Synthesis of 4-Quinolones through Nickel-Catalyzed Intramolecular Amination on the β-Carbon of o-(N-Alkylamino)propiophenones

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I. General and Materials. All NMR spectra were measured with Bruker AVANCE 400 (9.4 T magnet) spectrometer at ambient temperature. In $^1$H NMR spectra, chemical shifts (ppm) referenced to internal tetramethylsilane (0.00 ppm, in CDCl$_3$). In $^{13}$C NMR spectra, chemical shifts (ppm) referenced to the carbon signal of the deuterated solvents (δ 77.0 ppm in CDCl$_3$). All NMR data are quoted as chemical shift in ppm (δ), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, quint = quintet, sept = septet, m = multiplet), coupling constants (Hz), relative intensity. IR spectra and melting points were measured with JASCO FT/IR-4100 and Büchi Melting Point B-545, respectively. Elemental analyses and high-resolution mass spectra were performed by Service Centre of Elementary Analysis of Organic Compounds and Network Joint Research Center for Materials and Devices (Institute for Materials Chemistry and Engineering in Kyushu University, IMCE), respectively. Flash column chromatographies were performed with silica gel 60 (230–400 mesh, Merck). GC analyses were performed on an GL Science GC 4000 with Agilent Technologies J&W capillary column DB-1 (0.53 mm φ × 15 m, df 1.5 μm). The temperature program of GC analyses was 120 °C for 0.5 min, followed by a ramp from 120–280 °C at 40 °C/min and constant temperature for 3.5 min.

Benzene and chlorobenzene were dried with calcium hydride. Morpholine, piperidine, pyrrolidine, dibutylamine, diisopropylamine were dried with potassium hydroxide. These solvents and reagents were distilled under nitrogen atmosphere before use. Potassium phosphate (K$_3$PO$_4$) was used after the powders were heated under reduced pressure enough to remove water.

Propionitrile [107-12-0], boron trichloride (1 M solution in heptane) [10294-34-5], aluminum trichloride (AlCl$_3$) [7784-13-6], N-methylaniline [100-61-8], N-methyl-p-toluidine [623-08-5], 1,2,3,4-tetrahydroquinoline [635-46-1], N-ethylaniline [103-69-5], N-butylaniline[1126-78-9], N-benzylandiline [103-32-2], N-isopropylaniline [768-52-5], bis(cycloocta-1,5-diene)nickel(0) [Ni(cod)$_2$] [1295-35-8], dry N,N-dimethylformamide (dry DMF, H$_2$O < 50 ppm) [68-12-2], trimethylphosphine (1 M solution in THF) [594-09-2] were purchased and used without further purification.

II. Preparation of $o$-(N-Alkylamino)propiophenones 1.

General procedure for the synthesis of 1:

\[
\begin{align*}
\text{CH}_3\text{CH}_2\text{CN} & \quad \text{BCl}_3, \text{AlCl}_3 \\
\text{benzene} & \quad \text{reflux} \\
\end{align*}
\]

\(o\)-(N-alkylamino)propiophenone 1 was prepared from N-alkylaniline and propionitrile according to the literature procedure.\(^1\) To a stirred solution of boron trichloride (1.1 equiv. to N-alkylaniline) in dry benzene was added a solution of N-alkylaniline (1.0 equiv.) in dry benzene under ice cooling. To the
resulting boron trichloride–N-alkylaniline complex, propionitrile (2.0 equiv.), and aluminum trichloride (1.1 equiv.) were added successively. The solution was then refluxed for a few hours, and quenched with 1 N HCl \text{aq}. A solution of 4 N NaOH \text{aq.} was added until the pH of the aqueous solution become around 8. The mixture was extracted three times with EtOAc. The combined organic layer was washed with brine, dried with MgSO₄, and then evaporated under reduced pressure. The residue was purified with a flash column chromatography (EtOAc–hexane) to give o-(N-alkylamino)propiophenone 1.

1-[2-(Methylamino)phenyl]propan-1-one (1a). (Table 1)

The general procedure was followed with use of N-methylaniline (1.09 g, 10.2 mmol) and propionitrile (1.11 g, 20.1 mmol). The crude product was purified with a flash column chromatography (EtOAc–hexane = 1:30) to give 1a (842 mg, 52%) as a pale yellow solid. \(^1\)H NMR (400 MHz, CDCl₃, TMS): \(\delta = 1.20\) (t, \(J = 7.3\) Hz, 3H), 2.91 (s, 3H), 2.98 (q, \(J = 7.3\) Hz, 2H), 6.59 (t, \(J = 7.5\) Hz, 1H), 6.70 (d, \(J = 8.5\) Hz, 1H), 7.38 (t, \(J = 7.8\) Hz, 1H), 7.79 (d, \(J = 8.0\) Hz, 1H), 8.8 (br s, 1H); \(^{13}\)C \{{}^1\text{H}\} NMR (100 MHz, CDCl̄₃): \(\delta = 8.9, 29.2, 32.1, 111.2, 113.7, 117.0, 131.6, 134.7, 151.9, 203.4\); IR (thin film) 3324 m, 2977 w, 2936 w, 2903 w, 2817 w, 1640 s, 1520 s, 1510 w, 1478 w, 1459 m, 1424 m, 1376 w, 1266 w, 1226 w, 1170 s, 1064 w, 948 m, 748 s cm−1; Anal. Calcd for C₁₀H₁₃NO: C, 73.59; H, 8.03; N, 8.58. Found: C, 73.33; H, 8.03; N, 8.60.

1-[5-Methyl-2-(methylamino)phenyl]propan-1-one (1b). (Table 2, entry 1)

The general procedure was followed with use of N-methyl-p-toluidine (363 mg, 3.0 mmol) and propionitrile (336 mg, 6.1 mmol). The crude product was purified with a flash column chromatography (EtOAc–hexane =1:30) to give 1b (180 mg, 34%) as a pale yellow solid. Mp 30.1–30.2 °C; \(^1\)H NMR (400 MHz, CDCl₃, TMS): \(\delta = 1.20\) (t, \(J = 7.3\) Hz, 3H), 2.26 (s, 3H), 2.89 (q, \(J = 5.0\) Hz, 3H), 2.98 (q, \(J = 7.3\) Hz, 2H), 6.63 (d, \(J = 8.6\) Hz, 1H), 7.21 (dd, \(J = 8.6, 1.7\) Hz, 1H), 7.57 (s, 1H), 8.63 (br s, 1H); \(^{13}\)C \{{}^1\text{H}\} NMR (100 MHz, CDCl₃): \(\delta = 9.0, 20.3, 29.4, 32.2, 111.4, 117.0, 122.5, 131.4, 135.9, 150.1, 203.3\); IR (thin film) 3330 w, 2977 w, 2934 w, 2911 w, 1642 s, 1573 m, 1525 s, 1420 w, 1321 w, 1262 w, 1226 w,
1193 m, 1173 m, 966 w, 812 w cm$^{-1}$; Anal. Calcd for C$_{11}$H$_{15}$NO: C, 74.51; H, 8.53; N, 7.90. Found: C, 74.44; H, 8.62; N, 7.89.

1-(1,2,3,4-Tetrahydroquinolin-8-yl)propan-1-one (1c). (Table 2, entry 2)

The general procedure was followed with use of 1,2,3,4-tetrahydroquinoline (1.36 g, 10.0 mmol) and propionitrile (1.4 mL, 20.0 mmol). The crude product was purified with a flash column chromatography (EtOAc–hexane =1:20) to give 1c (1.37 g, 73%) as yellow oil. $^1$H NMR (400 MHz, CDCl$_3$, TMS): $\delta$ = 1.18 (t, $J$ = 7.3 Hz, 3H), 1.88 (quint, $J$ = 5.9 Hz, 2H), 2.75 (t, $J$ = 6.2 Hz, 2H), 2.93 (q, $J$ = 7.3 Hz, 2H), 3.40 (t, $J$ = 4.2 Hz, 2H), 6.42 (t, $J$ = 7.6 Hz, 1H), 7.00 (d, $J$ = 7.2 Hz, 1H), 7.57 (d, $J$ = 8.0 Hz, 1H), 9.03 (br s, 1H); $^{13}$C $\{^1$H$\}$ NMR (400 MHz, CDCl$_3$): $\delta$ = 9.0, 20.5, 27.8, 32.1, 40.9, 112.9, 115.6, 122.6, 129.4, 133.5, 148.3, 203.1; IR (neat) 3311 w, 2934 w, 2844 w, 1635 s, 1580 m, 1514 w, 1463 w, 1403 w, 1363 w, 1311 w, 1231 s, 1192 w, 1101 w, 1053 w, 741 w cm$^{-1}$; Anal. Calcd for C$_{12}$H$_{15}$NO: C, 76.16; H, 7.99; N, 7.40. Found: C, 76.17; H, 7.95; N, 7.37.

1-[2-(Ethylamino)phenyl]propan-1-one (1d). (Table 2, entry 4)

The general procedure was followed with use of N-ethylaniline (1.21 g, 10.0 mmol) and propionitrile (1.42 g, 20.0 mmol). The crude product was purified with a flash column chromatography (EtOAc–hexane =1:20) to give 1d (327 mg, 19%) as yellow oil. $^1$H NMR (400 MHz, CDCl$_3$, TMS): $\delta$ = 1.19 (t, $J$ = 7.3 Hz, 3H), 1.31 (t, $J$ = 7.2 Hz, 3H), 2.97 (q, $J$ = 7.3 Hz, 2H), 3.1–3.3 (m, 2H), 6.56 (t, $J$ = 7.4 Hz, 1H), 6.69 (d, $J$ = 8.4 Hz, 1H), 7.33 (t, $J$ = 7.8 Hz, 1H), 7.77 (d, $J$ = 8.4 Hz, 1H), 8.82 (br s, 1H); $^{13}$C $\{^1$H$\}$ NMR (100 MHz, CDCl$_3$): $\delta$ = 8.8, 14.4, 32.1, 37.1, 111.6, 113.6, 116.8, 131.6, 134.7, 151.0, 203.3; IR (neat) 3309 w, 2974 m, 2936 w, 2874 w, 1641 s, 1574 s, 1519 s, 1458 m, 1420 w, 1378 w, 1327 m, 1263 w, 1210 s, 1164 s, 1116 w, 1051 w, 951 w cm$^{-1}$; Anal. Calcd for C$_{13}$H$_{15}$NO: C, 74.28; H, 8.48; N, 8.03. Found: C, 74.54; H, 8.53; N, 7.90.
1-[2-((Butylamino)phenyl)propan-1-one (1e). (Table 2, entry 5)

![Chemical Structure of 1e]

The general procedure was followed with use of N-butylaniline (373 mg, 2.5 mmol) and propionitrile (285 mg, 5.2 mmol). The crude product was purified with a flash column chromatography (EtOAc–hexane = 1:30) to give 1e (287 mg, 56%) as pale yellow oil. $^1$H NMR (400 MHz, CDCl$_3$, TMS): $\delta = 0.99$ (t, $J = 7.3$ Hz, 3H), 1.23 (t, $J = 7.3$ Hz, 3H), 1.4–1.5 (m, 2H), 1.6–1.8 (m, 2H), 2.99 (q, $J = 7.2$ Hz, 2H), 3.1–3.3 (m, 2H), 6.56 (t, $J = 7.6$ Hz, 1H), 6.70 (d, $J = 8.4$ Hz, 1H), 7.36 (t, $J = 7.8$ Hz, 1H), 7.78 (dd, $J = 8.0$, 1.2 Hz, 1H), 8.90 (br s, 1H); $^{13}$C $\{$$^1$H$\}$ NMR (100 MHz, CDCl$_3$): $\delta = 8.9$, 13.9, 20.4, 31.2, 32.2, 42.3, 111.7, 113.6, 116.8, 131.7, 134.7, 151.2, 203.4; IR (neat) 3307 w, 2959 m, 2932 m, 2871 m, 1641 s, 1575 s, 1520 s, 1459 s, 1421 m, 1377 w, 1329 m, 1264 w, 1206 s, 1162 m, 1051 w, 1008 w, 948 m, 746 m cm$^{-1}$; Anal. Calcd for C$_{13}$H$_{19}$NO: C, 76.06; H, 9.33; N, 6.82. Found: C, 76.28; H, 9.37; N, 6.91.

1-[2-(Benzylamino)phenyl]propan-1-one (1f). [154010-87-4] (Table 2, entry 6)

![Chemical Structure of 1f]

The general procedure was followed with use of N-benzylaniline (915 mg, 5.0 mmol) and propionitrile (548 mg, 10.0 mmol). The crude product was purified with a flash column chromatography (EtOAc–hexane = 1:15) to give 1f (549 mg, 54%) as a pale yellow solid. Mp 55.3–55.4 °C; $^1$H NMR (400 MHz, CDCl$_3$, TMS): $\delta = 1.21$ (t, $J = 7.3$ Hz, 3H), 3.01 (q, $J = 7.3$ Hz, 2H), 4.45 (d, $J = 5.6$ Hz, 2H), 6.60 (t, $J = 7.4$ Hz, 1H), 6.66 (d, $J = 8.8$ Hz, 1H), 7.2–7.4 (m, 6H), 7.81 (d, $J = 8.0$ Hz, 1H), 9.34 (br s, 1H); $^{13}$C $\{$$^1$H$\}$ NMR (100 MHz, CDCl$_3$): $\delta = 8.9$, 32.3, 46.8, 112.2, 114.4, 117.4, 127.09, 127.13, 128.7, 131.7, 134.7, 138.7, 150.9, 203.6; IR (thin film) 3313 w, 2977 w, 2936 w, 1640 s, 1574 s, 1517 s, 1454 m, 1329 w, 1247 w, 1204 m, 1165 w, 1055 w, 949 w cm$^{-1}$; Anal. Calcd for C$_{16}$H$_{17}$NO: C, 80.03; H, 7.16; N, 5.85. Found: C, 80.15; H, 7.16; N, 5.79.
1-[2-(Isopropylamino)phenyl]propan-1-one (1g). (Table 2, entries 7 and 8)

\[ \text{1g} \]

The general procedure was followed with use of N-isopropylaniline (1.38 g, 10.2 mmol) and propionitrile (1.10 g, 20.0 mmol). The crude product was purified with a flash column chromatography (EtOAc–hexane = 1:10) to give \textbf{1g} (700 mg, 37%) as pale yellow oil. \textsuperscript{1}H NMR (400 MHz, CDCl\textsubscript{3}, TMS): \[ \delta = 1.20 \text{ (t, } J = 7.2 \text{ Hz, } 3\text{H)}, \ 1.27 \text{ (d, } J = 6.4 \text{ Hz, } 6\text{H)}, \ 2.98 \text{ (q, } J = 7.2 \text{ Hz, } 2\text{H)}, \ 3.6–3.8 \text{ (m, } 1\text{H)}, \ 6.54 \text{ (t, } J = 7.6 \text{ Hz, } 1\text{H)}, \ 6.72 \text{ (d, } J = 8.4 \text{ Hz, } 1\text{H)}, \ 7.32 \text{ (t, } J = 7.8 \text{ Hz, } 1\text{H)}, \ 7.78 \text{ (dd, } J = 8.1, 1.2 \text{ Hz, } 1\text{H)}, \ 8.92 \text{ (br s, } 1\text{H}); \text{ } \textsuperscript{13}C \{\text{\textsuperscript{1}H} \text{ NMR (100 MHz, CDCl}_{3}: \delta = 8.8, 22.7, 32.1, 43.0, 112.0, 113.3, 116.7, 131.8, 134.6, 150.2, 203.2; IR (neat) 3296 w, 2972 m, 2935 w, 1640 s, 1574 s, 1518 m, 1459 m, 1419 w, 1381 w, 1331 m, 1263 w, 1212 s, 1163 m, 1121 w, 1050 w, 947 w, 745 m cm}^{-1}; \text{ Anal. Calcd for C}_{12}H_{17}NO: C, 75.35; H, 8.96; N, 7.32. Found: C, 75.26; H, 8.99; N, 7.25.

### III. Nickel-Catalyzed Cyclization of o-(N-Alkylamino)propiophenone 1 for Synthesis of 2.

**General procedure for the transformation of o-(N-alkylamino)propiophenone 1 into 4-quinolone 2:**

In a nitrogen-filled drybox, a 4 mL screw-capped vial was charged with Ni(cod)\textsubscript{2} (5.6 mg, 0.020 mmol), K\textsubscript{3}PO\textsubscript{4} (424.5 mg, 2.0 mmol), and DMF (0.2 mL). After a magnetic stir bar was added, the vial was fitted with a septum cap, and removed from the drybox. A solution of trimethylphosphine in THF (60 \muL, 1 M solution, 0.060 mmol), chlorobenzene (0.20 mL, 1.97 mmol), o-(N-alkylamino)propiophenone (0.5 mmol) and morpholine (4.5 \muL, 0.05 mmol) were added. The resulting mixture was heated at 100 °C for 48 h. The reaction mixture was filtered through a celite pad to remove the insoluble inorganic salt. The filtrate was concentrated, and purified by silica gel column chromatography (EtOAc–MeOH).
Methylquinolin-4(1H)-one (2a). [83-54-5] (Table 1, entry 7)

The general procedure was followed with use of o-aminopropiophenone 1a (81.3 mg, 0.50 mmol). The crude product was purified with a flash column chromatography (EtOAc–methanol = 5:1) to give 2a (69.1 mg, 87%) as pale yellow oil. \( ^{1} \)H NMR (400 MHz, CDCl\(_3\), TMS): \( \delta = 3.79 \) (s, 3H), 6.23 (d, \( J = 7.8 \) Hz, 1H), 7.3–7.4 (m, 2H), 7.49 (d, \( J = 7.6 \) Hz, 1H), 7.67 (t, \( J = 7.8 \) Hz, 1H), 8.45 (d, \( J = 8.4 \) Hz, 1H); \( ^{13} \)C \( \{ ^{1} \)H \}\) NMR (100 MHz, CDCl\(_3\)): \( \delta = 40.6, 109.9, 115.3, 123.7, 126.7, 126.9, 132.1, 140.5, 143.7, 178.2; IR (neat) 3406 s, 3062 m, 2946 w, 2618 w, 2180 w, 1931 w, 1611 s, 1565 s, 1496 s, 1469 s, 1455 s, 1377 s, 1309 m, 1269 m, 1241 m, 1182 m, 1160 m, 1125 m, 1036 m, 965 w, 909 w, 873 w, 834 w cm\(^{-1}\).

1,6-Dimethylquinolin-4(1H)-one (2b). [325856-06-2] (Table 2, entry 1)

The general procedure was followed with use of o-aminopropiophenone 1b (34.8 mg, 0.20 mmol). The crude product was purified with a flash column chromatography (EtOAc–hexane = 1:1, then methanol–EtOAc = 1:10) to give 2b (31.6 mg, 93%) as a yellow solid. Mp 170.8–172.5 °C; \( ^{1} \)H NMR (400 MHz, CDCl\(_3\), TMS): \( \delta = 2.48 \) (s, 3H), 3.79 (s, 3H), 6.25 (d, \( J = 7.6 \) Hz, 1H), 7.31 (d, \( J = 7.2 \) Hz, 1H), 7.4–7.6 (m, 2H), 8.26 (s, 1H); \( ^{13} \)C \( \{ ^{1} \)H \}\) NMR (100 MHz, CDCl\(_3\)): \( \delta = 20.9, 40.6, 109.6, 115.2, 126.3, 126.8, 133.6, 133.7, 138.7, 143.3, 178.1; IR (thin film) 3393 s, 1613 m, 1562 s, 1496 m, 1448 m, 1375 w, 1232 w, 829 s cm\(^{-1}\); HRMS Calcd for [C\(_{11}\)H\(_{12}\)NO+H\(^{+}\)]: 174.0919, Found: 174.0919.

6,7-Dihydropyrido[3,2,1-ij]quinolin-1(5H)-one (2c). (Table 2, entry 2)

The general procedure was followed with use of o-aminopropiophenone 1c (96.3 mg, 0.51 mmol). The crude product was purified with a flash column chromatography (EtOAc–hexane = 1:2, then methanol–EtOAc = 1:10) to give 2c (78.3 mg, 83%) as a yellow solid. Mp 154.3–154.6 °C; \( ^{1} \)H NMR (400 MHz, CDCl\(_3\), TMS): \( \delta = 2.1–2.3 \) (m, 2H), 3.05 (t, \( J = 6.2 \) Hz, 2H), 4.10 (t, \( J = 5.8 \) Hz, 2H), 6.24 (d, \( J = 7.6 \) Hz, 1H), 7.2–7.3 (m, 1H), 7.40 (d, \( J = 7.2 \) Hz, 1H), 7.44 (d, \( J = 7.6 \) Hz, 1H), 8.26 (d, \( J = 8.1 \) Hz, 1H);
$^{13}$C \{\textit{H}\} NMR (100 MHz, CDCl$_3$): $\delta$ = 21.3, 27.0, 51.9, 109.6, 123.1, 124.6, 126.1, 126.9, 131.1, 137.5, 141.8, 178.2; IR (thin film) 3513 m, 3378 m, 3282 w, 2943 w, 1625 s, 1571 s, 1497 s, 1143 m, 1326 w, 1249 m, 1188 w, 1093 w, 1036 w, 910 w, 831 m, 794 s, 757 s cm$^{-1}$; HRMS Calcd for [C$_{12}$H$_{12}$NO$^+$$+$$H^+$]: 186.0919, Found: 186.0902.

Ethylquinolin-4(1H)-one (2d) [13720-89-3] and
(E)-1-[2-(ethylamino)phenyl]-3-morpholinoprop-2-en-1-one (3d). (Table 2, entry 4)

![Chemical structures of 2d and 3d](image)

The general procedure was followed with use of $o$-aminopropiophenone 1d (88.7 mg, 0.50 mmol). The crude product was purified with a flash column chromatography (EtOAc–hexane = 1:2, then methanol–EtOAc = 1:2) to give 2d (63.1 mg, 73%) and 3d (11.2 mg, 9%). 2g: a pale yellow solid; mp 102.3–102.4 °C; $^1$H NMR (400 MHz, CDCl$_3$, TMS): $\delta$ = 1.48 (t, $J$ = 7.2 Hz, 3H), 4.17 (q, $J$ = 7.2 Hz, 2H), 6.26 (d, $J$ = 7.7 Hz, 1H), 7.36 (t, $J$ = 7.5 Hz, 1H), 7.44 (d, $J$ = 8.6 Hz, 1H), 7.54 (d, $J$ = 7.7 Hz, 1H), 7.66 (t, $J$ = 7.6 Hz, 1H), 8.46 (d, $J$ = 8.0 Hz, 1H); $^{13}$C \{\textit{H}\} NMR (100 MHz, CDCl$_3$): $\delta$ = 14.4, 47.8, 110.2, 115.1, 123.4, 127.1, 127.3, 132.0, 139.4, 142.4, 178.1; IR (thin film) 3420 w, 1623 s, 1580 s, 1490 s, 1392 w, 1266 w, 1229 m, 1179 w, 1143 w, 830 w, 762 m cm$^{-1}$; Anal. Calcd for C$_{11}$H$_{11}$NO: C, 76.28; H, 6.40; N, 8.09. Found: C, 76.05; H, 6.50; N, 8.00.

3d: pale yellow oil; $^1$H NMR (400 MHz, CDCl$_3$, TMS): $\delta$ = 1.31 (t, $J$ = 7.2 Hz, 3H), 3.1–3.3 (m, 2H), 3.35 (t, $J$ = 4.8 Hz, 4H), 3.75 (t, $J$ = 4.8 Hz, 4H), 5.91 (d, $J$ = 12.8 Hz, 1H), 6.55 (t, $J$ = 7.8 Hz, 1H), 6.67 (d, $J$ = 8.4 Hz, 1H), 7.2–7.3 (m, 1H), 7.60 (d, $J$ = 12.8 Hz, 1H), 7.66 (d, $J$ = 6.8 Hz, 1H), 8.54 (br s, 1H).

Butylquinolin-4(1H)-one (2e) [37041-26-2] and
(E)-1-[2-(butylamino)phenyl]-3-morpholinoprop-2-en-1-one (3e). (Table 2, entry 5)

![Chemical structures of 2e and 3e](image)

The general procedure was followed with use of $o$-aminopropiophenone 1e (101.4 mg, 0.493 mmol). The crude product was purified with a flash column chromatography (EtOAc–hexane = 1:2, then methanol–EtOAc = 1:2) to give 2e (71.5 mg, 72%) and 3e (17.0 mg, 12%). 2e: pale yellow oil; $^1$H NMR (400 MHz, CDCl$_3$, TMS): $\delta$ = 0.99 (t, $J$ = 7.4 Hz, 3H), 1.42 (sept, $J$ = 6.3 Hz, 2H), 1.85 (quint, $J$ = 7.5 Hz, 2H), 4.11 (t, $J$ = 7.3 Hz, 2H), 6.26 (d, $J$ = 8.0 Hz, 1H), 7.37 (t, $J$ = 7.5 Hz, 1H), 7.43 (d, $J$ = 8.6 Hz, 1H),
7.52 (d, \(J = 7.7\) Hz, 1H), 7.67 (t, \(J = 7.8\) Hz, 1H), 8.48 (d, \(J = 8.1\) Hz, 1H); \(^{13}\)C \{\(^1\)H\} NMR (100 MHz, CDCl\(_3\)): \(\delta = 13.6, 20.0, 30.9, 53.0, 110.0, 115.2, 123.4, 127.3, 127.5, 132.0, 139.7, 143.0, 178.1; IR (neat) 3423 w, 3063 w, 2960 m, 2932 m, 2871 w, 1626 s, 1584 s, 1551 m, 1489 s, 1466 m, 1431 w, 1392 m, 1314 w, 1267 m, 1229 s, 1177 w, 1142 w, 1074 w, 1040 w, 925 w, 828 w, 762 m, 732 m \(\text{cm}^{-1}\); HRMS Calcd for [C\(_{13}\)H\(_{16}\)NO\(+H^+\)]: 202.1232, Found: 202.1256.

3e: pale yellow oil; \(^1\)H NMR (400 MHz, CDCl\(_3\), TMS): \(\delta = 0.95 (t, J = 7.2\) Hz, 3H), 1.4–1.6 (m, 2H), 1.67 (quint, \(J = 7.2\) Hz, 2H), 3.17 (q, \(J = 6.3\) Hz, 2H), 3.36 (t, \(J = 5.0\) Hz, 4H), 3.75 (t, \(J = 5.0\) Hz, 4H), 5.91 (d, \(J = 12.4\) Hz, 1H), 6.54 (t, \(J = 7.4\) Hz, 1H), 6.67 (d, \(J = 8.8\) Hz, 1H), 7.2–7.3 (m, 1H), 7.60 (d, \(J = 12.4\) Hz, 1H), 7.66 (d, \(J = 8.0\) Hz, 1H), 8.67 (br s, 1H).

Benzylquinolin-4(1\(H\))-one (2f). [24220-92-6] (Table 2, entry 6)

The general procedure was followed with use of o-aminopropiophenone 1f (119.4 mg, 0.50 mmol). The crude product was purified with a flash column chromatography (EtOAc–hexane = 1:5, then EtOAc) to give 2f (82.5 mg, 70%) as a pale yellow solid. Mp 121.4–121.8 ºC; \(^1\)H NMR (400 MHz, CDCl\(_3\), TMS): \(\delta = 5.32 (s, 2H), 6.34 (dd, J = 7.7, 1.4 Hz, 1H), 7.15 (d, J = 7.3 Hz, 2H), 7.2–7.4 (m, 5H), 7.53 (dd, \(J = 8.5, 7.2\) Hz, 1H), 7.64 (d, \(J = 8.0\) Hz, 1H), 8.47 (d, \(J = 8.0\) Hz, 1H); \(^{13}\)C \{\(^1\)H\} NMR (100 MHz, CDCl\(_3\)): \(\delta = 56.5, 110.4, 116.0, 123.7, 126.0, 127.0, 127.4, 128.3, 129.2, 132.1, 135.1, 140.1, 143.6, 178.3; IR (thin film) 3422 w, 3062 w, 1624 s, 1583 s, 1550 m, 1490 s, 1472 m, 1430 w, 1389 m, 1311 w, 1267 m, 1231 s, 1175 w, 1143 w, 1075 w, 1051 w, 1029 w, 910 w, 828 w, 762 m, 734 m, 708 m, 695 \(\text{cm}^{-1}\); Anal. Calcd for C\(_{16}\)H\(_{13}\)NO: C, 81.68; H, 5.57; N, 5.95. Found: C, 81.40; H, 5.60; N, 5.93.

Isopropylquinolin-4(1\(H\))-one (2g) and (\(E\))-1-[2-(isopropylamino)phenyl]-3-morpholinoprop-2-en-1-one (3g). (Table 2, entries 7 and 8)

The general procedure was followed with use of o-aminopropiophenone 1g (98.1 mg, 0.52 mmol). The crude product was purified with a flash column chromatography (EtOAc–hexane = 1:2, then EtOAc–methanol = 1:10) to give 2g (9.6 mg, 10%) and 3g (106.8 mg, 75%). 2g: pale yellow oil; \(^1\)H NMR (400 MHz, CDCl\(_3\), TMS): \(\delta = 1.55 (d, J = 6.8\) Hz, 6H), 4.89 (sept, \(J = 6.6\) Hz, 1H), 6.33 (d, \(J = 7.9\) Hz, 1H), 7.36 (t, \(J = 7.4\) Hz, 1H), 7.58 (d, \(J = 8.7\) Hz, 1H), 7.66 (t, \(J = 7.8\) Hz, 1H), 7.72 (d, \(J = 8.0\) Hz, 1H), 8.49 (d, \(J = 8.0\) Hz, 1H); \(^{13}\)C \{\(^1\)H\} NMR (100 MHz, CDCl\(_3\)): \(\delta = 22.0, 49.9, 110.2, 114.5, 123.2, 127.2,
127.4, 132.0, 137.3, 140.0, 177.7; IR (neat) 3423 w, 3064 w, 2978 w, 1627 s, 1586 s, 1550 m, 1490 s, 1467 w, 1358 m, 1328 w, 1270 w, 1217 m, 1191 m, 1088 w, 1038 w, 827 w, 762 m cm⁻¹; Anal. Calcd for C₁₂H₁₃NO: C, 76.98; H, 7.00; N, 7.48. Found: C, 76.70; H, 7.01; N, 7.40.

3g: pale yellow oil; ¹H NMR (400 MHz, CDCl₃, TMS): δ = 1.26 (d, J = 6.3 Hz, 6H), 3.1–3.6 (m, 5H), 3.7–3.9 (m, 4H), 5.90 (d, J = 12.6 Hz, 1H), 6.52 (t, J = 7.5 Hz, 1H), 6.69 (d, J = 8.5 Hz, 1H), 7.2–7.4 (m, 1H), 7.59 (d, J = 12.6 Hz, 1H), 7.6–7.8 (m, 1H), 8.69 (br s, 1H).

Alternatively, the general procedure was followed with use of o-aminopropiophenone 1g (95.1 mg, 0.50 mmol). To the crude reaction mixture was added ethanol (1.0 mL) and a drop of acetic acid, and then the resulting solution was refluxed for 4 days to give 2g (67.4 mg, 72%) as pale yellow oil.

IV. References
V. $^1$H and $^{13}$C {$^1$H} NMR Spectra of $o$-(N-Alkylamino)propiophenones 1a–1g.

Figure S-1. $^1$H NMR spectrum (CDCl$_3$) of 1a.

Figure S-2. $^{13}$C NMR spectrum (CDCl$_3$) of 1a.
Figure S-3. $^1$H NMR spectrum (CDCl$_3$) of 1b.

Figure S-4. $^{13}$C NMR spectrum (CDCl$_3$) of 1b.
Figure S-5. $^1$H NMR spectrum (CDCl$_3$) of 1c.

Figure S-6. $^{13}$C NMR spectrum (CDCl$_3$) of 1c.
Figure S-7. $^1$H NMR spectrum (CDCl$_3$) of 1d.

Figure S-8. $^{13}$C NMR spectrum (CDCl$_3$) of 1d.
Figure S-9. $^1$H NMR spectrum (CDCl$_3$) of 1e.

Figure S-10. $^{13}$C NMR spectrum (CDCl$_3$) of 1e.
Figure S-11. $^1$H NMR spectrum (CDCl$_3$) of 1f.

Figure S-12. $^{13}$C NMR spectrum (CDCl$_3$) of 1f.
Figure S-13. $^1$H NMR spectrum (CDCl$_3$) of 1g.

Figure S-14. $^{13}$C NMR spectrum (CDCl$_3$) of 1g.
VI. $^1$H and $^{13}$C ($^1$H) NMR Spectra of 4-Quinolones 2a–2g and β-Enaminones 3d, 3e, 3g.

Figure S-15. $^1$H NMR spectrum (CDCl$_3$) of 2a.

Figure S-16. $^{13}$C NMR spectrum (CDCl$_3$) of 2a.
Figure S-17. $^1$H NMR spectrum (CDCl$_3$) of 2b.

Figure S-18. $^{13}$C NMR spectrum (CDCl$_3$) of 2b.
Figure S-19. $^1$H NMR spectrum (CDCl$_3$) of 2c.

Figure S-20. $^{13}$C NMR spectrum (CDCl$_3$) of 2c.
Figure S-21. $^1$H NMR spectrum (CDCl$_3$) of 2d.

Figure S-22. $^{13}$C NMR spectrum (CDCl$_3$) of 2d.
Figure S-23. $^1$H NMR spectrum (CDCl$_3$) of 3d.

Figure S-24. $^1$H NMR spectrum (CDCl$_3$) of 2e.
Figure S-25. $^{13}$C NMR spectrum (CDCl$_3$) of 2e.

Figure S-26. $^1$H NMR spectrum (CDCl$_3$) of 3e.
Figure S-27. $^1$H NMR spectrum ($\text{CDCl}_3$) of 2f.

Figure S-28. $^{13}$C NMR spectrum ($\text{CDCl}_3$) of 2f.
Figure S-29. $^1$H NMR spectrum (CDCl$_3$) of 2g.

Figure S-30. $^{13}$C NMR spectrum (CDCl$_3$) of 2g.