Supporting Information

Visible Light Catalyzed Reaction of α-Bromochalcones with Chalcones: Direct Access to the Urundeuvine Scaffold
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Table of Contents

1. Experimental Section.................................................................................................. 1-3
2. Spectroscopic Data.................................................................................................... 3-13
3. Crystallographic Data............................................................................................. 14-15
4. HPLC Chromatogram of the Product Mixture of Reaction between 1s & 2h........ 16
5. References................................................................................................................ 17
6. Copies of 1H and 13C NMR Spectra........................................................................ 18-74
1. Experimental Section

1.1 General experimental information

All reactions were monitored by TLC, visualization was effected with UV and/or by developing in iodine. Melting points were recorded on a Precision melting point apparatus and are uncorrected. NMR spectra were recorded on a Brucker Avance spectrometer at 400 or 500 MHz ($^1$H) and 100 MHz ($^{13}$C). Chemical shifts are reported in $\delta$ (ppm) relative to TMS as the internal standard. To describe spin multiplicity, standard abbreviations such as s, d, t, q, m, dd referring to singlet, doublet, triplet, quartet, multiplet and doublet of doublet respectively, are used. The ESI-HRMS spectra were recorded on Agilent 6520-Q-Tof LC/MS system. The NMR yields of products were calculated through $^1$H NMR of crude reaction mixture using dibromo methane as internal standard and isolated yields were calculated after purification by column chromatography. Preparative HPLC was conducted on a 1200 infinity series system (Pumps, 1260 Prep. Pumps; Diode Array Detector, 1260 DAD VL; Fraction collector, 1260 FC-PS; Sampler, 1260 manual injector and Open LAB CDS software) from Agilent Technologies. Reverse phase column (Agilent 10 Prep-C18, 150 x 30 mm) was used and acetonitrile (Pump A, flow rate 20 ml/min) and water with 0.1 % TFA (Pump B, flow rate 4 ml/min) were used as mobile phase with isocratic elution.

All the chemicals and catalysts were purchased from commercial sources and used as received except DMSO which was freshly distilled over CaH$_2$ before the reaction. The chalcones 1a-1s are known compounds and were synthesized following literature protocols.$^1$ Similarly, all the $\alpha$-bromochalcones except 2c and 2f are known compounds and were synthesized according to the reported procedure.$^2$

1.2 General procedure for the photoredox catalyzed reaction

In an oven dried 5 mL snap vial equipped with a magnetic stirring bar, the $\alpha$-bromochalcone 2 (0.3 mmol), chalcone 1 (0.6 mmol, 2.0 equiv), K$_3$PO$_4$ (0.13 g, 0.6 mmol, 2.0 equiv) and photocatalyst fac-Ir(ppy)$_3$ (0.002 g, 0.003 mmol, 1.0 mol%) were dissolved in anhydrous DMSO (3 mL). The resulting reaction mixture was degassed by three “pump-freeze-thaw” cycles via a syringe needle. The vial was irradiated using 450 nm blue LEDs with a cooling device maintaining the temperature around 25 °C. After 36 h of irradiation (TLC monitoring), the reaction mixture was diluted with water (10 mL) and extracted with ethyl acetate (3 x 10 mL). The combined organic layers were dried (Na$_2$SO$_4$) and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel using hexane/ethyl acetate as eluent to afford the pure product 3.
1.3 General procedure for the oxidation of dihydronaphthalenes

The dihydronaphthalene \(3\) (0.1 mmol) and ammonium acetate (0.31 g, 0.4 mmol, 4.0 equiv) were dissolved in acetic acid (5 mL) and the reaction mixture was refluxed for 9-12 h (TLC monitoring). The reaction mixture was diluted with water (10 mL) and extracted with ethyl acetate (3 x 10 mL). The combined organic layers were dried (\(\text{Na}_2\text{SO}_4\)) and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel using hexane/ethyl acetate as eluent to afford the pure product 4.

2. Spectroscopic Data

\((Z)-2\text{-bromo-1-(5-bromo-2,4-dimethoxyphenyl)-3-(2-bromo-4,5-dimethoxyphenyl) prop-2-en-1-one (2c).}\)

Yellow solid; \(R_f\) 0.50 (25% EtOAc/hexane); Mp 163-164 °C; \(^1\text{H NMR}\) (400 MHz, CDCl\(_3\)) \(\delta\) 7.79 (s, 1H), 7.68 (s, 1H), 7.58 (s, 1H), 7.00 (s, 1H), 6.44 (s, 1H), 3.91 (s, 3H), 3.84 (s, 3H), 3.85 (s, 3H), 3.79 (s, 3H); \(^{13}\text{C NMR}\) (100 MHz, CDCl\(_3\)) \(\delta\) 188.78, 159.21, 158.57, 150.94, 147.81, 141.81, 134.32, 126.06, 125.16, 120.56, 117.11, 115.31, 112.99, 102.23, 96.34, 56.47, 56.25, 56.23, 56.15; \(\text{HRMS}\) for C\(_{19}\)H\(_{17}\)Br\(_3\)O\(_5\): calcd. (M+H): 562.8699, found: 562.8697

\((Z)-2\text{-bromo-3-phenyl-1-(thiophen-2-yl)prop-2-en-1-one (2f).}\)

Yellow oil; \(R_f\) 0.50 (5% EtOAc/hexane); \(^1\text{H NMR}\) (400 MHz, CDCl\(_3\)) \(\delta\) 7.87-7.80 (m, 3H), 7.74 (dd, \(J = 3.8\) Hz, 1.1 Hz, 1H), 7.68 (dd, \(J = 5.0\) Hz, 1.2 Hz, 1H), 7.36-7.40 (m, 3H), 7.10 (dd, \(J = 5.0\) Hz, 3.8 Hz, 1H); \(^{13}\text{C NMR}\) (100 MHz, CDCl\(_3\)) \(\delta\) 183.03, 141.35, 140.02, 135.12, 134.81, 133.68, 130.25, 130.13, 128.57, 128.15, 120.78; \(\text{HRMS}\) for C\(_{13}\)H\(_{9}\)BrOS: calcd. (M+H): 292.9630, found: 292.9633

\((1-(4\text{-methoxyphenyl})-1,2\text{-dihydronaphthalene-2,3-diyl)bis(phenylmethanone) (3a).}\)

White solid; isolated yield 75% (69 mg). \(R_f\) 0.50 (10% EtOAc/hexane); Mp 123-125 °C; \(^1\text{H NMR}\) (400 MHz, CDCl\(_3\)) \(\delta\) 7.90-7.92 (m, 2H), 7.64-7.66 (m, 2H), 7.46-7.49 (m, 2H), 7.39 (d, \(J = 7.9\) Hz, 3H), 7.36 (d, \(J = 3.2\) Hz, 2H), 7.14-7.23 (m, 3H), 7.00-7.04 (m, 2H), 6.90-6.94 (m, 1H), 6.69-6.73 (m, 2H), 5.16 (d, \(J = 4.0\) Hz, 1H), 4.43 (d, \(J = 4.0\) Hz, 1H), 3.67 (s, 3H); \(^{13}\text{C NMR}\) (100 MHz, CDCl\(_3\)) \(\delta\) 198.91, 196.36, 158.60, 142.07, 137.84, 137.31, 136.18, 135.04, 134.67, 132.92, 131.94, 131.61, 130.83, 129.49, 129.43, 129.07, 128.78, 128.74, 128.64, 128.28, 127.59, 114.19, 55.26, 49.68, 46.27; \(\text{HRMS}\) for C\(_{31}\)H\(_{24}\)O\(_3\): calcd. (M+H): 445.1798, found: 445.1804

\((1\text{-phenyl-1,2-dihydronaphthalene-2,3-diyl)bis(phenylmethanone) (3b).}\)

Yellow solid; isolated yield 72% (89 mg). \(R_f\) 0.50 (10% EtOAc/hexane); Mp 97-98 °C; \(^1\text{H NMR}\) (400 MHz, CDCl\(_3\)) \(\delta\) 7.99 (d, \(J = 7.6\) Hz, 2H), 7.72 (d, \(J = 7.0\) Hz, 2H), 7.53-7.57 (m, 2H), 7.44-
7.47 (m, 5H), 7.24-7.31 (m, 5H), 7.17-7.20 (m, 3H), 6.99-7.01 (m, 1H), 5.25 (d, $J = 3.9$ Hz, 1H), 4.54 (d, $J = 3.8$ Hz, 1H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 198.76, 196.31, 142.88, 142.12, 137.82, 136.88, 136.12, 134.61, 132.95, 131.95, 131.73, 130.85, 129.51, 129.42, 129.16, 128.82, 128.80, 128.28, 127.74, 127.70, 127.11, 49.51, 47.02; HRMS for C$_{30}$H$_{22}$O$_2$: calcd. (M+H)$^+$: 415.1693, found: 415.1688

(3-Benzoyl-1-(p-tolyl)-1,2-dihydronaphthalen-2-yl)(4-methoxyphenyl)methanone (3c). White solid; isolated yield 51% (70 mg). $R_f$ 0.50 (10% EtOAc/hexane); Mp 112-113 °C; $^1$H NMR (400 MHz, CDCl$_3$) δ 7.92-7.95 (m, 2H), 7.64-7.66 (m, 2H), 7.45-7.49 (m, 1H), 7.35-7.39 (m, 3H), 7.14-7.22 (m, 3H), 7.00 (br s, 4H), 6.92-6.94 (m, 1H), 6.86-6.88 (m, 2H), 5.12 (d, $J = 3.3$ Hz, 1H), 4.41 (d, $J = 3.3$ Hz, 1H), 3.80 (s, 3H), 2.21 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 196.96, 196.40, 163.52, 142.12, 140.36, 137.97, 137.25, 136.66, 134.56, 131.86, 131.66, 131.19, 130.77, 129.50, 129.45, 129.16, 128.68, 128.25, 127.53, 127.47, 113.89, 55.49, 48.99, 46.78, 20.99; HRMS for C$_{32}$H$_{26}$O$_3$: calcd. (M+H)$^+$: 459.1955, found: 459.1960

(3-Benzoyl-1-(4-methoxyphenyl)-1,2-dihydronaphthalen-2-yl)(p-tolyl)methanone (3d). Yellow gummy solid; isolated yield 55% (75 mg). $R_f$ 0.50 (15% EtOAc/hexane); $^1$H NMR (400 MHz, CDCl$_3$) δ 7.84 (d, $J = 8.6$ Hz, 2H), 7.63-7.67 (m, 2H), 7.46-7.50 (m, 1H), 7.35-7.40 (m, 3H), 7.14-7.23 (m, 5H), 7.01-7.05 (m, 2H), 6.91-6.93 (m, 1H), 6.71-6.74 (m, 2H), 5.14 (d, $J = 3.6$ Hz, 1H), 4.42 (d, $J = 3.3$ Hz, 1H), 3.69 (s, 3H), 2.35 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 198.26, 196.40, 158.56, 143.76, 142.04, 137.93, 137.33, 135.32, 134.61, 133.42, 131.88, 131.63, 130.77, 129.44, 129.38, 129.10, 128.97, 128.66, 128.25, 127.55, 114.18, 55.26, 49.41, 46.28, 21.65; HRMS for C$_{32}$H$_{26}$O$_3$: calcd. (M+H)$^+$: 459.1955, found: 459.1958

(3-Benzoyl-1-(4-methoxyphenyl)-1,2-dihydronaphthalen-2-yl)(2-methoxyphenyl)methanone (3e). Yellow gummy solid; isolated yield 45% (64 mg). $R_f$ 0.50 (20% EtOAc/hexane); $^1$H NMR (400 MHz, CDCl$_3$) δ 7.56-7.58 (m, 2H), 7.58 (d, $J = 7.6$ Hz, 1H), 5.27 (d, $J = 2.3$ Hz, 1H), 4.53 (d, $J = 1.9$ Hz, 1H), 3.74 (s, 3H), 3.67 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 200.60, 196.21, 158.24, 157.70, 140.85, 138.11, 137.68, 135.52, 134.66, 132.98, 131.88, 131.68, 130.50, 130.41, 129.41, 129.29, 129.21, 128.45, 128.13, 127.91, 127.47, 120.79, 113.79, 111.46, 55.60, 55.21, 52.99, 44.87; HRMS for C$_{32}$H$_{26}$O$_4$: calcd. (M+H)$^+$: 475.1904, found: 475.1902

(3-Benzoyl-1-(4-methoxyphenyl)-1,2-dihydronaphthalen-2-yl)(3-methoxyphenyl)methanone (3f). Yellow gummy solid; isolated yield 50% (71 mg). $R_f$ 0.50 (20% EtOAc/hexane); $^1$H NMR (400 MHz, CDCl$_3$) δ 7.65-7.67 (m, 2H), 7.58 (d, $J = 7.6$ Hz, 1H),
7.46-7.50 (m, 1H), 7.37-7.40 (m, 4H), 7.31 (t, $J = 8.0$ Hz, 1H), 7.16-7.24 (m, 3H), 7.02-7.05 (m, 3H), 6.93-6.95 (m, 1H), 6.73 (d, $J = 8.6$ Hz, 2H), 5.13 (d, $J = 3.7$ Hz, 1H), 4.45 (d, $J = 3.5$ Hz, 1H), 3.74 (s, 3H), 3.68 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 198.58, 196.30, 159.91, 158.63, 142.00, 137.87, 137.52, 137.33, 135.11, 134.59, 131.94, 131.62, 130.84, 129.60, 129.48, 129.42, 128.72, 128.28, 127.60, 121.36, 119.82, 114.22, 112.85, 55.40, 55.26, 49.84, 46.26; HRMS for C$_{32}$H$_{26}$O$_4$: calcd. (M+H)$^+$: 475.1904, found: 475.1898

(3-Benzoyl-1-(4-methoxyphenyl)-1,2-dihydronaphthalen-2-yl)(4-methoxyphenyl) methanone (3g). Yellow gummy solid; isolated yield 62% (88 mg). $R_f$ 0.50 (15% EtOAc/hexane); $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.93 (d, $J = 8.8$ Hz, 2H), 7.66 (d, $J = 7.1$ Hz, 2H), 7.46-7.49 (m, 1H), 7.34-7.40 (m, 3H), 7.15-7.22 (m, 3H), 7.03 (d, $J = 8.6$ Hz, 2H), 6.91-6.93 (m, 1H), 6.87 (d, $J = 8.8$ Hz, 2H), 6.72 (d, $J = 8.6$ Hz, 2H), 5.12 (d, $J = 3.8$ Hz, 1H), 4.42 (d, $J = 3.7$ Hz, 1H), 3.80 (s, 3H), 3.68 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 197.25, 196.45, 163.50, 158.56, 142.00, 137.94, 137.46, 135.39, 134.73, 131.89, 131.61, 131.15, 130.76, 129.46, 129.07, 128.82, 128.69, 128.26, 127.51, 114.19, 113.88, 55.49, 55.26, 49.19, 46.50; HRMS for C$_{32}$H$_{26}$O$_4$: calcd. (M+H)$^+$: 475.1904, found: 475.1894

(3-Benzoyl-1-(4-(methylthio)phenyl)-1,2-dihydronaphthalen-2-yl)(4-methoxyphenyl) methanone (3h). Yellow solid; isolated yield 60% (88 mg). $R_f$ 0.50 (15% EtOAc/hexane); $R_f$ 0.50 (10% EtOAc/hexane); $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.92 (d, $J = 8.9$ Hz, 2H), 7.66 (d, $J = 7.1$ Hz, 2H), 7.46-7.49 (m, 1H), 7.34-7.40 (m, 3H), 7.15-7.22 (m, 3H), 7.06 (dd, $J = 21.1$ Hz, 8.4 Hz, 4H), 6.91-6.93 (m, 1H), 6.82-6.88 (m, 2H), 5.12 (d, $J = 3.6$ Hz, 1H), 4.42 (d, $J = 3.6$ Hz, 1H), 3.79 (s, 3H), 2.36 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 197.00, 196.36, 163.56, 141.93, 140.18, 137.88, 137.13, 136.92, 134.60, 131.93, 131.63, 131.14, 130.81, 129.51, 129.45, 129.08, 128.72, 128.28, 128.16, 127.67, 127.18, 113.92, 55.49, 48.91, 46.72, 15.96; HRMS for C$_{32}$H$_{26}$O$_3$: calcd. (M+H)$^+$: 491.1675, found: 491.1674

(3-Benzoyl-1-(4-fluorophenyl)-1,2-dihydronaphthalen-2-yl)(4-ethoxyphenyl)methanone (3i). White solid; isolated yield 57% (79 mg). $R_f$ 0.50 (10% EtOAc/hexane); Mp 99-101 °C; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.89 (d, $J = 8.8$ Hz, 2H), 7.65 (d, $J = 7.2$ Hz, 2H), 7.45-7.49 (m, 1H), 7.33-7.39 (m, 3H), 7.16-7.22 (m, 3H), 7.05-7.08 (m, 2H), 6.84-6.90 (m, 5H), 5.10 (d, $J = 4.2$ Hz, 1H), 4.45 (d, $J = 4.1$ Hz, 1H), 3.78 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 197.24, 196.36, 163.58, 161.81 (d, $J = 244.5$ Hz), 141.73, 138.82 (d, $J = 3.5$ Hz), 137.81, 136.98, 134.77, 132.00, 131.61, 131.06, 130.84, 129.53, 129.44, 129.32 (d, $J = 7.9$ Hz), 128.96, 128.87, 128.29, 127.74, 115.64 (d, $J = 21.3$ Hz), 113.92, 55.48, 49.16, 46.60; HRMS for C$_{31}$H$_{23}$FO$_3$: calcd. (M+H)$^+$: 463.1704, found: 463.1705
(3-Benzoyl-1-(4-fluorophenyl)-1,2-dihydronaphthalen-2-yl)(4-fluorophenyl)methanone (3j). White solid; isolated yield 45% (60 mg). \( R_f \) 0.50 (15% EtOAc/hexane); Mp 136-138 °C; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \( \delta \) 7.89 (dd, \( J = 8.6 \) Hz, 5.4 Hz, 2H), 7.65 (d, \( J = 7.2 \) Hz, 2H), 7.49 (t, \( J = 7.5 \) Hz, 1H), 7.39 (t, \( J = 7.6 \) Hz, 2H), 7.34 (s, 1H), 7.19-7.22 (m, 3H), 7.01-7.08 (m, 4H), 6.85-6.91 (m, 3H), 5.10 (d, \( J = 5.2 \) Hz, 1H), 4.46 (d, \( J = 5.2 \) Hz, 1H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \( \delta \) 197.98, 196.31, 165.70 (d, \( J = 253.4 \) Hz), 161.87 (d, \( J = 244.5 \) Hz), 141.92, 138.16, 137.55, 136.91, 134.86, 132.78, 132.7, 131.48, 131.27 (d, \( J = 9.3 \) Hz), 131.01, 129.60, 129.54, 129.46, 129.40, 128.81, 128.37, 127.83, 115.72 (d, \( J = 21.1 \) Hz), 49.78, 46.73; HRMS for C\(_{30}\)H\(_{20}\)F\(_2\)O\(_2\): calcd. (M+H\(^+\)) 451.1504, found: 451.1503

(1-(4-Chlorophenyl)-1,2-dihydronaphthalene-2,3-diyl)bisis(phenylmethanone) (3k). White solid; isolated yield 65% (87 mg). \( R_f \) 0.50 (10% EtOAc/hexane); Mp 119-120 °C; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \( \delta \) 7.86-7.88 (m, 2H), 7.60-7.62 (m, 2H), 7.45-7.49 (m, 2H), 7.35-7.39 (m, 4H), 7.33 (s, 1H), 7.12-7.20 (m, 5H), 7.01 (d, \( J = 8.9 \) Hz, 2H), 6.88-6.90 (m, 1H), 5.12 (d, \( J = 4.0 \) Hz, 1H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \( \delta \) 198.58, 196.21, 141.87, 141.29, 137.67, 136.43, 136.09, 134.42, 133.07, 132.95, 132.06, 131.60, 130.97, 129.63, 129.40, 129.11, 129.02, 128.96, 128.71, 128.32, 127.91, 49.33, 46.34; HRMS for C\(_{30}\)H\(_{21}\)ClO\(_2\): calcd. (M+H\(^+\)) 449.1303, found: 449.1313

(3-Benzoyl-1-(3-nitrophenyl)-1,2-dihydronaphthalen-2-yl)(4-methoxyphenyl)methanone (3l). Yellow gummy solid; isolated yield 52% (76 mg). \( R_f \) 0.50 (20% EtOAc/hexane); \(^1\)H NMR (400 MHz, CDCl\(_3\)) \( \delta \) 7.99-8.00 (m, 2H), 7.89 (d, \( J = 8.7 \) Hz, 2H), 7.65 (d, \( J = 7.3 \) Hz, 2H), 7.45-7.49 (m, 2H), 7.37-7.41 (m, 4H), 7.19-7.28 (m, 4H), 6.92 (br d, \( J = 6.8 \) Hz, 1H), 6.86 (br d, \( J = 8.7 \) Hz, 2H), 5.13 (d, \( J = 3.7 \) Hz, 1H), 4.59 (d, \( J = 3.5 \) Hz, 1H), 3.79 (s, 3H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \( \delta \) 196.45, 196.18, 163.75, 148.55, 144.99, 141.74, 137.56, 135.68, 134.26, 133.93, 132.18, 131.19, 131.15, 131.04, 129.89, 129.80, 129.40, 128.88, 128.55, 128.38, 128.29, 129.72, 122.24, 114.05, 55.53, 48.65, 46.82; HRMS for C\(_{31}\)H\(_{23}\)NO\(_5\): calcd. (M+H\(^+\)) 490.1649, found: 490.1646

(3-Benzoyl-1-phenyl-1,2-dihydronaphthalen-2-yl)(pyridin-2-yl)methanone (3m). White solid; isolated yield 60% (74 mg). \( R_f \) 0.50 (20% EtOAc/hexane); \(^1\)H NMR (400 MHz, CDCl\(_3\)) \( \delta \) 8.69-8.71 (m, 1H), 7.90-7.92 (m, 1H), 7.71-7.75 (m, 1H), 7.58-7.61 (m, 2H), 7.43-7.48 (m, 1H), 7.38-7.41 (m, 1H), 7.33-7.37 (m, 3H), 7.16-7.25 (m, 7H), 7.08-7.12 (m, 1H), 6.90-6.92 (m, 1H), 5.78 (d, \( J = 4.0 \) Hz, 1H), 4.74 (d, \( J = 4.0 \) Hz, 1H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \( \delta \) 198.58, 196.08, 152.32, 148.79, 142.80, 141.86, 137.82, 136.93, 135.29, 132.51, 131.80, 130.61, 129.43, 129.29, 129.22, 128.39, 128.26, 128.20, 127.66, 127.02,
126.73, 122.92, 48.92, 46.35; HRMS for C$_{29}$H$_{21}$NO$_2$: calcd. (M+H)$^+$: 416.1645, found: 416.1641

(3-Benzoyl-1-phenyl-1,2-dihyronaphthalen-2-yl)(thiophen-2-yl)methanone (3n). Yellow solid; isolated yield 47% (60 mg). $R_f$ 0.50 (15% EtOAc/hexane); Mp 97-98 °C; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.77 (dd, $J$ = 3.8 Hz, 1.0 Hz, 1H), 7.64-7.66 (m, 2H), 7.57 (dd, $J$ = 5.0 Hz, 1.1 Hz, 1H), 7.46-7.50 (m, 1H), 7.36-7.40 (m, 3H), 7.18-7.24 (m, 5H), 7.13-7.15 (m, 3H), 7.06 (dd, $J$ = 5.0 Hz, 3.8 Hz, 1H), 6.96-6.98 (m, 1H), 4.97 (d, $J$ = 4.1 Hz, 1H), 4.56 (d, $J$ = 4.2 Hz, 1H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 196.22, 191.25, 142.96, 142.91, 142.27, 137.75, 136.94, 134.09, 133.91, 132.67, 132.01, 131.68, 130.96, 129.54, 129.44, 129.17, 128.85, 128.31, 128.26, 127.85, 127.70, 127.16, 51.44, 47.65; HRMS for C$_{28}$H$_{20}$O$_2$: calcd. (M+H)$^+$: 421.1257, found: 421.1260

1-(3-Benzoyl-1-phenyl-1,2-dihyronaphthalen-2-yl)butan-1-one (3o). Yellow gummy solid; isolated yield 52% (59 mg). $R_f$ 0.50 (10% EtOAc/hexane); $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.62 (d, $J$ = 7.1 Hz, 2H), 7.47-7.50 (m, 1H), 7.37-7.40 (m, 2H), 7.15-7.23 (m, 7H), 7.07 (d, $J$ = 7.1 Hz, 2H), 7.00 (d, $J$ = 7.0 Hz, 1H), 4.57 (d, $J$ = 5.5 Hz, 1H), 4.23 (d, $J$ = 5.5 Hz, 1H), 2.47-2.55 (m, 1H), 2.14-2.25 (m, 1H), 1.38-1.45 (m, 2H), 0.71 (t, $J$ = 7.4 Hz, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 209.68, 196.71, 142.26, 141.40, 137.84, 137.67, 135.01, 132.02, 131.62, 130.95, 129.31, 129.26, 128.93, 128.74, 128.36, 128.10, 127.59, 127.04, 54.92, 46.45, 44.12, 16.78, 13.58; HRMS for C$_{27}$H$_{24}$O$_2$: calcd. (M+H)$^+$: 381.1849, found: 381.1853

(3-Benzoyl-1-phenyl-1,2-dihyronaphthalen-2-yl)(cyclopropyl)methanone (3p). White solid; isolated yield 45% (51 mg). $R_f$ 0.50 (10% EtOAc/hexane); Mp 147-148 °C; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.63-7.65 (m, 2H), 7.47-7.51 (m, 1H), 7.37-7.41 (m, 2H), 7.13-7.24 (m, 7H), 7.05-7.09 (m, 3H), 4.67 (d, $J$ = 4.4 Hz, 1H), 4.52 (d, $J$ = 4.5 Hz, 1H), 1.92-1.99 (m, 1H), 0.83-0.92 (s, 1H), 0.63-0.82 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 208.64, 196.67, 142.52, 141.36, 137.98, 137.83, 134.25, 131.99, 131.47, 130.98, 129.37, 129.30, 129.05, 128.66, 128.34, 127.97, 127.53, 126.93, 55.20, 45.94, 20.09, 11.40, 11.28; HRMS for C$_{27}$H$_{22}$O$_2$: calcd. (M+H)$^+$: 379.1693, found: 379.1686

Ethyl 3-benzoyl-1-phenyl-1,2-dihyronaphthalene-2-carboxylate (3q). White gummy solid; isolated yield 52% (59 mg). $R_f$ 0.50 (15% EtOAc/hexane); $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.65 (d, $J$ = 7.0 Hz, 2H), 7.46-7.50 (m, 1H), 7.36-7.40 (m, 2H), 7.16-7.23 (m, 6H), 7.13 (d, $J$ = 7.1 Hz, 1H), 7.09 (d, $J$ = 7.0 Hz, 1H), 7.04 (d, $J$ = 7.1 Hz, 2H), 4.75 (d, $J$ = 4.0 Hz, 1H), 4.29 (d, $J$ = 4.1 Hz, 1H), 3.98 (q, $J$ = 7.1 Hz, 2H), 1.00 (t, $J$ = 7.1 Hz, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 192.52, 168.54, 138.41, 136.01, 134.26, 133.56, 129.95, 128.22,
127.85, 127.08, 125.69, 124.87, 124.09, 123.96, 123.23, 57.47, 43.39, 42.83, 10.28; HRMS for C_{18}H_{20}O_3: calcd. (M+H)^+ : 383.1642, found: 383.1638

(3-Benzoyl-6-methyl-4-phenyl-3,4-dihydronaphthalen-2-yl)(p-tolyl)methanone (3r). Yellow oil; isolated yield 56% (74 mg). R_f 0.50 (10% EtOAc/hexane); ^1H NMR (400 MHz, CDCl_3) δ 7.95 (d, J = 7.3 Hz, 2H), 7.55 (d, J = 8.0 Hz, 2H), 7.47-7.51 (m, 1H), 7.41 (d, J = 7.8 Hz, 2H), 7.37-7.38 (poorly resolved m, 1H), 7.17-7.22 (m, 5H), 7.11-7.15 (m, 4H), 6.99-7.01 (poorly resolved m, 1H), 6.76 (br s, 1H), 5.14 (d, J = 3.6 Hz, 1H), 4.42 (d, J = 3.5 Hz, 1H), 2.36 (s, 3H), 2.19 (s, 3H); ^13C NMR (100 MHz, CDCl_3) δ 198.70, 196.01, 143.16, 142.46, 141.92, 141.23, 136.77,136.13, 135.20, 133.57, 132.88, 130.00, 129.56, 129.44, 129.23, 128.92, 128.83, 128.79, 128.62, 128.44, 127.70, 127.02, 49.57, 46.98, 21.61; HRMS for C_{32}H_{26}O_3: calcd. (M+H)^+ : 443.2006, found: 443.2010

(1-(4-Methoxyphenyl)-7-methyl-1,2-dihydronaphthalene-2,3-diyl)bis(p-tolylmethanone) (3s). Yellow solid; isolated yield 66% (92 mg). R_f 0.50 (15% EtOAc/hexane); Mp 120-121 °C; ^1H NMR (400 MHz, CDCl_3) δ 7.85 (d, J = 8.2 Hz, 2H), 7.55 (d, J = 8.0 Hz, 2H), 7.16-7.20 (m, 4H), 7.10 (br d, J = 7.7 Hz, 1H), 7.01-7.03 (m, 2H), 6.96 (br d, J = 7.7 Hz, 1H), 6.71-6.73 (m, 3H), 5.08 (d, J = 3.3 Hz, 1H), 4.35 (d, J = 3.2 Hz, 1H), 3.68 (s, 3H), 2.35 (s, 3H), 2.34 (s, 3H), 2.17 (s, 3H); ^13C NMR (100 MHz, CDCl_3) δ 198.21, 196.07, 158.51, 143.65, 142.38, 141.83, 141.23, 136.77, 136.13, 135.20, 133.57, 132.88, 130.00, 129.56, 129.44, 129.23, 128.92, 128.83, 128.79, 128.62, 128.44, 127.70, 127.02, 49.57, 46.98, 21.64, 21.60; HRMS for C_{34}H_{30}O_3: calcd. (M+H)^+ : 487.2268, found: 487.2267

(3-(2-Methoxybenzoyl)-4-(4-methoxyphenyl)-6-methyl-3,4-dihydronaphthalen-2-yl)(p-tolyl)methanone (3t). Brown solid; isolated yield 60% (90 mg). R_f 0.50 (20% EtOAc/hexane); Mp 145-146 °C; ^1H NMR (400 MHz, CDCl_3) δ 7.45 (d, J = 7.2 Hz, 2H), 7.38-7.40 (m, 1H), 7.30-7.35 (m, 1H), 7.19 (s merged with CDCl_3 peak, 1H), 7.13 (d, J = 7.6 Hz, 2H), 7.07 (d, J = 7.6 Hz, 1H), 6.96 (d, J = 8.3 Hz, 3H), 6.83-6.89 (m, 3H), 6.68 (d, J = 7.6 Hz, 2H), 5.21 (br s, 1H), 4.49 (br s, 1H), 3.72 (s, 3H), 3.67 (s, 3H), 2.33 (s, 3H), 2.20 (s, 3H); ^13C NMR (100 MHz, CDCl_3) δ 200.67, 195.90, 158.21, 157.68, 142.16, 140.81, 140.64, 137.72, 135.81, 135.46, 133.67, 132.86, 130.40, 130.01, 129.55, 129.32, 129.20, 128.77, 128.48, 128.19, 128.05, 120.73, 113.78, 111.44, 55.57, 55.21, 53.08, 44.86, 21.62, 21.58; HRMS for C_{34}H_{30}O_4: calcd. (M+H)^+ : 503.2217, found: 503.2213

(3-(3-Methoxybenzoyl)-4-(4-methoxyphenyl)-6-methyl-3,4-dihydronaphthalen-2-yl)(p-tolyl)methanone (3u). Yellow solid; isolated yield 53% (80 mg). R_f 0.50 (20% EtOAc/hexane); Mp 98-101 °C; ^1H NMR (400 MHz, CDCl_3) δ 7.57 (d, J = 7.8 Hz, 1H), 7.54 (d, J = 8.1 Hz, 2H), 7.40 (t, J = 2.2 Hz, 1H), 7.34 (s, 1H), 7.30 (t, J = 8.0 Hz, 1H), 7.17 (d, J =
8.0 Hz, 2H), 7.11 (d, J = 7.7 Hz, 1H), 7.02 (d, J = 8.8 Hz, 2H), 6.98 (d, J = 7.3 Hz, 1H), 6.71-6.76 (m, 3H), 5.06 (d, J = 3.4 Hz, 1H), 4.38 (d, J = 3.4 Hz, 1H), 3.74 (s, 3H), 3.68 (s, 3H), 2.35 (s, 3H), 2.18 (s, 3H); 13C NMR (100 MHz, CDCl₃) δ 198.51, 196.02, 159.87, 158.55, 142.47, 141.82, 141.22, 137.49, 137.20, 135.38, 135.23, 133.54, 129.95, 129.57, 129.41, 129.10, 128.93, 128.68, 128.35, 121.41, 119.83, 114.17, 112.80, 55.40, 55.25, 49.88, 46.21, 21.63, 21.61; HRMS for C₃₄H₃₀O₄: calcd. (M+H)⁺: 503.2217, found: 503.2218

(3-(4-Methoxybenzoyl)-6-methyl-4-(4-(methylthio)phenyl)-3,4-dihyronaphthalen-2-yl)(p-tolyl)methanone (3v). Yellow solid; isolated yield 82% (127 mg). Rₗ 0.50 (15% EtOAc/hexane); Mp 98-100 °C; 1H NMR (400 MHz, CDCl₃) δ 7.93 (d, J = 8.8 Hz, 2H), 7.55 (d, J = 8.0 Hz, 2H), 7.33 (s, 1H), 7.17 (d, J = 8.0 Hz, 2H), 7.02-7.12 (m, 5H), 6.98 (d, J = 7.8 Hz, 1H), 6.87 (d, J = 8.8 Hz, 2H), 6.74 (s, 1H), 5.07 (d, J = 3.2 Hz, 1H), 4.35 (d, J = 3.0 Hz, 1H), 3.80 (s, 3H), 2.35, 2.37 (2s merged, 6H), 2.17 (s, 3H); 13C NMR (100 MHz, CDCl₃) δ 197.00, 196.06, 163.51, 142.45, 141.73, 141.18, 140.46, 137.00, 136.84, 135.28, 133.60, 131.17, 129.93, 129.59, 129.45. 129.13, 128.93, 128.77, 128.41, 128.15, 127.18, 113.89, 55.48, 48.98, 46.72, 21.61, 15.98; HRMS for C₃₄H₃₀O₃S: calcd. (M+H)⁺: 519.1988, found: 519.1992

(3-Benzoyl-4-(4-fluorophenyl)-6-methyl-3,4-dihydronaphthalen-2-yl)(p-tolyl)methanone (3w). White solid; isolated yield 45% (62 mg). Rₗ 0.50 (10% EtOAc/hexane); Mp 92-94 °C; 1H NMR (500 MHz, CDCl₃) δ 7.90 (d, J = 7.4 Hz, 2H), 7.54 (d, J = 8.0 Hz, 2H), 7.47 (t, J = 7.6 Hz, 1H), 7.37 (t, J = 7.8 Hz, 2H), 7.33 (s, 1H), 7.17 (d, J = 8.0 Hz, 2H), 7.12 (d, J = 7.7 Hz, 1H), 7.04-7.07 (m, 2H), 7.00 (d, J = 7.5 Hz, 1H), 6.86 (t, J = 8.6 Hz, 2H), 6.72 (s, 1H), 5.10 (d, J = 4.0 Hz, 1H), 4.41 (d, J = 4.0 Hz, 1H), 2.35 (s, 3H), 2.17 (s, 3H); 13C NMR (100 MHz, CDCl₃) δ 198.88, 195.99, 164.19, 160.15, 158.45, 158.30, 158.23, 154.85, 145.87, 140.26, 135.16, 135.03, 134.55, 134.29, 132.96, 128.54, 125.00, 122.31, 120.23, 119.90, 114.99, 113.61, 105.29, 21.61; HRMS for C₃₂H₂₅FO₂: calcd. (M+H)⁺: 461.1911, found: 461.1907

(5-Bromo-2,4-dimethoxyphenyl)(8-bromo-3-(2,4-dimethoxybenzoyl)-5,6-dimethoxy-4-(4-methoxyphenyl)-3,4-dihyronaphthalen-2-yl)methanone (3x). Yellow solid; isolated yield 40% (93 mg). Rₗ 0.50 (50% EtOAc/hexane); Mp 120-121 °C; 1H NMR (400 MHz, CDCl₃) δ 7.62-7.64 (m, 1H), 7.57 (s, 1H), 7.51 (s, 1H), 7.14 (d, J = 8.6 Hz, 2H), 7.00 (s, 1H), 6.77 (d, J = 8.7 Hz, 2H), 6.50-6.53 (m, 3H), 5.40 (s, 1H), 4.91 (s, 1H), 3.98 (s, 3H), 3.88 (s, 3H), 3.87 (s, 3H), 3.85 (s, 3H), 3.77 (s, 6H), 3.43 (s, 3H); 13C NMR (100 MHz, CDCl₃) δ 197.66, 193.33, 164.19, 160.15, 158.45, 158.30, 158.23, 154.85, 145.87, 140.26, 135.16, 135.03, 134.55, 134.29, 132.96, 128.54, 125.00, 122.31, 120.23, 119.90, 114.99, 113.61, 105.29,
(7-Chloro-1-(4-chlorophenyl)-1,2-dihydronaphthalene-2,3-diyl)bis(phenylmethanone) (3y). Yellow solid; isolated yield 50% (72 mg). \( R_f \) 0.50 (15% EtOAc/hexane); Mp 115-117 °C; \(^1H\) NMR (400 MHz, CDCl\(_3\)) \( \delta \) 7.87-7.89 (m, 2H), 7.60-7.62 (m, 2H), 7.47-7.52 (m, 2H), 7.36-7.41 (m, 4H), 7.30 (s, 1H), 7.16-7.19 (m, 4H), 7.00-7.03 (m, 2H), 6.91 (br s, 1H), 5.13 (d, \( J = 3.9 \) Hz, 1H), 4.42 (d, \( J = 3.9 \) Hz, 1H); \(^{13}C\) NMR (100 MHz, CDCl\(_3\)) \( \delta \) 198.24, 195.94, 140.50, 140.45, 140.27, 138.24, 137.44, 136.54, 135.83, 134.70, 133.26, 132.21, 130.59, 130.13, 129.37, 129.24, 129.15, 129.01, 128.79, 128.73, 128.38, 128.14, 49.05, 46.19; HRMS for \( C_{36}H_{34}BrO_2 \): calcd. (M+H)\(^+\): 781.0642, found: 781.0643

(7-Fluoro-1-phenyl-1,2-dihydronaphthalene-2,3-diyl)bis(phenylmethanone) (3z). White solid; isolated yield 54% (70 mg). \( R_f \) 0.50 (10% EtOAc/hexane); Mp 90-92 °C; \(^1H\) NMR (400 MHz, CDCl\(_3\)) \( \delta \) 7.91 (d, \( J = 7.6 \) Hz, 2H), 7.63 (d, \( J = 7.5 \) Hz, 2H), 7.48 (t, \( J = 7.5 \) Hz, 2H), 7.38 (t, \( J = 7.7 \) Hz, 4H), 7.33 (s, 1H), 7.13-7.23 (m, 4H), 7.09-7.11 (m, 2H), 6.85-6.90 (m, 1H), 6.66 (dd, \( J = 9.2 \) Hz, 2.4 Hz, 1H), 5.17 (d, \( J = 4.2 \) Hz, 1H), 4.45 (d, \( J = 4.1 \) Hz, 1H); \(^{13}C\) NMR (100 MHz, CDCl\(_3\)) \( \delta \) 198.81, 196.13, 164.03 (d, \( J = 250.8 \) Hz), 142.07, 140.91, 139.83 (d, \( J = 7.9 \) Hz), 137.70, 136.02, 134.21 (d, \( J = 2.4 \) Hz), 133.08, 132.01, 131.24 (d, \( J = 8.6 \) Hz), 129.37, 128.97, 128.77, 128.68, 128.32, 128.01 (d, \( J = 3.1 \) Hz), 127.69, 127.40, 116.51 (d, \( J = 22.4 \) Hz), 114.70 (d, \( J = 21.8 \) Hz), 49.10, 47.22; HRMS for \( C_{30}H_{21}F_2O_2 \): calcd. (M+H)\(^+\): 483.1598, found: 483.1603

(3-Benzoyl-7-fluoro-1-phenyl-1,2-dihydronaphthalen-2-yl)(thiophen-2-yl)methanone (3za). Yellow gummy solid; isolated yield 58% (76 mg). \( R_f \) 0.50 (15% EtOAc/hexane); \(^1H\) NMR (400 MHz, CDCl\(_3\)) \( \delta \) 7.75 (d, \( J = 3.6 \) Hz, 1H), 7.62 (d, \( J = 7.3 \) Hz, 2H), 7.57 (d, \( J = 4.8 \) Hz, 1H), 7.46-7.49 (m, 1H), 7.35-7.39 (m, 2H), 7.31 (s, 1H), 7.10-7.23 (m, 6H), 7.05 (t, \( J = 4.6 \) Hz, 1H), 6.85-6.92 (m, 1H), 6.69 (dd, \( J = 9.2 \) Hz, 2.2 Hz, 1H), 4.95 (d, \( J = 4.2 \) Hz, 1H), 4.52 (d, \( J = 4.2 \) Hz, 1H); \(^{13}C\) NMR (100 MHz, CDCl\(_3\)) \( \delta \) 196.03, 191.25, 164.10 (d, \( J = 250.8 \) Hz), 142.86, 142.10, 141.04, 139.89 (d, \( J = 7.9 \) Hz), 137.64, 134.28, 133.48, 132.79, 132.06, 131.26 (d, \( J = 8.7 \) Hz), 129.39, 128.98, 128.33, 127.98, 127.78, 127.44, 116.54 (d, \( J = 22.7 \) Hz), 114.69 (d, \( J = 21.7 \) Hz), 50.98, 47.78; HRMS for \( C_{30}H_{19}FO_2S \): calcd. (M+H)\(^+\): 439.1163, found: 439.1161

(3-Benzoyl-4-phenyl-3,4-dihydronaphthalen-2-yl)(thiophen-2-yl)methanone (3zb). Yellow solid; isolated yield 55% (69 mg). \( R_f \) 0.50 (10% EtOAc/hexane); Mp 111-113 °C; \(^1H\) NMR (400 MHz, CDCl\(_3\)) \( \delta \) 7.88-7.90 (m, 2H), 7.68 (dd, \( J = 3.8 \) Hz, 1.1 Hz, 1H), 7.66 (s, 1H), 7.57 (dd, \( J = 5.0 \) Hz, 1.1 Hz, 1H), 7.44-7.48 (m, 1H), 7.34-7.38 (m, 2H), 7.30-7.32 (m, 4H), 7.28-7.30 (m, 5H), 7.18-7.20 (m, 2H), 7.07-7.10 (m, 2H), 7.00-7.02 (m, 2H), 6.96 (s, 1H), 6.85-6.88 (m, 2H), 6.68 (dd, \( J = 9.2 \) Hz, 1.1 Hz, 1H), 5.13 (d, \( J = 3.9 \) Hz, 1H), 4.45 (d, \( J = 4.1 \) Hz, 1H); \(^{13}C\) NMR (100 MHz, CDCl\(_3\)) \( \delta \) 198.25, 196.13, 140.45, 140.27, 138.24, 137.44, 136.54, 135.83, 134.70, 133.26, 132.21, 130.59, 130.13, 129.37, 129.24, 129.15, 129.01, 128.18, 128.14, 128.01, 49.05, 46.19; HRMS for \( C_{30}H_{21}F_2O_2 \): calcd. (M+H)\(^+\): 433.1598, found: 433.1603
1H), 7.15-7.23 (m, 4H), 7.06-7.11 (m, 4H), 6.93 (br d, J = 6.8 Hz, 1H), 5.12 (d, J = 4.2 Hz, 1H), 4.45 (d, J = 4.2 Hz, 1H); ^13C NMR (100 MHz, CDCl$_3$) δ 198.56, 187.30, 142.75, 142.71, 140.04, 136.89, 136.10, 134.82, 133.34, 133.28, 132.93, 131.69, 130.77, 129.45, 129.12, 128.80, 128.60, 127.77, 127.73, 127.12, 50.03, 47.08; HRMS for C$_{28}$H$_{20}$O$_2$: calcd. (M+H)$^+$: 421.1257, found: 421.1257

Ethyl 3-benzoyl-4-phenyl-3,4-dihydronaphthalene-2-carboxylate (3zc). White solid; isolated yield 57% (65 mg). $R_f$ 0.50 (15% EtOAc/hexane); Mp 101-102 °C; ^1H NMR (400 MHz, CDCl$_3$) δ 7.94-7.66 (m, 2H), 7.85 (s, 1H), 7.52-7.56 (m, 1H), 7.42-7.46 (m, 2H), 7.34-7.36 (m, 1H), 7.14-7.23 (m, 5H), 7.05-7.08 (m, 2H), 6.88 (d, J = 7.3 Hz, 1H), 4.98 (d, J = 3.0 Hz, 1H), 4.35 (d, J = 3.0 Hz, 1H), 4.10 (q, J = 7.1 Hz, 2H), 1.15 (t, J = 7.1 Hz, 3H); ^13C NMR (100 MHz, CDCl$_3$) δ 198.28, 166.58, 143.51, 138.98, 136.23, 135.84, 133.06, 131.57, 130.46, 129.33, 129.12, 128.83, 128.82, 128.73, 127.69, 127.54, 127.05, 126.11, 60.90, 49.18, 46.93, 14.08; HRMS for C$_{26}$H$_{22}$O$_3$: calcd. (M+H)$^+$: 383.1642, found: 383.1644

(6,7-Dimethoxy-1-(4-methoxyphenyl)-1,2-dihydronaphthalene-2,3-diyl)bis((2,4-dimethoxy phenyl)methanone) (3zd). Yellow solid; $R_f$ 0.50 (50% EtOAc/hexane); Mp 185-187 °C; ^1H NMR (400 MHz, CDCl$_3$) δ 7.65 (d, J = 8.6 Hz, 1H), 7.21 (d, J = 8.4 Hz, 1H), 7.16 (s, 1H), 7.06 (d, J = 8.3 Hz, 2H), 6.71 (d, J = 8.3 Hz, 2H), 6.48 (s, 1H), 6.42-6.46 (m, 4H), 5.26 (s, 1H), 4.31 (s, 1H), 3.79 (s, 6H), 3.76 (s, 3H), 3.74 (s, 3H), 3.70 (2 s merged, 6H), 3.65 (s, 3H); ^13C NMR (100 MHz, CDCl$_3$) δ 197.67, 195.04, 164.23, 162.36, 160.35, 158.94, 158.19, 150.59, 147.86, 141.75, 136.84, 134.59, 133.59, 131.62, 131.37, 128.42, 124.86, 122.06, 120.07, 113.65, 112.10, 105.35, 104.15, 98.88, 98.52, 55.91, 55.88, 55.71, 55.68, 55.51, 55.45, 55.24, 51.58, 45.50; HRMS for C$_{37}$H$_{36}$O$_9$: calcd. (M+H)$^+$: 625.2432, found: 625.2431

(7,8-Dimethoxy-1-(4-methoxyphenyl)-1,2-dihydronaphthalene-2,3-diyl)bis((2,4-dimethoxy phenyl)methanone) (3ze). White solid; $R_f$ 0.50 (50% EtOAc/hexane); Mp 125-127 °C; ^1H NMR (400 MHz, CDCl$_3$) δ 7.56 (d, J = 8.9 Hz, 1H), 7.02-7.09 (m, 4H), 6.71 (s, 1H), 6.65 (d, J = 8.5 Hz, 2H), 6.51 (s, 1H), 6.39-6.48 (m, 4H), 4.93 (s, 1H), 4.58 (s, 1H), 3.81 (s, 9H), 3.77 (s, 3H), 3.73 (s, 3H), 3.67 (s, 3H), 3.61 (s, 3H); ^13C NMR (100 MHz, CDCl$_3$) δ 199.01, 195.34, 164.33, 162.31, 159.76, 158.90, 158.24, 150.50, 148.17, 140.10, 137.10, 135.09, 133.26, 130.97, 128.63, 127.78, 126.34, 122.33, 120.14, 113.54, 112.78, 111.80, 105.56, 104.13, 98.91, 98.44, 57.55, 55.90, 55.84, 55.66, 55.57, 55.44, 55.14, 39.58; HRMS for C$_{37}$H$_{36}$O$_9$: calcd. (M+H)$^+$: 625.2432, found: 625.2431

(3-Benzoyl-1-(p-tolyl)naphthalen-2-yl)(4-methoxyphenyl)methanone (4a). Yellow solid; isolated yield 56% (25 mg). $R_f$ 0.50 (20% EtOAc/hexane); Mp 138-140 °C; ^1H NMR (400...
MHz, CDCl$_3$) δ 8.11 (s, 1H), 7.93 (d, $J = 8.4$ Hz, 1H), 7.85-7.88 (m, 2H), 7.68 (d, $J = 8.4$ Hz, 1H), 7.51-7.61 (m, 5H), 7.43-7.47 (m, 2H), 7.04, 7.11 (ABq, $J = 7.9$ Hz, 4H), 6.67-6.71 (m, 2H), 3.76 (s, 3H), 2.28 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 196.77, 196.25, 162.90, 138.98, 137.55, 137.46, 137.26, 135.04, 133.78, 133.44, 132.88, 131.97, 131.54, 131.16, 130.68, 130.50, 129.12, 128.69, 128.54, 128.30, 127.40, 126.99, 113.14, 55.33, 21.22; HRMS for C$_{32}$H$_{24}$O$_3$: calcd. (M+H)$^+$: 457.1798, found: 457.1796  
(3-Benzoyl-1-(4-methoxyphenyl)naphthalen-2-yl)(3-methoxyphenyl)methanone (4b). Yellow solid; isolated yield 60% (28 mg). $R_f$ 0.50 (25% EtOAc/hexane); Mp 169-171 °C; $^1$H NMR (400 MHz, CDCl$_3$) δ 8.06 (s, 1H), 7.87 (d, $J = 7.5$ Hz, 1H), 7.80-7.82 (m, 2H), 7.63 (d, $J = 8.3$ Hz, 1H), 7.46-7.55 (m, 3H), 7.38-7.42 (m, 2H), 7.00-7.07 (m, 5H), 6.81-6.84 (m, 1H), 6.68-6.72 (m, 2H), 3.69 (s, 3H), 3.64 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 198.17, 196.07, 159.21, 159.03, 140.01, 138.95, 137.72, 137.40, 134.96, 133.98, 132.88, 132.10, 132.04, 131.45, 130.48, 129.20, 128.85, 128.80, 128.48, 128.33, 127.51, 126.93, 122.50, 119.21, 113.37, 112.65, 55.30, 55.20; HRMS for C$_{32}$H$_{24}$O$_4$: calcd. (M+H)$^+$: 473.1747, found: 473.1752  
(3-Benzoyl-1-(4-methoxyphenyl)naphthalen-2-yl)(4-methoxyphenyl)methanone (4c). White solid; isolated yield 30% (14 mg). $R_f$ 0.50 (15% EtOAc/hexane); Mp 194-195 °C; $^1$H NMR (400 MHz, CDCl$_3$) δ 8.04 (s, 1H), 7.86 (d, $J = 7.9$ Hz, 1H), 7.80-7.82 (m, 2H), 7.63 (d, $J = 8.2$ Hz, 1H), 7.46-7.54 (m, 5H), 7.39 (t, $J = 7.7$ Hz, 2H), 7.07 (d, $J = 8.2$ Hz, 2H), 6.70 (d, $J = 8.5$ Hz, 2H), 6.62 (d, $J = 8.8$ Hz, 2H), 3.69, 3.70 (2 s, 6H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 196.91, 196.25, 158.97, 138.56, 137.79, 137.44, 135.08, 133.91, 132.89, 132.01, 131.91, 131.51, 131.14, 130.52, 129.15, 128.70, 128.63, 128.30, 127.38, 126.90, 113.35, 113.18, 55.32, 55.19; HRMS for C$_{32}$H$_{24}$O$_4$: calcd. (M+H)$^+$: 473.1747, found: 473.1747  
(3-(3-Methoxybenzoyl)-4-(4-methoxyphenyl)-6-methylnaphthalen-2-yl)(p-tolyl)methanone (4d). White solid; isolated yield 50% (25 mg). $R_f$ 0.50 (25% EtOAc/hexane); Mp 130-132 °C; $^1$H NMR (400 MHz, CDCl$_3$) δ 8.02 (s, 1H), 7.77 (d, $J = 8.7$ Hz, 1H), 7.71 (d, $J = 7.8$ Hz, 2H), 7.37 (br d, $J = 5.2$ Hz, 2H), 7.19 (d merged with CDCl$_3$ peak, $J = 7.6$ Hz, 2H), 7.00-7.06 (m, 5H), 6.82 (d, $J = 6.8$ Hz, 1H), 6.70 (d, $J = 8.4$ Hz, 2H), 3.71 (s, 3H), 3.64 (s, 3H), 2.37 (s, 6H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 198.33, 195.75, 159.18, 158.91, 143.59, 140.13, 139.09, 138.18, 137.91, 134.90, 134.29, 134.12, 132.11, 131.23, 130.64, 130.23, 129.68, 129.04, 128.99, 128.74, 128.68, 125.84, 122.50, 119.16, 113.32, 112.55, 55.28, 55.18, 22.16, 21.70; HRMS for C$_{34}$H$_{28}$O$_4$: calcd. (M+H)$^+$: 501.2060, found: 501.2067
(3-(4-Methoxybenzoyl)-6-methyl-4-(4-(methylthio)phenyl)naphthalen-2-yl)(p-tolyl) methanone (4e). White solid; isolated yield 26% (13 mg). \( R_f \) 0.50 (20% EtOAc/hexane); Mp 205-207 °C; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \( \delta \) 8.01 (s, 1H), 7.76 (d, \( J = 8.3 \) Hz, 1H), 7.69 (d, \( J = 8.2 \) Hz, 2H), 7.45-7.48 (m, 2H), 7.35-7.37 (m, 1H), 7.33 (br s, 1H), 7.18 (d, \( J = 7.9 \) Hz, 2H), 7.05 (s, 4H), 6.60-6.64 (m, 2H), 3.70 (s, 3H), 2.36, 2.37, 2.38 (3s merged, 9H); \(^13\)C NMR (100 MHz, CDCl\(_3\)) \( \delta \) 196.85, 195.83, 162.88, 143.65, 139.09, 137.86, 137.50, 134.34, 133.77, 133.32, 132.01, 131.47, 131.23, 131.12, 130.66, 130.18, 129.66, 129.02, 128.98, 125.69, 113.17, 55.33, 22.16, 21.71, 15.56; HRMS for C\(_{34}\)H\(_{28}\)O\(_3\)S: calcd. (M+H): 517.1832, found: 517.1829

(6,7-Dimethoxy-1-(4-methoxyphenyl)naphthalene-2,3-diyl)bis((2,4-dimethoxyphenyl) methanone) (4f). White solid; isolated yield 14% (9 mg). \( R_f \) 0.50 (60% EtOAc/hexane); Mp 138-140 °C; \(^1\)H NMR (500 MHz, CDCl\(_3\)) \( \delta \) 7.80 (s, 1H), 7.36 (d, \( J = 8.7 \) Hz, 1H), 7.32 (d, \( J = 8.1 \) Hz, 1H), 7.09 (s, 1H), 7.04 (d, \( J = 7.7 \) Hz, 2H), 6.80 (s, 1H), 6.70 (d, \( J = 7.7 \) Hz, 2H), 6.38-6.40 (br m, 2H), 6.22 (d, \( J = 8.4 \) Hz, 1H), 6.13 (s, 1H), 3.92 (s, 3H), 3.78 (s, 3H), 3.70 (s, 6H), 3.67 (s, 3H), 3.63 (s, 3H), 3.42 (s, 3H); \(^13\)C NMR (100 MHz, CDCl\(_3\)) \( \delta \) 195.07, 194.53, 164.02, 163.57, 160.64, 160.35, 158.57, 150.99, 149.91, 139.07, 135.42, 135.11, 133.69, 133.40, 131.59, 130.30, 129.83, 129.33, 127.88, 122.37, 121.86, 113.22, 107.33, 105.63, 104.47, 104.37, 98.79, 98.06, 55.95, 55.80, 55.72, 55.48, 55.42, 55.35, 55.15; HRMS for C\(_{37}\)H\(_{34}\)O\(_9\): calcd. (M+H): 623.2276, found: 623.2274

(7,8-Dimethoxy-1-(4-methoxyphenyl)naphthalene-2,3-diyl)bis((2,4-dimethoxyphenyl) methanone) (4g). White solid; isolated yield 13% (8 mg). \( R_f \) 0.50 (60% EtOAc/hexane); Mp 147-149 °C; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \( \delta \) 7.86 (s, 1H), 7.09-7.19 (m, 4H), 6.82 (d, \( J = 7.8 \) Hz, 2H), 6.37 (d, \( J = 8.3 \) Hz, 2H), 6.16-6.19 (m, 1H), 6.07 (br s, 2H), 3.95 (s, 3H), 3.80 (s, 3H), 3.68 (s, 3H), 3.66 (s, 3H), 3.55 (s, 3H), 3.48 (s, 3H), 3.41 (s, 3H); \(^13\)C NMR (100 MHz, CDCl\(_3\)) \( \delta \) 197.17, 196.70, 164.38, 163.87, 160.76, 160.02, 158.19, 151.14, 149.81, 139.07, 138.43, 133.75, 133.46, 132.99, 131.37, 130.78, 127.79, 127.38, 127.02, 122.29, 122.23, 112.61, 107.03, 104.40, 104.15, 104.09, 98.22, 98.11, 55.96, 55.91, 55.58, 55.40, 55.11; HRMS for C\(_{37}\)H\(_{34}\)O\(_9\): calcd. (M+H): 623.2276, found: 623.2274
3. Crystallographic Data

3.1 Crystallographic data for 3l

![Crystal Structure Diagram](image)

**Figure 1.** ORTEP diagram drawn with 30% ellipsoid probability for non-H atoms of the crystal structure of compound 3l determined at 293 K.

**Crystallization:** Crystals of compound 3l were grown from the solvent DCM:EtOH (1:3) by slow evaporation method.

**Table 1.** Crystal data and structure refinement details for 3l

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<th>Compound</th>
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3.2 Crystallographic data for 3x

![Crystal structure diagram](image)

**Figure 2** ORTEP diagram drawn with 30% ellipsoid probability for non-H atoms of the crystal structure of compound 3x determined at 293 K.

**Crystallization:** Crystals of compound 3x were grown from the solvent DCM:EtOH (1:3) by slow evaporation method.

**Table 2** Crystal data and structure refinement details for 3x

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<tr>
<th>Compound</th>
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<tbody>
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4. Experimental HPLC Chromatogram of the Product Mixture of Reaction between 1s & 2h
5. References


6. Copies of $^1$H and $^{13}$C NMR Spectra

Figure 1: $^1$H NMR spectrum of 3a

Figure 2: $^1$H NMR spectrum of 3a (expansion)
Figure 3: $^{13}$C NMR spectrum of 3a

Figure 4: $^1$H NMR spectrum of 3b
Figure 5: $^1$H NMR spectrum of 3b (expansion)

Figure 6: $^{13}$C NMR spectrum of 3b
Figure 7: $^1$H NMR spectrum of 3c

Figure 8: $^1$H NMR spectrum of 3c (expansion)
Figure 9: $^{13}$C NMR spectrum of 3c

Figure 10: $^1$H NMR spectrum of 3d
Figure 11: $^1$H NMR spectrum of 3d (expansion)

Figure 12: $^{13}$C NMR spectrum of 3d
Figure 13: $^1$H NMR spectrum of 3e

Figure 14: $^1$H NMR spectrum of 3e (expansion)
Figure 15: $^{13}$C NMR spectrum of 3e

Figure 16: $^1$H NMR spectrum of 3f
Figure 17: $^1$H NMR spectrum of 3f (expansion)

Figure 18: $^{13}$C NMR spectrum of 3f
Figure 19: $^1$H NMR spectrum of 3g

Figure 20: $^1$H NMR spectrum of 3g (expansion)
Figure 21: $^{13}$C NMR spectrum of 3g

Figure 22: $^1$H NMR spectrum of 3h
Figure 23: $^1$H NMR spectrum of 3h (expansion)

Figure 24: $^{13}$C NMR spectrum of 3h
Figure 25: $^1$H NMR spectrum of 3i

Figure 26: $^1$H NMR spectrum of 3i (expansion)
Figure 27: $^{13}$C NMR spectrum of 3i

Figure 28: $^1$H NMR spectrum of 3j
Figure 29: $^1$H NMR spectrum of 3j (expansion)

Figure 30: $^{13}$C NMR spectrum of 3j
Figure 31: $^1$H NMR spectrum of 3k

Figure 32: $^1$H NMR spectrum of 3k (expansion)
Figure 33: $^{13}$C NMR spectrum of 3k

Figure 34: $^1$H NMR spectrum of 3l
Figure 35: $^1$H NMR spectrum of 3l (expansion)

Figure 36: $^{13}$C NMR spectrum of 3l
Figure 37: $^1$H NMR spectrum of 3m

Figure 38: $^1$H NMR spectrum of 3m (expansion)
Figure 39: $^{13}$C NMR spectrum of 3m

Figure 40: $^1$H NMR spectrum of 3n
**Figure 41:** $^1$H NMR spectrum of 3n (expansion)

**Figure 42:** $^{13}$C NMR spectrum of 3n
Figure 43: $^1$H NMR spectrum of 3o

Figure 44: $^1$H NMR spectrum of 3o (expansion)
Figure 45: $^{13}$C NMR spectrum of 3o

Figure 46: $^1$H NMR spectrum of 3p
Figure 47: $^1$H NMR spectrum of 3p (expansion)

Figure 48: $^{13}$C NMR spectrum of 3p
Figure 49: $^1$H NMR spectrum of 3q

Figure 50: $^1$H NMR spectrum of 3q (expansion)
Figure 51: $^{13}$C NMR spectrum of 3q

Figure 52: $^1$H NMR spectrum of 3r
Figure 53: $^1$H NMR spectrum of 3r (with expansion)

Figure 54: $^{13}$C NMR spectrum of 3r
Figure 55: \textsuperscript{1}H NMR spectrum of 3s

Figure 56: \textsuperscript{1}H NMR spectrum of 3s (expansion)
Figure 57: $^1$C NMR spectrum of 3s

Figure 58: $^1$H NMR spectrum of 3t
Figure 59: $^1$H NMR spectrum of 3t (expansion)

Figure 60: $^{13}$C NMR spectrum of 3t
Figure 61: $^1$H NMR spectrum of 3u

Figure 62: $^1$H NMR spectrum of 3u (expansion)
Figure 63: $^{13}$C NMR spectrum of 3u

Figure 64: $^1$H NMR spectrum of 3v
Figure 65: $^1$H NMR spectrum of 3v (expansion)

Figure 66: $^{13}$C NMR spectrum of 3v
Figure 67: $^1$H NMR spectrum of 3w

Figure 68: $^1$H NMR spectrum of 3w (expansion)
Figure 71: $^1$H NMR spectrum of 3x (expansion)

Figure 72: $^{13}$C NMR spectrum of 3x
Figure 73: $^1$H NMR spectrum of 3y

Figure 74: $^1$H NMR spectrum of 3y (expansion)
Figure 75: $^{13}$C NMR spectrum of 3y

Figure 76: $^1$H NMR spectrum of 3z
Figure 77: $^1$H NMR spectrum of 3z (expansion)

Figure 78: $^{13}$C NMR spectrum of 3z
Figure 79: $^1$H NMR spectrum of 3za

Figure 80: $^1$H NMR spectrum of 3za (expansion)
Figure 81: $^{13}$C NMR spectrum of 3za

Figure 82: $^1$H NMR spectrum of 3zb
Figure 83: $^1$H NMR spectrum of 3zb (expansion)

Figure 84: $^{13}$C NMR spectrum of 3zb
Figure 85: $^1$H NMR spectrum of 3zc

Figure 86: $^1$H NMR spectrum of 3zc (expansion)
Figure 87: $^{13}$C NMR spectrum of 3zc

Figure 88: $^1$H NMR spectrum of 3zd
Figure 89: $^1$H NMR spectrum of 3zd (expansion)

Figure 90: $^{13}$C NMR spectrum of 3zd
Figure 91: $^1$H NMR spectrum of 3ze

Figure 92: $^1$H NMR spectrum of 3ze (expansion)
Figure 93: $^{13}$C NMR spectrum of 3ze

Figure 94: $^1$H NMR spectrum of 4a
Figure 95: $^1$H NMR spectrum of 4a (expansion)

Figure 96: $^{13}$C NMR spectrum of 4a
Figure 97: $^1$H NMR spectrum of 4b

Figure 98: $^1$H NMR spectrum of 4b (expansion)
Figure 99: $^{13}$C NMR spectrum of 4b

Figure 100: $^1$H NMR spectrum of 4c
Figure 101: $^1$H NMR spectrum of 4c (expansion)

Figure 102: $^{13}$C NMR spectrum of 4c
Figure 103: $^1$H NMR spectrum of 4d

Figure 104: $^1$H NMR spectrum of 4d (expansion)
Figure 105: $^{13}$C NMR spectrum of 4d

Figure 106: $^1$H NMR spectrum of 4e
Figure 107: $^1$H NMR spectrum of 4e (expansion)

Figure 108: $^{13}$C NMR spectrum of 4e
Figure 109: $^1$H NMR spectrum of 4f

Figure 110: $^1$H NMR spectrum of 4f (expansion)
Figure 111: $^{13}$C NMR spectrum of 4f

Figure 112: $^1$H NMR spectrum of 4g
Figure 113: $^1$H NMR spectrum of 4g (expansion)

Figure 114: $^{13}$C NMR spectrum of 4g