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Supplementary Material

Synthesis and Characterization of *c*-**1** and *t*-**1**

General Procedures. Solvents and chemicals used for synthesis were of reagent grade unless otherwise noted. 2,2'-bipyridine, α-phenylacetonitrile, 4-pyridine-carboxyaldehyde, selenium dioxide, ethylene diamine, pyridine and *p*-toluenesulfonic acid were used as received. All organic compounds were purified by liquid chromatography on silica gel (230-400 mesh) and the transition metal complexes were purified by precipitation from diethyl ether followed by chromatography on neutral alumina (Fisher, Brockman Grade III). Proton and carbon NMR spectra were obtained on a Varian Gemini 300 MHz spectrophotometer.

α-isonicotinoyl-α-phenylacetonitrile (**7**).[S1,S2] An ethanolic solution of sodium ethoxide was prepared by dissolving sodium spheres (Aldrich, 5-8 mm diameter, 1.86 g, 81 mmol) in 25 mL of ethanol. This solution was maintained under a blanket of Ar during the course of the reaction. After 40 minutes, the sodium spheres had completely dissolved at which point methyl isonicotinate (12 g, 85 mmol) and α-phenylacetonitrile (13.5 g, 131 mmol) were added to the solution. Immediately after the two reactants were added the reaction mixture became viscous and turned yellow. Stirring of the viscous reaction mixture was effected by using a mechanical stirrer. The reaction was allowed to reflux for approximately 3 hours. After cooling, the thick reaction mixture was poured into 100 mL of distilled water and the aqueous solution was extracted with 3 x 50 mL portions of diethyl ether to remove unreacted starting materials. The basic aqueous layer was subsequently neutralized by addition of approximately 200 mL of 5 M HCl whereupon a fluffy yellow solid precipitated. After insuring that the pH of the solution was less than 5, the yellow solid was collected on a Buchner funnel and dried overnight in vacuo. Compound **7** was obtained as a yellow solid, yield 11.9 g (64%). Note that **7** is insoluble in most NMR solvents and was therefore used for the next step without characterization.

2-phenyl-1-(4-pyridyl)ethanone (**8**).[S1,S2] To a 1 L round bottom filled with 600 mL of concentrated HCl, 12.3 g of **7** (55 mmol) was added and the reaction was allowed to reflux overnight (≈ 12 hours). The HCl was evaporated under reduced pressure and then saturated

sodium bicarbonate was added to the remaining brown-yellow residue until the pH > 8 (ca. 400 mL was required). The resulting aqueous solution was extracted three times with 50 mL portions of CH_2Cl_2. The organic layers were combined, dried over $MgSO_4$ and then the solvent was evaporated under reduced pressure to afford **8** as a pale yellow solid, yield 5.7 g (53%). *Spectral Data.* ^{1}H NMR (300 MHz, $CDCl_3$) δ 4.55 (s, 2H), 6.99 - 7.50 (m, 5H), 7.75 (dd, 2H), 8.75 (d, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 46.8, 122.6, 128.3, 129.9, 130.5, 134.3, 143.5, 152.0, 198.0.

1-phenyl-2-(4-pyridyl)ethanedione (**9**).[S3] **8** (3 g, 15 mmol) was placed in a 1 L round bottom flask to which 25 mL of glacial acetic acid was added followed by 2.1 g (20 mmol) of SeO_2 and the reaction was stirred by using a magnetic stirrer. The reaction temperature was maintained between 40 and 50° C for 40 minutes after which time TLC (silica gel, 2% MeOH/$CHCl_3$) indicated that the starting material at $R_f = 0.20$ was entirely converted to product **8** at $R_f = 0.65$. The acetic acid was evaporated under reduced pressure leaving crude **8** as a viscous brick-red oil. The oil was dissolved in 3 mL of 2% MeOH/$CHCl_3$ and then eluted through a short column of silica (h = 7 cm, diam = 5 cm, packed in a 60 mL sintered glass funnel) in an effort to eliminate the brick-red selenium impurity. Upon evaporation of the solvent after the silica filtration step it was clear that some red selenium impurity remained in the oily product. Thus, the product was dissolved in ca. 50 mL of ethanol and refluxed whereupon more of the selenium impurity precipitated. Upon cooling, the insoluble impurities were removed by centrifugation. The reflux/centriguge step was repeated several times as needed until no further precipitates were observed whereupon the ethanol was evaporated under reduced pressure. Compound **9** was finally obtained as a brown oil, yield 2.5 g (80%). *Spectral Data.* ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.55 (t, 2H), 7.70 (t, 1H), 7.80 (d, 2H), 8.00 (d, 2H), 8.88 (d, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 123.6, 130.3, 131.1, 133.3, 136.5, 140.2, 151.7, 193.5, 193.8.

2-phenyl-3-(4-pyridyl)-5,6-dihydropyrazine (**10**).[S4] **9** (0.20 g, 1.0 mmol) was dissolved in 75 mL of benzene and 0.56 g (1.0 mmole) of ethylene diamine was added whereupon the solution became cloudy. The solution was refluxed under a Dean-Stark trap for 2 hours during which time

TLC (silica gel, 5% MeOH/CH_2Cl_2) was used to monitor the progress of the reaction. Over the course of 1 hr a product was observed to appear at $R_f \approx 0.3$; however, at this point a strong spot due to **9** remained at $R_f \approx 0.6$. The reaction was accelerated by addition of a 5-fold excess of ethylene diamine (2.8 g, 50 mmole). (Additional ethylene diamine was requred because during the course of the reaction this compound distills into the Dean-Stark trap.) After an additional 1 hr period, TLC indicated that **9** was completely consumed and therfore the reaction was stopped. Benzene and excess ethylene diamine were evaporated under reduced pressure and the final product was dried in vacuo. Product **10** was obtained as a white solid, yield 0.24 g (100%). *Spectral Data.* ^{1}H NMR (300 MHz, $CDCl_3$) δ 3.75 (s, 4H), 7.34 (m, 7H), 8.60 (d, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 45.5, 46.3, 123.9, 127.7, 128.3, 128.7, 129.2, 129.6, 130.1, 143.3, 149.8.

2-phenyl-3-(4-pyridyl)piperazine (**11**).[S4] In a typical procedure, **10** (140 mg, 0.6 mmol) was dissolved in 10 mL of MeOH in a 25 mL round bottom flask and the resulting solution was purged with dry N_2 gas. This solution was cooled to -30° C by using an isopropanol/dry ice bath and then sodium cyanoborohydride (0.73 g, 1.2 mmol) was added. A buffer solution of pyridinium tosylate was prepared by dissolving pyridine (0.08 g, 1.0 mmol) and *p*-toluenesulfonic acid (0.19 g, 1 mmol) in 2 mL of MeOH. The pyridinium sulfonate buffer solution was then added to the cold reaction mixture and the resulting solution immediately turned a scarlet color. Samples for TLC analysis were removed from the reaction mixture at regular intervals and prepared for analysis as follows. Several drops of the reaction mixture were placed in a small vial, the reaction mixture was made basic by by addition several drops of 12 N NaOH, and then the aqueous methanolic solution was extracted with several drops of CH_2Cl_2. The CH_2Cl_2 extract was then spotted onto a silica gel TLC plate which was then developed using 5% MeOH/CH_2Cl_2 as eluant. By using this procedure it was clear that after 1 hr the spot at $R_f = 0.4$ due to **10** had vanished leaving a cone-shaped, streaked spot with $R_f \leq 0.1$ which was attributed to product **11**. The reaction was then allowed to warm to room temperature and the MeOH was evaporated under reduced pressure. The crude red-colored product was dissolved in a mixture of 10 mL of CH_2Cl_2

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and 15 mL of 12 N NaOH. A thick emulsion developed which was cleared up by adding 5 mL of saturated aqueous NaCl. A fluffly, whitish precipitate in the organic layer was redissolved by addition of another 10 mL of CH_2Cl_2. The organic layer was separated and then extracted with at least two more 10 mL portions of 12 N NaOH. At this point the organic layer was colorless in appearance. The CH_2Cl_2 layer was dried over $MgSO_4$, the solvent was evaporated under reduced pressure and the residue was dried in vacuo for 20 hr. Note that column chromatography could not be used to purify **11**; in a trial run with silica gel and eluting with 10% MeOH/CH_2Cl_2, only 5% of the material placed on the column was recovered. Product **11** was obtained as a viscous brown liquid, yield 140 mg (98%). This procedure yields **11** as a 1:1 mixture of cis and trans diastereomers. *Spectral Data.* ^{1}H NMR (300 MHz, $CDCl_3$) δ 2.15 (s, 2H), 2.85 - 3.35 (m, 8H), 3.60 - 3.70 (dd, 2H, trans methines, 9 Hz), 4.2 - 4.3 (dd, 2H, cis methines, J = 4 Hz), 6.85 - 7.4 (m, 12 H), 8.2 - 8.63 (m, 4H).

1,4-dimethyl-2-phenyl-3-(4-pyridyl)piperazine (**12**).[S5] A solution was prepared by dissolving **11** (740 mg, 3.1 mmol) and paraformaldehyde (920 mg, 31 mmol) in 40 mL of dry THF (freshly distilled from Na/K-benzophenone). This solution was allowed to stir under nitrogen while 0.8 g (21 mmol) of sodium borohydride (Aldrich, 0.4 g tablets) was added as a powder. The suspension gradually became turbid and within 15 min turned black in color. At this point trifluoroacetic acid (20 mL) was added drop-wise by means of an addition funnel to the solution over a period of 30 minutes. During addition of the trifluoroacetic acid the dark solution cleared up and turned yellow. After 1 hr, TLC analysis (silica gel, 6% MeOH/CH_2Cl_2 eluant, samples prepared as described above under procedure for **11**) indicated that although a new spot due to **12** at $R_f \approx 0.45$ had appeared, the spot at $R_f \leq 0.1$ due to starting material **11** was still apparent. Therefore, an additional 0.4 g of $NaBH_4$ (10.6 mmol) was added to the solution. After an additional 1 hr period TLC analysis indicated that the starting material was completely consumed. The reaction mixture was worked up according to the procedure described under preparation of **11**. Dimethylpiperidine **12** was obtained as a viscous orange-brown oil, yield 800 mg (98%). The product comprises a mixture of the cis and trans diastereomers in approximately

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1:1 ratio. *Spectral Data.* ^{1}H NMR (300 MHz, $CDCl_3$) δ 2.01 - 2.07 (set of 4 singlets, 6H), 2.5 - 3.2 (m, 6H), 6.5 - 8.5 (m, 9H). GC-MS (EI) analysis indicates two major components; short retention time: [M^+] 267 (8% rel. abund.); long retention time: [M^+] 267 (4% rel. abund.).

Separation of cis-12 and trans-12. Semi-preparative reversed phase HPLC was used to separate the cis and trans isomers. All separations were performed on a Whatman ODS-3 Magnum 9 semi-preparative column using a Rainin Dynamax dual-head HPLC system. An isocratic mobile phase consisting of 60% MeOH/H_2O with 0.01 M triethylamine was used at a flow rate of 2.5 mL/min and detection wavelength of 254 nm. Under these conditions, *trans*-**12** has retention time of 11.4 minutes and *cis*-**12** has a retention time of 16.5 minutes. In a typical procedure, 100 mg of crude **12** was dissolved in 500 μL of MeOH and 50 μL aliquots (10 mg of **12**) were injected for each HPLC run. The individual fractions were collected as they eluted off of the column and stored in separate containers. After the separation the solvent was evaporated from each fraction under reduced pressure and the residues were dried in vacuo. Approximately 45 mg each of *cis*-**12** and *trans*-**12** were obtained from HPLC separation of 100 mg of crude **12**. Both isomers were obtained as white, microcrystalline solids. The stereochemistry of the isomers was established by comparing the observed m.p.'s and ^{1}H NMR spectra of *c*-**1** and *t*-**1** with those of the corresponding isomers of 1,4-dimethyl-2,3-diphenylpiperazine.[S6] *Data for cis-12.* m.p. 86° C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 2.15 (s, 3H), 2.20 (s, 3H), 2.81 (m, 2H), 3.20 (m, 2H), 3.90 (d, 2H), 7.20 - 7.32 (m, 7H), 8.35 (d, 2H). *Data for trans-12.* m.p. 263° C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 2.07 (s, 3H), 2.13 (s, 3H), 2.81 (m, 2H), 3.08 (dd, 2H), 3.20 (t, 2H), 6.4 - 7.8 (m, 7H), 8.33 (d, 2H).

(bpy)Re(CO)$_3$(TFMS). (bpy)Re(CO)$_3$Cl (0.13 g, 0.28 mmol) was suspended in 5 mL of freshly distilled methylene chloride (from CaH_2 pellets) and to this suspension was carefully and slowly added 0.25 mL (4.2 mmol) of trifluoromethanesulfonic acid (Aldrich). Immediately the suspension became a clear yellow solution which was allowed to stir at room temperature for 40 minutes. 50 mL of diethyl ether was then added to the solution which after about 1 minute developed a thick, pale yellow precipitate that was collected and washed with excess ether on a

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medium porosity sintered glass funnel. The product was obtained as a light yellow powder, yield 0.11 g (68%).

c-1. Compound *cis*-**12** (0.045 g, 0.17 mmol) was placed in a 50 mL round bottom flask and dissolved in 5 mL of freshly distilled, dry THF (Na/K, benzophenone). Freshly prepared (bpy)$Re(CO)_3OSO_2CF_3$ (0.055 g, 0.1 mmol) and 0.21 g (1.3 mmol) of NH_4PF_6 were then added to the solution. TLC (10% CH_3CN/CH_2Cl_2, alumina) was used to monitor the reaction while it was stirred at room temperature under nitrogen for a period of 14 hours. Product *c*-**1** was apparent by TLC as a bright yellow, luminescent cone-shaped spot at $R_f \approx 0.7$. After 14 hours, the reaction mixture was filtered to remove excess NH_4PF_6 and the THF was evaporated under reduced pressure. The crude product was then dissolved in ca. 0.5 mL of CH_2Cl_2 and then precipitated by dropping the solution into 25 mL of diethyl ether with stirring. The product was collected by filtration on a medium porosity sintered glass funnel. Further purification was effected by chromatography on alumina (10% CH_3CN/CH_2Cl_2 eluant). Following chromatography, the solvent was evaporated and the product was precipitated again from CH_2Cl_2/diethyl ether. The final product was obtained as a yellow microcrystalline solid, yield 30 mg (40%). *Spectral Data.* ^1H NMR (300 MHz, CD_3CN) δ 1.96 (s, 3H, buried in CD_3CN), 2.16 (s, 3H), 2.40 - 3.1 (m, 4H), 3.47 (d, 1H, J = 4.5 Hz), 3.61 (d, 1H, J = 4.5 Hz), 6.89 (d, 2H), 7.02 (t, 2H), 7.15 (d, 2H), 7.75 (m, 2H), 7.87 (d, 2H), 8.31 (m, 4H), 9.17 (t, 2H). ^{13}C NMR (75 MHz, CD_3CN) δ 40.3, 42.8, 50.4, 53.2, 69.7, 70.9, 123.2, 127.5, 128.3, 128.6, 130.2, 139.2, 140.0, 149.7, 152.4, 153.0. HRMS (FAB, positive ion) calc'd for $C_{30}H_{29}N_5O_3Re$, 694.183 (M^+); observed, 694.181.

t-1. This compound was prepared exactly as described above for *c*-**1**, except *trans*-**12** was used in place of *cis*-**12**. *Spectral Data.* ^1H NMR (300 MHz, CD_3CN) δ 2.1 (s, 3H, buried in CD_3CN), 2.16 (s, 3H), 2.40 (m, 2H), 2.94 (d, 2H), 2.61 (d, 1H, J = 8.7 Hz), 2.90 (d, 1H, J = 8.7 Hz), 7.07 (s, 2H), 7.2 - 7.6 (broad s, 2H), 7.42 (t, 2H), 7.84 (t, 1H), 7.92 (t, 1H), 8.12 (d, 2H), 8.50 (m, 4H), 9.22 (d, 1H), 9.35 (d, 1H); ^{13}C NMR (75 MHz, CD_3CN) δ 41.3, 42.2,

51.4, 54.3, 70.0, 71.8, 124.3, 125.9, 128.6, 128.9, 129.7, 140.9, 141.0, 151.6, 153.5, 153.6. HRMS (FAB, positive ion) calc'd for $C_{30}H_{29}N_5O_3Re$, 694.183 (M^+); observed, 694.175.

References for Supplementary Material

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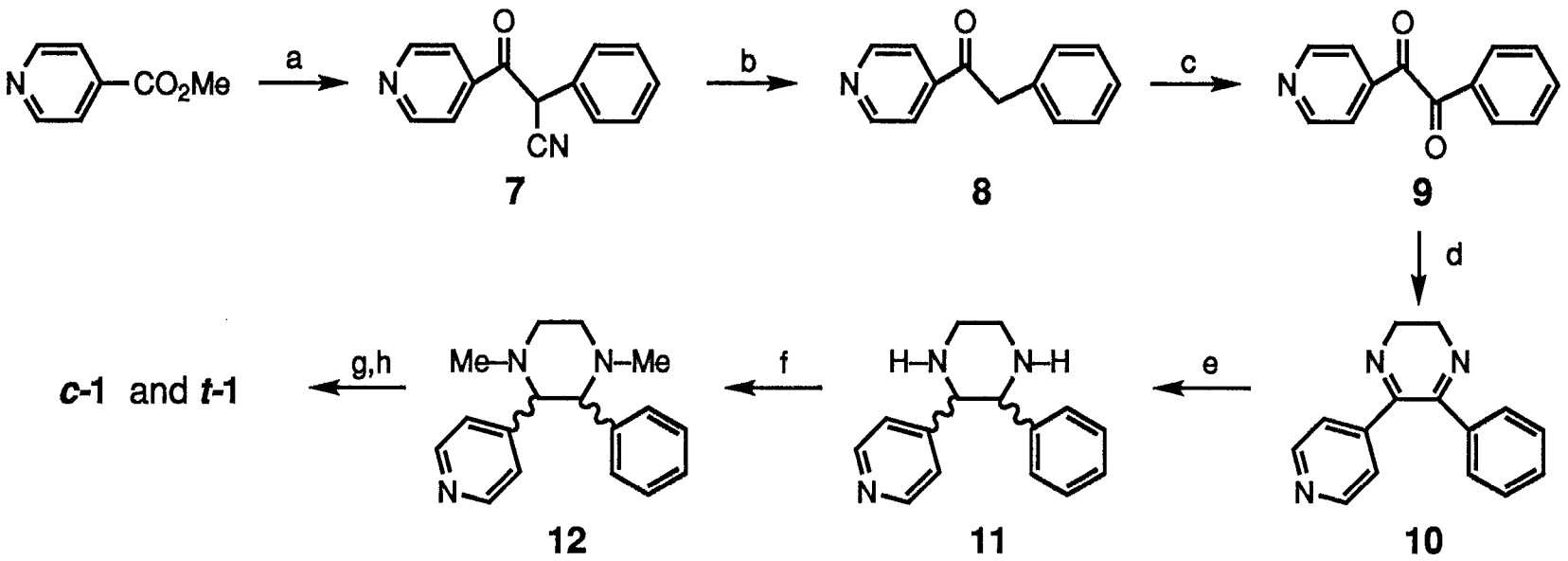
Scheme S-1



a) NaOEt/EtOH, phenylacetonitrile, reflux; b) 12 M HCl, reflux; c) glacial AcOH, SeO_2, 50° C; d) 1,2-ethanediamine, benzene, reflux; e) MeOH, $NaBH_3(CN)$, pyridinium tosylate, –30°C; f) CH_2O, THF, $NaBH_4$, TFA; g) semi-preparative reversed phase HPLC separation of isomers; h) $(bpy)Re(CO)_3(TFMS)$, NH_4PF_6, THF.