Supporting Information

Acid-ionic polymer as recyclable catalyst for one-pot three-component Mannich reaction

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General remarks

All chemicals were purchased from commercial sources and used without further purification. The reactions were carried out using a shaker, VORTEMP 1550. $^1$H and $^{13}$C NMR spectra were recorded using a BRUKER AVANC (400 MHz). High-resolution mass spectra (HRMS) data were recorded at Mahidol University using a Bruker Daltonics - micrOTOF-Q. Infrared spectra were determined on a PERKIN ELMER FT/IR-2000S spectrophotometer. Analytical
thin-layer chromatography (TLC) was conducted on pre-coated TLC plates; silica gel 60F-254 [E. Merck, Darmstadt, Germany]. Open-column chromatography was carried out using silica gel 60 PF254 [E. Merck, Darmstadt, Germany]. Melting points were measured using a Melting point apparatus (Griffin) and are uncorrected.

**General procedure for the preparation of acid-functionalized ionic polymers**

**PS-Im (I):** Chloromethyl Merrifield resin (5.0023 g, 1.80 mmol/g Cl loading) was placed in a vial (50 mL) pretreated with Sigmacote® and DMF (27.0 mL) was added. The suspension was shaken until resin was fully swollen. Then, imidazole (1.2230 g, 17.96 mmol) and K$_2$CO$_3$ (3.7211 g, 26.92 mmol) were added to the suspension, respectively. The mixture suspension was continually shaken at 60°C using a shaker with a speed of 800 r.p.m. for 24 h. The resulting resin was cooled and collected into a plastic syringe equipped with polyethylene frit, and wash with water, methanol and diethyl ether respectively, and dried under reduced pressure to give PS-Im (I) in >99% (5.6385 g, 1.80 mmol/g Cl loading).

**[Ps-Im][X] (II, III):** Resin PS-Im (I) (1.0000 g, 1.80 mmol/g Cl loading) was placed in a vial (50 mL) pretreated with Sigmacote® and toluene (3.0 mL) was added. Then, para-toluenesulfonic acid (pTsOH) (0.7228 g, 3.8 mmol) or trifluoromethanesulfonic acid (TfOH) (318 µL, 3.6 mmol) was added to the suspension. The mixture suspension was continually...
shaken at 60°C using a shaker with a speed of 800 r.p.m. for 24 h. The resulting resin was cooled and collected into a plastic syringe equipped with polyethylene frit, and wash with acetone, methanol and diethyl ether respectively, and dried under reduced pressure to give [PS-Im][pTSA] (II) in 95% (1.2771 g, 1.71 mmol/g Cl loading) or [PS-Im][OTf] (III) in >99% (1.4970 g, 1.80 mmol/g Cl loading).

**PS-Im (I):** Chloromethyl Merrifield resin (5.0023 g, 1.80 mmol/g Cl loading) was placed in a vial (50 mL) pretreated with Sigmacote® and DMF (27.0 mL) was added. The suspension was shaken until resin was fully swollen. Then, imidazole (1.2230 g, 17.96 mmol) and K₂CO₃ (3.7211 g, 26.92 mmol) were added to the suspension, respectively. The mixture suspension was continually shaken at 60°C using a shaker with a speed of 800 r.p.m. for 24 h. The resulting resin was cooled and collected into a plastic syringe equipped with polyethylene frit, and wash with water, methanol and diethyl ether respectively, and dried under reduced pressure to give **PS-Im (I)** in quantitative yield (5.6385 g, 1.80 mmol/g Cl loading).

**PS-BsIm (IV):** Resin **PS-Im (I)** (2.0000 g, 1.80 mmol/g Cl loading) was placed in a vial (50 mL) pretreated with Sigmacote® and toluene (7.0 mL) was added. The suspension was added
1,4-butanesultone (1.50 mL, 14.68 mmol) in portion at room temperature. The mixture suspension was continually shaken at 90°C using a shaker with a speed of 800 r.p.m. for 24 h. The resulting resin was cooled and collected into a plastic syringe equipped with polyethylene frit, and wash with toluene, methanol and diethyl ether respectively, and dried under reduced pressure to give PS-BsIm (IV) in most-quantitative yield (2.5064 g, 1.80 mmol/g Cl loading).

[PS-BsIm][X] (V, VI): Resin PS-BsIm (IV) (0.5000 g, 1.80 mmol/g Cl loading) was placed in a vial (20 mL) pretreated with Sigmacote® and toluene (3.0 mL) was added. Then, para-toluenesulfonic acid (pTsOH) (0.3493 g, 1.8 mmol) or trifluoromethanesulfonic acid (TfOH) (159 µL, 1.8 mmol) was added to the suspension. The mixture suspension was continually shaken at 60°C using a shaker with a speed of 800 r.p.m. for 24 h. The resulting resin was cooled and collected into a plastic syringe equipped with polyethylene frit, and wash with acetone, methanol and diethyl ether respectively, and dried under reduced pressure to give [PS-BsIm][pTSA] (V) in 69% (0.4630 g, 1.24 mmol/g Cl loading) or [PSSIM][OTf] (VI) in 72% (0.4593 g, 1.30 mmol/g Cl loading).

**General procedure for one-pot three-component Mannich-type reaction**

![Mannich reaction diagram]

A mixture of aldehyde (1) (1.0 mmol), amine (2) (1.0 mmol) and catalyst III (10 mol%) in MeCN (3.0 mL) was suspended at room temperature, then ketone (3) (1.2 mmol) was added. The mixture suspension was shaken at room temperature using a shaker with a speed of 800 r.p.m. and monitored by TLC. After complete conversion, the solution was separated from
resin catalyst using filtration, a plastic syringe equipped with polyethylene frit and washed with ethyl acetate (4×5 mL). The filtered resin catalyst was dried under reduced pressure for the next experiment. The combine filtrate was concentrated using a rotary evaporator, and purified by column chromatography (SiO₂, 10-20% ethyl acetate/n-hexane as eluent) to give the desired products 4a-o in 24-96% yields.

Physical and Spectral data of Mannich products

2-[(4-nitrophenyl)(phenylamino)methyl]-cyclohexanone (4a): 9f,18d,15 93% yield (0.3002 g) as a yellow solid (syn:anti = 33:67); m.p. 94-98 °C; Rf = 0.20 (20% EtOAc/n-hexane); IR (Neat): 3403, 2938, 1706, 1601, 1518, 1345, 751, 693 cm⁻¹; ¹H-NMR (400 MHz, CDCl₃): δ 1.68-1.79 (m, 3H, CH₃), 1.90-2.10 (m, 3H, CH₃), 2.29-2.46 (m, 2H, CH₂), 2.79-2.96 (m, 1H, CH), 4.70 (d, 0.77H, J = 7.0 Hz, anti-CH), 4.85 (d, 0.24H, J = 5.5 Hz, syn-CH), 6.48-6.56 (m, 2H, ArH), 6.70 (t, 1H, J = 7.0 Hz, ArH), 7.06-7.13 (m, 2H, ArH), 7.57 (d, 2H, J = 8.5 Hz, ArH), 8.15 (d, 2H, J = 8.5 Hz, ArH); ¹³C-NMR (100 MHz, CDCl₃): δ 24.46 (anti), 24.91 (syn), 27.01 (syn), 27.74 (anti), 29.05 (syn), 31.99 (anti), 42.38 (anti), 42.42 (syn), 56.18 (syn), 56.92 (anti), 57.22 (syn), 57.92 (anti), 113.61 (2C, anti), 114.04 (2C, syn), 118.26 (anti), 118.39 (syn), 123.60 (2C, syn), 123.65 (2C, anti), 128.27 (2C, anti), 128.59 (2C, syn), 129.14 (2C, syn), 129.25 (2C, anti), 146.45 (anti), 146.57 (syn), 147.03 (syn, anti), 149.51 (syn), 149.65 (anti), 210.60 (syn), 211.79 (anti).
2-[phenyl(phenylamino)methyl]-cyclohexanone (4b): \(^8\text{b,9a,10a,13a,13b,15,16,18d}\) 73% yield (0.2050 g) as a yellow solid (syn:anti = 26:74); m.p. 102-106 °C; \(R_f = 0.41\) (20% EtOAc/n-hexane); IR (Neat): 3399, 2936, 1702, 1602, 1505, 1451, 1317, 749, 702 cm\(^{-1}\); \(^1\)H-NMR (400 MHz, CDCl\(_3\)): \(\delta\) 1.63-1.73 (m, 2H, CH\(_2\)), 1.80-1.96 (m, 4H, CH\(_2\)), 2.29-2.48 (m, 2H, CH\(_2\)), 2.75-2.85 (m, 1H, CH), 4.61 (d, 0.77H, \(J = 7.0\) Hz, anti-CH), 4.80 (d, 0.28H, \(J = 4.5\) Hz, syn-CH), 6.56 (dd, 2H, \(J = 3.0, 7.5\) Hz, ArH), 6.65 (t, 1H, \(J = 7.5\) Hz, ArH), 7.04-7.10 (m, 2H, ArH), 7.17-7.24 (m, 1H, ArH), 7.27-7.33 (m, 2H, ArH), 7.33-7.41 (m, 2H, ArH), 7.51 (2H, ArH), 113.68 (2C), 114.04 (2C, syn), 117.59 (anti), 117.65 (syn), 126.96 (syn), 127.15 (anti), 127.24 (2C, anti), 127.48 (2C, syn), 128.33 (2C, syn), 128.43 (2C, anti), 128.96 (2C, syn), 129.02 (2C, anti), 141.50 (syn), 141.55 (anti), 147.04 (anti), 147.42 (syn), 211.29 (syn), 212.84 (anti).

2-[(3-nitrophenyl)(phenylamino)methyl]-cyclohexanone (4c): \(^9\text{c,18d}\) 89% yield (0.2285 g) as a yellow solid (syn:anti = 46:54); m.p. 104-106 °C; \(R_f = 0.19\) (10% EtOAc/n-hexane); IR (Neat): 3406, 2939, 1706, 1602, 1527, 1349, 751, 692 cm\(^{-1}\); \(^1\)H-NMR (400 MHz, CDCl\(_3\)): \(\delta\)
1.60-1.85 (m, 3H, CH₂), 1.90-2.15 (m, 3H, CH₂), 2.28-2.48 (m, 2H, CH₂), 2.82-2.90 (m, 1H, CH), 4.70 (d, 0.67H, \(J = 5.0\) Hz, \(\text{anti-CH}\)), 4.85 (d, 0.47H, \(J = 4.5\) Hz, \(\text{syn-CH}\)), 6.52 (d, 2H, \(J = 7.5\) Hz, ArH), 6.64-6.71 (m, 1H, ArH), 7.06-7.12 (m, 2H, ArH), 7.46 (t, 1H, \(J = 8.0\) Hz, ArH), 7.74-7.80 (m, 1H, ArH), 8.04-8.10 (m, 1H, ArH), 8.21-8.26 (m, 1H, ArH); \(^{13}\)C-NMR (100 MHz, CDCl₃): \(\delta\) 24.40 (\(\text{anti}\)), 24.88 (\(\text{syn}\)), 27.07 (\(\text{syn}\)), 27.76 (\(\text{anti}\)), 29.22 (\(\text{syn}\)), 31.97 (\(\text{anti}\)), 42.36 (\(\text{anti}\)), 42.42 (\(\text{syn}\)), 56.23 (\(\text{anti}\)), 57.02 (\(\text{syn, anti}\)), 57.61 (\(\text{syn}\)), 113.44 (2C, \(\text{anti}\)), 113.94 (2C, \(\text{syn}\)), 118.00 (\(\text{anti}\)), 118.24 (\(\text{syn}\)), 122.17 (\(\text{anti}\)), 122.20 (\(\text{syn}\)), 122.24 (\(\text{anti}\)), 122.46 (\(\text{syn}\)), 129.14 (2C, \(\text{syn}\)), 129.22 (2C, \(\text{anti}\)), 129.25 (\(\text{syn}\)), 129.31 (\(\text{anti}\)), 133.57 (\(\text{anti}\)), 134.13 (\(\text{syn}\)), 144.11 (\(\text{syn}\)), 144.45 (\(\text{anti}\)), 146.58 (\(\text{syn}\)), 146.65 (\(\text{anti}\)), 148.37 (\(\text{syn, anti}\)), 210.70 (\(\text{syn}\)), 211.86 (\(\text{anti}\)).

2-[(4-fluorophenyl)(phenylamino)methyl]-cyclohexanone (4d): 76% yield (0.2263 g) as a yellow solid (\(\text{syn:anti} = 26:74\)); m.p. 98-102 °C; \(R_f = 0.38\) (20% EtOAc/n-hexane); IR (Neat): 3397, 2938, 1705, 1603, 1507, 1222, 838, 750, 693 cm\(^{-1}\); \(^1\)H-NMR (400 MHz, CDCl₃): \(\delta\) 1.55-1.75 (m, 2H, CH₂), 1.75-2.09 (m, 4H, CH₂), 2.29-2.47 (m, 2H, CH₂), 2.74-2.84 (m, 1H, CH), 4.60 (d, 0.78H, \(J = 6.5\) Hz, \(\text{anti-CH}\)), 4.74 (d, 0.27H, \(J = 4.5\) Hz, \(\text{syn-CH}\)), 6.53 (dd, 2H, \(J = 4.5\), 8.0 Hz, ArH), 6.66 (t, 1H, \(J = 8.0\) Hz, ArH), 6.94-7.01 (m, 2H, ArH), 7.08 (t, 2H, \(J = 8.0\) Hz, ArH), 7.30-7.38 (m, 2H, ArH); \(^{13}\)C-NMR (100 MHz, CDCl₃): \(\delta\) 23.84 (\(\text{anti}\)), 24.83 (\(\text{syn}\)), 26.98 (\(\text{syn}\)), 27.81 (\(\text{anti}\)), 28.95 (\(\text{syn}\)), 31.36 (\(\text{anti}\)), 41.93 (\(\text{anti}\)), 42.42 (\(\text{syn}\)), 56.45 (\(\text{syn}\)), 56.89 (\(\text{syn}\)), 57.34 (\(\text{anti}\)), 57.57 (\(\text{anti}\)), 113.77 (2C, \(\text{anti}\)), 114.05 (2C, \(\text{syn}\)), 115.16 (d, \(J = 21\) Hz, 2×\(\text{syn-C-F}\)), 115.31 (d, \(J = 21\) Hz, 2×\(\text{anti-C-F}\)), 117.87 (\(\text{syn, anti}\)), 128.81 (d, \(J = 8.0\) Hz, 3×\(\text{CH-F}\)).
Hz, 2×anti-C-F), 129.02 (2C, syn), 129.08 (2C, anti), 129.12 (d, J = 8.0 Hz, 2×syn-C-F), 137.00 (d, J = 3.0 Hz, syn-C-F), 137.20 (d, J = 3.0 Hz, anti-C-F), 146.79 (anti), 147.16 (syn), 161.85 (d, J = 244 Hz, syn-, anti-C-F), 211.30 (syn), 212.65 (anti); HRMS (ESI) m/z C_{19}H_{20}FNO [M+Na]^+ calcd 320.1421, found 320.1423.

2-[(2,4-dichlorophenyl)(phenylamino)methyl]-cyclohexanone (4e): 130 96% yield (0.3319 g) as a yellow oil (syn:anti = 41:59); R_f = 0.64 (20% EtOAc/n-hexane); IR (Neat): 3396, 2938, 1706, 1603, 1505, 1468, 749 cm⁻¹; \(^1\)H-NMR (400 MHz, CDCl₃): δ 1.55-1.80 (m, 3H, CH₂), 1.89-2.14 (m, 3H, CH₂), 2.26-2.51 (m, 2H, CH₂), 2.84-2.98 (m, 1H, CH), 4.83 (d, 0.54H, J = 4.5 Hz, anti-CH), 5.26 (d, 0.37H, J = 3.5 Hz, syn-CH), 6.48 (d, 1H, J = 8.0 Hz, ArH), 6.52 (d, 1H, J = 7.5 Hz, ArH), 6.65-6.70 (m, 1H, ArH), 7.06-7.13 (m, 2H, ArH), 7.16 (dd, 1H, J = 2.0, 8.5 Hz, ArH), 7.34 (d, 0.54H, J = 2.0 Hz, anti-ArH), 7.38 (d, 0.36H, J = 2.0 Hz, syn-ArH), 7.46 (d, 0.59H, J = 8.5 Hz, anti-ArH), 7.56 (d, 0.41H, J = 8.5 Hz, syn-ArH); \(^{13}\)C-NMR (100 MHz, CDCl₃): δ 24.90 (anti), 27.04 (syn), 27.59 (syn), 28.03 (anti), 29.67 (syn), 32.82 (anti), 42.30 (syn), 42.93 (anti), 53.14 (syn), 53.95 (anti), 54.98 (anti), 55.32 (syn), 113.45 (2C, syn), 114.06 (2C, anti), 117.98 (syn), 118.27 (anti), 127.29 (syn), 127.39 (anti), 128.99 (anti), 129.06 (2C, syn), 129.22 (2C, anti), 129.54 (syn), 130.08 (anti), 130.58 (syn), 133.21 (anti), 133.26 (syn), 133.33 (syn), 133.79 (anti), 137.31 (anti), 137.70 (syn), 146.40 (syn), 146.78 (anti), 210.59 (syn), 213.04 (anti).
2-[(4-methoxyphenyl)(phenylamino)methyl]-cyclohexanone (4f): $^{10a,15,18d}$ 61% yield (0.1887 g) as a yellow oil (syn:anti = 28:72); $R_f = 0.34$ (20% EtOAc/n-hexane); IR (Neat): 3386, 2935, 1702, 1603, 1509, 1249, 732, 693, 511 cm$^{-1}$; $^1$H-NMR (400 MHz, CDCl$_3$): δ 1.55-1.76 (m, 3H, CH$_2$), 1.76-1.96 (m, 3H, CH$_2$), 2.25-2.47 (m, 2H, CH$_2$), 2.65-2.74 (m, 1H, CH), 3.76 (s, 3H, OMe), 4.58 (d, 0.79H, $J = 7.0$ Hz, anti-CH), 4.72 (d, 0.30H, $J = 4.0$ Hz, syn-CH), 6.49-6.57 (m, 2H, ArH), 6.59-6.66 (m, 1H, ArH), 6.83 (d, 2H, $J = 8.5$ Hz, ArH), 7.01-7.10 (m, 2H, ArH), 7.28 (d, 2H, $J = 8.5$ Hz, ArH); $^{13}$C-NMR (100 MHz, CDCl$_3$): δ 23.48 (anti), 24.75 (syn), 26.96 (syn), 27.82 (anti), 28.94 (syn), 31.04 (anti), 41.63 (anti), 42.38 (syn), 55.15 (OMe, syn, anti), 56.57 (syn), 56.83 (syn), 57.31 (anti), 57.59 (anti), 113.62 (2C, anti), 113.69 (2C, syn), 113.83 (2C, anti), 114.01 (2C, syn), 117.42 (anti), 117.55 (syn), 128.23 (2C, anti), 128.57 (2C, syn), 128.95 (2C, syn), 128.99 (2C, anti), 133.35 (syn), 133.58 (anti), 147.22 (anti), 147.47 (syn), 158.61 (anti), 159.68 (syn), 211.60 (syn), 212.99 (anti).

2-[(Furan-2-yl)(phenylamino)methyl]-cyclohexanone (4g): $^{8b,9a,13b}$ 80% yield (0.2148 g) as a brown solid (syn:anti = 26:74); m.p. = 82-84 °C; $R_f = 0.50$ (20% EtOAc/n-hexane); IR (Neat): 3387, 2937, 1706, 1602, 1505, 1316, 1149, 1009, 749, 692, 598 cm$^{-1}$; $^1$H-NMR (400
MHz, CDCl$_3$): δ 1.60-1.77 (m, 3H, CH$_2$), 1.84-2.06 (m, 3H, CH$_2$), 2.30-2.47 (m, 2H, CH$_2$), 2.89-3.05 (m, 1H, CH), 4.81 (d, 0.67H, $J = 5.5$ Hz, anti-CH), 4.87 (d, 0.24H, $J = 4.5$ Hz, syn-CH), 6.18-6.21 (m, 1H, Het-H), 6.24-6.28 (m, 1H, Het-H), 6.62-6.74 (m, 3H, ArH), 7.11-7.17 (m, 2H, ArH), 7.28-7.31 (m, 1H, Het-H); $^{13}$C-NMR (100 MHz, CDCl$_3$): δ 24.25 (anti), 24.67 (syn), 26.84 (syn), 27.58 (anti), 29.65 (anti), 30.78 (anti), 42.06 (anti), 42.20 (syn), 51.91 (syn), 52.17 (anti), 54.03 (syn), 54.42 (anti), 106.86 (anti), 107.15 (syn), 110.30 (syn, anti), 113.69 (2C, anti), 113.99 (2C, syn), 118.00 (anti), 118.15 (syn), 129.13 (2C, syn), 129.15 (2C, anti), 141.14 (syn), 141.26 (anti), 147.10 (syn), 147.13 (anti), 154.58 (anti), 154.85 (syn), 211.00 (syn), 211.84 (anti).

![Chemical Structure Image](image-url)

2-[(pyridin-2-yl)(phenylamino)methyl]-cyclohexanone (syn-4h):$^{8b,10a}$ 15% yield (0.0410 g) of syn-isomer as a brown solid; m.p. = 138-140 °C; $R_f = 0.29$ (20% EtOAc/n-hexane); IR (Neat): 3392, 3051, 2929, 2859, 1704, 1602, 1505, 1470, 1434, 1317, 749, 692 cm$^{-1}$; $^1$H-NMR (400 MHz, CDCl$_3$): δ 1.65-1.82 (m, 4H, CH$_2$), 1.88-2.15 (m, 2H, CH$_2$), 2.31-2.37 (m, 2H, CH$_2$), 3.30-3.38 (m, 1H, CH), 4.79 (d, 1H, $J = 4.0$ Hz, CH), 6.60 (d, 2H, $J = 7.5$ Hz, ArH), 6.66 (t, 1H, $J = 7.5$ Hz, ArH), 7.09-7.15 (m, 3H, ArH, Pyr-H), 7.48 (d, 1H, $J = 7.5$ Hz, Pyr-H), 7.59 (td, 1H, $J = 1.0, 7.5$ Hz, Pyr-H), 8.52 (brd, 1H, $J = 4.5$ Hz, Pyr-H); $^{13}$C-NMR (100 MHz, CDCl$_3$): δ 24.63, 27.71, 31.62, 42.47, 55.41, 58.68, 113.11 (2C), 117.34, 121.81, 121.91, 129.27 (2C), 136.47, 147.35, 148.69, 161.25, 213.10; HRMS (ESI) $m/z$ C$_{18}$H$_{20}$N$_2$O $[M+Na]^+$ calcd 303.1473, found 303.1472.
2-[(pyridin-2-yl)(phenylamino)methyl]-cyclohexanone (anti-4h): 8b,10a 11% yield (0.0304 g) of anti-isomer as a yellow solid; m.p. = 112-114 °C; \( R_f = 0.07 \) (20% EtOAc/n-hexane); IR (Neat): 3378, 2938, 1706, 1602, 1505, 1434, 1261, 749, 693 cm\(^{-1}\); \(^1\)H-NMR (400 MHz, CDCl\(_3\)): \( \delta \) 1.60-1.73 (m, 3H, CH\(_2\)), 1.85-1.99 (m, 1H, CH\(_2\)), 2.00-2.09 (m, 1H, CH\(_2\)), 2.23-2.40 (m, 3H, CH\(_2\)), 3.06-3.14 (m, 1H, CH\(_2\)), 4.96 (d, 1H, \( J = 6.5 \) Hz, CH), 6.61-6.69 (m, 3H, ArH), 7.07-7.16 (m, 3H, ArH, Pyr-H), 7.43 (d, 1H, \( J = 7.5 \) Hz, Pyr-H), 7.59 (t, 1H, \( J = 7.5 \) Hz, Pyr-H), 8.53 (d, 1H, \( J = 4.0 \) Hz, Pyr-H); \(^{13}\)C-NMR (100 MHz, CDCl\(_3\)): \( \delta \) 24.98, 27.64, 29.79, 42.45, 56.02, 57.84, 113.95 (2C), 117.73, 121.97, 123.08, 129.11 (2C), 136.29, 147.59, 148.97, 161.48, 211.64; HRMS (ESI) \( m/z \) C\(_{18}\)H\(_{20}\)N\(_2\)O [M+H]\(^+\) calcd 281.1654, found 281.1666.

![Structure of 4j](image)

2-[(phenyl)(4-bromophenylamino)methyl]-cyclohexanone (4j): 96% yield (0.3433 g) as a yellow solid (syn:anti = 28:72); m.p. 108-111 °C; \( R_f = 0.36 \) (20% EtOAc/n-hexane); IR (Neat): 3398, 2937, 1702, 1592, 1495, 813, 702 cm\(^{-1}\); \(^1\)H-NMR (400 MHz, CDCl\(_3\)): \( \delta \) 1.54-1.74 (m, 3H, CH\(_2\)), 1.76-2.07 (m, 3H, CH\(_2\)), 2.30-2.47 (m, 2H, CH\(_2\)), 2.75-2.87 (m, 1H, CH), 4.52 (d, 0.71H, \( J = 7.0 \) Hz, anti-CH), 4.73 (d, 0.27H, \( J = 4.0 \) Hz, syn-CH), 6.40-6.48 (m, 2H, ArH), 7.14 (d, 2H, \( J = 8.5 \) Hz, ArH), 7.20-7.37 (m, 5H, ArH); \(^{13}\)C-NMR (100 MHz, CDCl\(_3\)): \( \delta \) 23.3 (anti), 24.81 (syn), 26.87 (syn), 27.89 (anti), 28.48 (syn), 31.52 (anti), 41.94 (anti), 42.34 (syn), 56.33 (syn), 57.21 (anti), 57.36 (syn), 58.40 (anti), 109.41 (syn, anti), 115.40 (2C, anti), 115.69 (2C, syn), 127.16 (syn), 127.20 (2C, anti), 127.35 (anti), 127.43 (2C, syn), 128.43 (2C, syn), 128.53 (2C, anti), 131.67 (2C, syn), 131.74 (2C, anti), 140.86 (syn), 140.97
(anti), 146.03 (anti), 146.42 (syn), 211.26 (syn), 212.77 (anti); HRMS (ESI) m/z C_{19}H_{20}BrNO [M+Na]^+ calcd 380.0620, found 380.0621.

2-[(4-nitrophenyl)(4-bromophenylamino)methyl]-cyclohexanone (4k): 91% yield (0.3675 g) as a yellow solid (syn:anti = 38:62); m.p. 66-70 °C; R_f = 0.16 (20% EtOAc/n-hexane); IR (Neat): 3403, 2939, 1706, 1594, 1516, 1346, 814 cm^{-1}; ^1H-NMR (400 MHz, CDCl_3): δ 1.50-1.80 (m, 3H, CH_2), 1.89-2.11 (m, 3H, CH_2), 2.28-2.48 (m, 2H, CH_2), 2.79-2.96 (m, 1H, CH), 4.62 (d, 0.64H, J = 5.5 Hz, anti-CH), 4.79 (d, 0.39H, J = 4.0 Hz, syn-CH), 6.36-6.45 (m, 2H, ArH), 7.14-7.19 (m, 2H, ArH), 7.50-7.58 (m, 2H, ArH), 8.16 (d, 2H, J = 8.5 Hz, ArH); ^13C-NMR (100 MHz, CDCl_3): δ 24.57 (anti), 24.88 (syn), 26.91 (syn), 27.79 (anti), 28.92 (syn), 32.21 (anti), 42.38 (syn), 42.50 (anti), 55.96 (syn), 56.80 (anti), 57.32 (syn), 58.16 (anti), 110.02 (syn), 110.20 (anti), 115.24 (2C, anti), 115.64 (2C, syn), 123.68 (2C, syn), 123.73 (2C, anti), 128.21 (2C, anti), 128.55 (2C, syn), 131.88 (2C, syn), 131.98 (2C, anti), 145.52 (syn), 145.62 (anti), 147.13 (anti), 147.17 (syn), 148.82 (syn), 149.05 (anti), 210.57 (syn), 211.77 (anti); HRMS (ESI) m/z C_{19}H_{19}BrN_2O_3 [M+Na]^+ calcd 425.0471, found 425.0479.
2-[(4-nitrophenyl)(4-fluoro-3-methylphenylamino)methyl]-cyclohexanone (4l): 82% yield (0.2920 g) as an orange viscous oil (syn:anti = 31:69); RF = 0.18 (20% EtOAc/n-hexane); IR (Neat): 3457, 2937, 1706, 1516, 1345, 1217, 855 cm\(^{-1}\); \(^1\)H-NMR (400 MHz, CDCl\(_3\)): \(\delta\) 1.51-1.82 (m, 4H, CH\(_2\)), 1.90-2.00 (m, 2H, CH\(_2\)), 2.12 (brs, 3H, Me), 2.30-2.45 (m, 2H, CH\(_2\)), 2.77-2.85 (m, 1H, CH), 4.61 (d, 0.82H, \(J = 5.5\) Hz, anti-CH), 4.78 (d, 0.29H, \(J = 4.5\) Hz, syn-CH), 6.18-6.25 (m, 1H, ArH), 6.30-6.35 (m, 1H, ArH), 6.71 (t, 1H, \(J = 9.0\) Hz, ArH), 7.55 (d, 2H, \(J = 8.5\) Hz, ArH), 8.16 (d, 2H, \(J = 8.5\) Hz, ArH); \(^{13}\)C-NMR (100 MHz, CDCl\(_3\)): \(\delta\) 14.72 (d, \(J = 3.0\) Hz, syn-, anti-Me-F), 24.47 (anti), 24.90 (syn), 27.00 (syn), 27.75 (anti), 28.79 (syn), 32.00 (anti), 40.40 (syn), 42.39 (anti), 56.21 (syn), 57.01 (anti), 57.78 (syn), 58.46 (anti), 111.61 (d, \(J = 7.0\) Hz, anti-C-F), 112.20 (d, \(J = 7.0\) Hz, syn-C-F), 115.14 (d, \(J = 23\) Hz, syn-C-F), 115.22 (d, \(J = 23\) Hz, anti-C-F), 116.38 (d, \(J = 4.0\) Hz, anti-C-F), 116.96 (d, \(J = 4.0\) Hz, syn-C-F), 123.60 (2C, syn), 123.64 (2C, anti), 125.20 (d, \(J = 18.0\) Hz, syn-C-F), 125.30 (d, \(J = 18\) Hz, anti-C-F), 128.23 (2C, anti), 128.49 (2C, syn), 142.71 (d, \(J = 3.0\) Hz, anti-C-F, syn, anti), 147.04 (d, \(J = 3.0\) Hz, syn-C-F), 149.49 (syn), 149.78 (anti), 154.73 (d, \(J = 234\) Hz, anti-C-F), 154.90 (d, \(J = 234\) Hz, syn-C-F), 210.66 (syn), 211.78 (anti); HRMS (ESI) \(m/z\) C\(_{20}\)H\(_{21}\)FN\(_2\)O\(_3\) [M+Na]\(^{+}\) calcd 379.1428, found 379.1430.

2-[(4-methoxyphenyl)(4-bromophenylamino)methyl]-cyclohexanone (4m): 76% yield (0.2940 g) as a yellow oil (syn:anti = 25:75); RF = 0.34 (20% EtOAc/n-hexane); IR (Neat): 3391, 2934, 1702, 1594, 1510, 1247, 1177, 1033, 814, 503 cm\(^{-1}\); \(^1\)H-NMR (400 MHz, CDCl\(_3\)): \(\delta\) 1.47-1.65 (m, 3H, CH\(_2\)), 1.70-1.91 (m, 3H, CH\(_2\)), 2.20-2.39 (m, 2H, CH\(_2\)), 2.58-
2.66 (m, 1H, CH), 3.70 (s, 3H, OMe), 4.42 (d, 0.77H, \( J = 7.0 \text{ Hz, anti-CH} \)), 4.58 (d, 0.28H, \( J = 4.0 \text{ Hz, syn-CH} \)), 6.30-6.36 (m, 2H, ArH), 6.73-6.79 (m, 2H, ArH), 7.03-7.09 (m, 2H, ArH), 7.14-7.19 (m, 2H, ArH); \(^{13}\text{C-NMR (100 MHz, CDCl}_3\)): \( \delta \) 23.66 (anti), 24.73 (syn), 26.84 (syn), 27.85 (anti), 28.75 (syn), 31.27 (anti), 41.80 (anti), 42.34 (syn), 55.15 (syn, anti-OMe), 56.31 (syn), 56.92 (syn), 57.43 (anti), 57.54 (anti), 109.08 (anti), 109.25 (syn), 113.76 (2C, syn), 113.89 (2C, anti), 115.26 (2C, anti), 115.62 (2C, syn), 128.17 (2C, anti), 128.52 (2C, syn), 131.65 (2C, syn, anti), 132.53 (syn), 132.99 (anti), 146.27 (anti), 146.50 (syn), 158.59 (syn), 158.69 (anti), 211.55 (syn), 212.90 (anti); HRMS (ESI) \( m/z \) C\(_{20}\)H\(_{22}\)BrNO\(_2\) [M+Na]\(^{+}\) calcd 410.0732, found 410.0728.

\[ \text{2-[(4-nitrophenyl)(3-methoxyphenylamino)methyl]-cyclohexanone (4n): } 29\% \text{ yield (0.1016 g) as a yellow oil ( syn:anti = 34:66); } R_f = 0.19 \text{ (20\% EtOAc/n-hexane); IR (Neat): } 3392, 2938, 1706, 1598, 1518, 1346, 1210, 1163, 855, 736, 702, 689 \text{ cm}^{-1}; \text{ } ^1\text{H-NMR (400 MHz, CDCl}_3\)): \( \delta \) 1.53-1.67 (m, 3H, CH\(_2\)), 1.68-1.85 (m, 2H, CH\(_2\)), 1.88-1.98 (m, 1H, CH\(_2\)), 2.27-2.47 (m, 2H, CH\(_2\)), 2.79-2.88 (m, 1H, CH), 3.69 (s, 3H, OMe), 4.68 (d, 0.65H, \( J = 5.0 \text{ Hz, anti-CH} \)), 4.82 (d, 0.45H, \( J = 4.0 \text{ Hz, syn-CH} \)), 6.03 (t, 1H, \( J = 2.0 \text{ Hz, ArH} \)), 6.12 (brd, 1H, \( J = 7.5 \text{ Hz, ArH} \)), 6.23 (ddd, 1H, \( J = 2.0, 5.0, 7.5 \text{ Hz, ArH} \)), 6.99 (td, 1H, \( J = 2.0, 8.0 \text{ Hz, ArH} \)), 7.53-7.58 (m, 2H, ArH), 8.15 (d, 2H, \( J = 8.5 \text{ Hz, ArH} \)); \(^{13}\text{C-NMR (100 MHz, CDCl}_3\)): \( \delta \) 24.44 (anti), 24.89 (syn), 26.97 (syn), 27.75 (anti), 29.16 (syn), 32.04 (anti), 42.39 (syn, anti), 54.98 (syn, anti-OMe), 56.07 (syn), 56.97 (anti), 57.25 (syn), 57.79 (anti), 99.67 (anti), 100.23 (syn), 103.00 (anti), 103.33 (syn), 106.51 (anti), 107.02 (syn), 123.60 (2C, syn),}
123.66 (2C, \textit{anti}), 128.14 (2C, \textit{anti}), 128.58 (2C, \textit{syn}), 129.91 (\textit{syn}), 130.02 (\textit{anti}), 147.01 (\textit{syn}), 147.06 (\textit{anti}), 148.00 (\textit{syn}), 148.07 (\textit{anti}), 149.41 (\textit{syn}), 149.79 (\textit{anti}), 160.61 (\textit{syn}), 160.70 (\textit{anti}), 210.60 (\textit{syn}), 211.79 (\textit{anti}); HRMS (ESI) \textit{m/z} C_{20}H_{22}BrN_{2}O_{4} [M+Na]^+ calcd 377.1477, found 377.1482.

\textbf{1-(4-nitropyphenyl)(phenylamino)hexan-3-one (4o):} 24\% yield (0.0749 g) as a yellow oil; \textit{R}_f = 0.34 (20\% EtOAc/\textit{n}-hexane); IR (Neat): 3395, 2963, 1709, 1602, 1519, 1345, 750, 694 cm^{-1}; \textsuperscript{1}H-NMR (400 MHz, CDCl\textsubscript{3}): \textit{\delta} 0.85 (t, 3H, \textit{J} = 7.0 Hz), 1.55 (hex, 2H, \textit{J} = 7.0 Hz, \textit{CH}_{2}), 2.31-2.38 (m, 2H, \textit{CH}_{2}), 2.94 (d, 2H, \textit{J} = 6.0 Hz, \textit{CH}_{2}), 4.93 (t, 1H, \textit{J} = 6.0 Hz, CH), 6.49 (d, 2H, \textit{J} = 7.5 Hz, ArH), 6.70 (t, 1H, \textit{J} = 7.5 Hz, ArH), 7.10 (t, 2H, \textit{J} = 7.5 Hz, ArH), 7.56 (d, 2H, \textit{J} = 8.5 Hz, ArH), 8.17 (d, 2H, \textit{J} = 8.5 Hz, ArH); \textsuperscript{13}C-NMR (100 MHz, CDCl\textsubscript{3}): \textit{\delta} 13.54, 16.88, 45.53, 49.58, 53.89, 113.78 (2C), 118.46, 124.04 (2C), 127.36 (2C), 129.26 (2C), 146.16, 147.25, 150.54, 208.42; HRMS (ESI) \textit{m/z} C_{18}H_{20}N_{2}O_{3} [M+Na]^+ calcd 313.1552, found 313.1550.
$^1$H and $^{13}$C NMR spectra of $\beta$-amino carbonyl compounds

2-[(4-nitrophenyl)(phenylamino)methyl]-cyclohexanone (4a):

$^1$H-NMR (400 MHz, CDCl$_3$)

$^{13}$C-NMR (100 MHz, CDCl$_3$)
2-[phenyl(phenylamino)methyl]-cyclohexanone (4b):

$^1$H-NMR (400 MHz, CDCl$_3$)

$^{13}$C-NMR (100 MHz, CDCl$_3$)
2-[(3-nitrophenyl)(phenylamino)methyl]-cyclohexanone (4c):  
$^1$H-NMR (400 MHz, CDCl$_3$)

$^{13}$C-NMR (100 MHz, CDCl$_3$)
2-[(4-fluorophenyl)(phenylamino)methyl]-cyclohexanone (4d):

$^1$H-NMR (400 MHz, CDCl$_3$)

$^{13}$C-NMR (100 MHz, CDCl$_3$)
2-[(2,4-dichlorophenyl)(phenylamino)methyl]-cyclohexanone (4e): 
$^1$H-NMR (400 MHz, CDCl$_3$)

$^{13}$C-NMR (100 MHz, CDCl$_3$)
2-[(4-methoxyphenyl)(phenylamino)methyl]-cyclohexanone (4f):

$^1$H-NMR (400 MHz, CDCl$_3$)

$^{13}$C-NMR (100 MHz, CDCl$_3$)
2-[(Furan-2-yl)(phenylamino)methyl]-cyclohexanone (4g):

$^1$H-NMR (400 MHz, CDCl$_3$)

$^{13}$C-NMR (100 MHz, CDCl$_3$)
**syn-2-[(pyridin-2-yl)(phenylamino)methyl]-cyclohexanone (syn-4h):**

$^1$H-NMR (400 MHz, CDCl$_3$)

$^{13}$C-NMR (100 MHz, CDCl$_3$)
*anti*-2-[(pyridin-2-yl)(phenylamino)methyl]-cyclohexanone (*anti*-4h):

$^1$H-NMR (400 MHz, CDCl$_3$)

$^{13}$C-NMR (100 MHz, CDCl$_3$)
2-[(phenyl)(4-bromophenylamino)methyl]-cyclohexanone (4j):

$^1$H-NMR (400 MHz, CDCl$_3$)

$^{13}$C-NMR (100 MHz, CDCl$_3$)
2-[(4-nitrophenyl)(4-bromophenylamino)methyl]-cyclohexanone (4k):

$^1$H-NMR (400 MHz, CDCl$_3$)

$^{13}$C-NMR (100 MHz, CDCl$_3$)
2-[(4-nitrophenyl)(4-fluoro-3-methylphenylamino)methyl]-cyclohexanone (4l):

$^1$H-NMR (400 MHz, CDCl$_3$)

$^{13}$C-NMR (100 MHz, CDCl$_3$)
2-[(4-methoxyphenyl)(4-bromophenylamino)methyl]-cyclohexanone (4m):

$^1$H-NMR (400 MHz, CDCl$_3$)

$^{13}$C-NMR (100 MHz, CDCl$_3$)
2-[(4-nitrophenyl)(3-methoxyphenylamino)methyl]-cyclohexanone (4n):

$^1$H-NMR (400 MHz, CDCl$_3$)

$^{13}$C-NMR (100 MHz, CDCl$_3$)
1-(4-nitrophenyl)(phenylamino)hexan-3-one (4o):

$^1$H-NMR (400 MHz, CDCl$_3$)

$^{13}$C-NMR (100 MHz, CDCl$_3$)