO, 300MHz): δ 1.09 (t, 3H), 2.27 (s, 3H), 3.99 (q, 2H), 5.15 (d, 1H), 7.20-7.35 (m, 5H), 9.63 (s, 1H), 10.29 (s, 1H); FT-IR (KBr, cm^{-1}): 1578.3, 1672.7, 3181.2, 3339.8; MS (m/z):276.31 (M^{+}). Anal. Calcd. for $C_{14}H_{16}O_2N_2S$: C, 60.85; H, 5.84; N, 10.14. Found: C, 60.78; H, 5.90; N, 10.08.

4k. 5-(Ethoxycarbonyl)-4-(3-hydroxyphenyl)-6-methyl-3,4-dihydropyrimidin-2(1H)-thione:



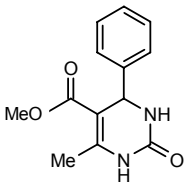
M.P. 184-185 ^{o}C; ^{1}H NMR (DMSO, 300MHz): δ 1.14 (t, 3H), 2.30 (s, 3H), 4.03 (q, 2H), 5.12 (d, 1H), 6.74-7.12 (m, 4H), 9.42 (s, 1H), 9.64 (s, 1H), 10.31 (s, 1H); FT-IR (KBr, cm^{-1}): 1574.7, 1620.3, 1654.9, 1670.6, 3180.1, 3300.8; MS (m/z): 292.31(M^{+}). Anal. Calcd. for $C_{14}H_{16}O_3N_2S$: C, 57.52; H, 5.52; N, 9.58. Found: C, 57.59; H, 5.47; N, 9.52.

4l. 5-(Ethoxycarbonyl)-6-methyl-4-(4-methoxyphenyl)-3,4-dihydropyrimidin-2(1H)-thione:



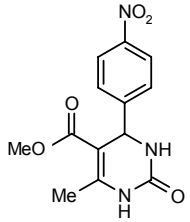
M.P. 150-151 ^{o}C; ^{1}H NMR (DMSO, 300MHz): δ 1.09 (t, 3H), 2.26 (s, 3H), 3.72 (s, 3H), 3.99 (q, 2H), 5.11 (s, 1H), 6.88-7.16 (m, 4H), 9.49 (s, 1H), 10.21 (s, 1H); FT-IR (KBr, cm^{-1}): 1561.4, 1599.0, 1651.2, 3250.8; MS (m/z):306.32 (M^{+}). Anal. Calcd. for $C_{15}H_{18}O_3N_2S$: C, 58.80; H, 5.92; N, 9.14. Found: C, 58.74; H, 5.97; N, 9.19.

4m. 5-(Methoxycarbonyl)-6-methyl-4-phenyl-3,4-dihydropyrimidin-2(1H)-one:



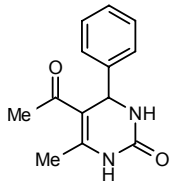
M.P.207-208 ^{o}C; ^{1}H NMR (DMSO, 300MHz): δ 2.21 (s, 3H), 3.56 (s, 3H), 5.18 (d, 1H), 7.26-7.33 (m, 5H), 7.78 (s, 1H), 9.23 (s, 1H); FT-IR (KBr, cm^{-1}): 1642.0, 1701.1, 3231.8; MS (m/z):246.21 (M^{+}). Anal. Calcd. for $C_{13}H_{14}O_3N_2$: C, 63.40; H, 5.73; N, 11.38. Found: C, 63.33; H, 5.79; N, 11.32.

4n. 5-(Methoxycarbonyl)-6-methyl-4-(4-nitrophenyl)-3,4-dihydropyrimidin-2(1H)-one:



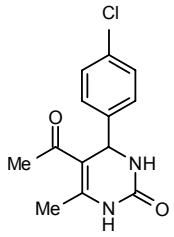
M.P. 235-236 ^{o}C; ^{1}H NMR (DMSO, 300MHz): δ 2.26 (s, 3H), 3.52 (s, 3H), 5.31 (d, 1H), 7.53-8.19 (m, 4H), 7.89 (s, 1H), 9.31 (s, 1H); FT-IR (KBr, cm^{-1}): 1692.8, 1712.6, 3232.4; MS (m/z):291.21 (M^{+}). Anal. Calcd. for $C_{13}H_{13}O_5N_3$: C, 53.61; H, 4.50; N, 14.43. Found: C, 53.56; H, 4.53; N, 14.37.

4o. 5-Aceto-6-methyl-4-phenyl-3,4-dihydropyrimidin-2(1H)-one:



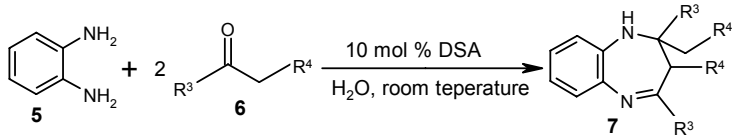
M.P. 233-234 ^{o}C; ^{1}H NMR (DMSO, 300MHz): δ 2.09 (s, 3H), 2.24 (s, 3H), 5.27 (d, 1H), 7.25-7.34 (m, 5H), 7.77 (s, 1H), 9.21 (s, 1H); FT-IR (KBr, cm^{-1}): 1642.9, 1714.7, 3240.8; MS (m/z):230.22 (M^{+}). Anal. Calcd. for $C_{13}H_{14}O_2N_2$: C, 67.81; H, 6.13; N, 12.17. Found: C, 67.77; H, 6.17; N, 12.13.

4p. 5-Aceto-4-(4-chlorophenyl)-6-methyl-3,4-dihydropyrimidin-2(1H)-one:



M.P. 231-232 ^{o}C; ^{1}H NMR (DMSO, 300MHz): δ 2.18 (s, 3H), 2.31 (s, 3H), 5.15 (s, 1H), 7.25-7.37 (m, 4H), 7.78 (s, 1H), 9.21 (s, 1H); FT-IR (KBr, cm^{-1}): 1642.9, 1714.7, 3240.8; MS (m/z):264.76 (M^{+}). Anal. Calcd. for $C_{13}H_{13}O_2N_2Cl$: C, 58.99; H, 4.95; N, 10.58. Found: C, 58.92; H, 4.89; N, 10.51.

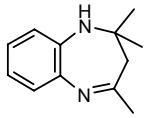
General Procedure for the formation of 1,5-benzodiazepines:



In a 50 ml round-bottom flask, *o*-phenylenediamines (1mmol) and ketones (2.2 mmol) were stirred in presence of dodecyl sulfonic acid (10 mol %) in H_2O (10 ml) at the room temperature. The reaction was monitored by TLC. After completion of the reaction, the product was extracted with ethyl acetate (2 x 25 ml), washed the organic layer with brine (2 x 15 ml), dried over Na_2SO_4 and concentrated. The products were separated and purified by column chromatography on silica gel (60-120 mesh) using ethyl acetate/hexane mixture as eluent to afford pure 1,5-benzodiazepines.

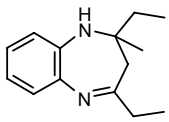
Spectral Data of the 1,5-benzodiazepines Obtained by the Condensation of *o*-Phenylenediamines and ketones:

7a. 2,2,4-Trimethyl-2,3-dihydro-1H-1,5-benzodiazepine:



M.P. 136-137 ^oC; ^1H NMR ($CDCl_3$, 300MHz): δ 1.35 (s, 6H), 2.21 (s, 2H), 2.35 (s, 3H), 3.45 (s, 1H), 6.62-7.31 (m, 4H); FT-IR (KBr, cm^{-1}): 3340.4, 1650.8; MS (m/z): 188.21 (M^+). Anal. Calcd. for $C_{12}H_{16}N_2$: C, 76.55; H, 8.57; N, 14.88. Found: C, 76.49; H, 8.51; N, 14.80.

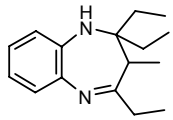
7b. 2,4-Diethyl-2-methyl-2,3-dihydro-1H-1,5-benzodiazepine:



M.P. 137-138 ^oC; ^1H NMR ($CDCl_3$, 300MHz): δ 0.97 (t, 3H), 1.26 (t, 3H), 1.72 (q, 2H), 2.15 (m, 2H), 2.34 (s, 3H), 2.69 (q, 2H), 3.45 (s, 1H), 6.65-7.33 (m, 4H); FT-IR (KBr, cm^{-1}): 3332.0, 1638.5;

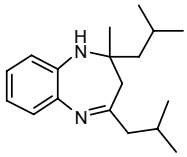
MS (m/z): 216.27 (M^+). Anal. Calcd. for $C_{14}H_{20}N_2$: C, 77.73; H, 9.32; N, 12.95. Found: C, 77.65; H, 9.24; N, 12.83.

7c. 2,2,4-triethyl-3-methyl-2,3-dihydro-1H-1,5-benzodiazepine:



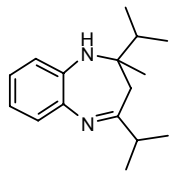
M.P. 143-144 ^oC; ^1H NMR ($CDCl_3$, 300MHz): δ 0.75-1.05 (m, 10H), 1.20-1.40 (m, 4H), 1.48-1.64 (m, 2H), 2.40-2.59 (m, 2H), 2.87 (q, 1H), 3.73 (s, 1H), 6.55 (d, 1H), 6.64 (t, 1H), 6.90 (t, 1H), 7.36 (d, 1H); FT-IR (KBr, cm^{-1}): 3321.0, 1638.2; MS (m/z): 244.29 (M^+). Anal. Calcd. for $C_{14}H_{20}N_2$: C, 78.64; H, 9.90; N, 11.46. Found: C, 78.54; H, 9.80; N, 11.31.

7d. 2-Methyl-2,4-diisobutyl-2,3-dihydro-1H-1,5-benzodiazepine:



M.P. 118-120 ^oC; ^1H NMR ($CDCl_3$, 300MHz): δ 0.95-1.05 (m, 12H), 1.33 (s, 3H), 1.49-1.52 (m, 2H), 1.65-1.75 (m, 1H), 2.05-2.25 (m, 3H), 2.24 (d, 2H), 6.60-6.65 (m, 1H), 6.85-6.95 (m, 2H), 7.05-7.15 (m, 1H); FT-IR (KBr, cm^{-1}): 3330.7, 1637.5; MS (m/z): 272.32 (M^+). Anal. Calcd. for $C_{18}H_{28}N_2$: C, 79.36; H, 10.36; N, 10.28. Found: C, 79.27; H, 10.23; N, 10.19.

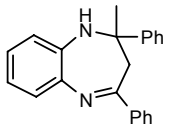
7e. 2-Methyl-2,4-diisopropyl-2,3-dihydro-1H-1,5-benzodiazepine:



M.P. 118-119 ^oC; ^1H NMR ($CDCl_3$, 300MHz): δ 0.94 (d, 6H), 1.13 (s, 3H), 1.42 (d, 6H), 1.86 (m, 1H), 2.17 (m, 1H), 2.46-2.54 (d, 1H), 2.57-2.64 (d, 1H), 3.65 (s, 1H), 6.61-7.32 (m, 4H); FT-IR

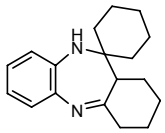
(KBr, cm^{-1}): 3333.9, 1634.6; MS (m/z): 244.27 (M^+). Anal. Calcd. for $C_{16}H_{24}N_2$: C, 78.64; H, 9.90; N, 11.46. Found: C, 78.53; H, 9.81; N, 11.34.

7f. 2-Methyl-2,4-diphenyl-2,3-dihydro-1H-1,5-benzodiazepine:



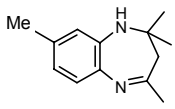
M.P. 150-151 ^oC; ^1H NMR ($CDCl_3$, 300MHz): δ 1.80 (s, 3H), 2.95 (d, 1H), 3.16 (d, 1H), 3.44 (s, 1H), 6.53-7.02 (m, 3H), 7.16-7.34 (m, 7H), 7.55-7.65 (m, 4H); FT-IR (KBr, cm^{-1}): 3330.9, 1635.2; MS (m/z): 312.48 (M^+). Anal. Calcd. for $C_{22}H_{20}N_2$: C, 84.58; H, 6.45; N, 8.97. Found: C, 84.51; H, 6.38; N, 8.91.

7g. 10-Spirocyclohexane-2,3,4,10,11,11a-hexahydro-1H-dibenzo[b,e][1,4] diazepine:



M.P. 136-137 ^oC; ^1H NMR ($CDCl_3$, 300MHz): δ 1.23-1.86 (m, 16H), 2.30-2.70 (m, 3H), 4.47 (s, 1H), 6.69-7.70 (m, 4H); FT-IR (KBr, cm^{-1}): 3290.9, 1640.2; MS (m/z): 268.24 (M^+). Anal. Calcd. for $C_{18}H_{24}N_2$: C, 80.55; H, 9.01; N, 10.44. Found: C, 80.46; H, 9.10; N, 10.35.

7h. 2,2,4-Trimethyl-2,3-dihydro-8-methyl-1H-1,5-benzodiazepine:



M.P. 128-129 ^oC; ^1H NMR ($CDCl_3$, 300MHz): δ 1.30 (s, 6H), 2.19 (s, 2H), 2.23 (s, 3H), 2.80 (s, 3H), 6.67 (s, 1H), 6.70-6.80 (m, 1H), 7.05-7.10 (m, 1H); FT-IR (KBr, cm^{-1}): 3325.4, 1665.8; MS (m/z): 202.23 (M^+). Anal. Calcd. for $C_{13}H_{18}N_2$: C, 77.18; H, 8.97; N, 13.85. Found: C, 77.11; H, 8.86; N, 13.79.