Supporting Information

Reactivity and Mechanistic Insight into Cross Coupling Reaction between Isochromans and β-Keto Esters through C-H Bond Activation under Visible Light Irradiation

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1. General Information

$^1$H NMR and $^{13}$C NMR spectra were recorded using a Bruker Avance DPX 400 MHz or 100 MHz instrument and referenced to the internal solvent signals. Mass spectra were obtained using a Q-Exactive instrument. Cyclic voltammetric measurement was recorded on Princeton Applied Research Model 283 Potentiostat/Galvanostat. A three-electrode-system is used for the measurement, with a 3 mm glass carbon working electrode, a platinum sheet counter electrode, and a saturated calomel electrode (SCE) reference electrode. The electrolyte solution (0.1 M of $n$-Bu$_4$NPF$_6$ in CH$_3$CN) was degassed by bubbling with argon for 20 min before measurement. The working electrode was polished with a 0.05 μm alumina paste for 5 min before use. ESR spectra were recorded using a Bruker E500 spectrometer at X-band, with 100Hz field modulation frequency. Commercially available reagents and solvents were used without further purification. All photoreactions were performed using common dry, inert atmosphere techniques. Irradiation with blue light was performed using High Power UV LED TY-LED 450 nm 3W® TaoYuan LED ($\lambda = 450\pm 10$ nm, 600mA). Reactions were monitored by TLC, and column chromatography purifications were carried out using silica gel GF254.
2. Preparation of Substrates

Preparation of Isochroman Derivatives (1b–1g)

A mixture of the substituted phenylethyl alcohol (7.5 mmol), (2-methoxyethoxy)methyl (MEM) chloride (1.3 mL, 11.25 mmol) and \(N,N\)-diisopropylethylamine (1.5 mL, 11.25 mmol) in dry dichloromethane (15 mL) was stirred under argon atmosphere for 2.5 h at room temperature. The reaction mixture was then washed with 1 M HCl (2 × 15 mL), dried (MgSO\(_4\)) and the solvent was removed \textit{in vacuo}. The crude MEM acetal was dissolved in dry dichloromethane (5 mL) and added to a cooled (0 °C) solution of titanium tetrachloride (1.3 mL, 11.25 mmol) in dry dichloromethane (45 mL). The reaction was carried out under argon atmosphere, stirring and keeping the temperature at 0 °C, for 2.5 h. Then the mixture was quenched by the addition of methanol (2 mL) and 1 M NaHCO\(_3\) (15 mL). The organic phase was washed with brine (25 mL), dried (MgSO\(_4\)) and evaporated under reduced pressure. Purification by column chromatography afforded the substituted isochroman.

Preparation of Substrate (1h)

A mixture of 1-(bromomethyl)-4-methylbenzene (0.56 g, 3.0 mmol) and FeSO\(_4\)·7H\(_2\)O (0.84 g, 3.0 mmol) were refluxed in methanol (5.0 mL) at 75 °C for 12 h. After that, the reaction mixture was cooled to room temperature, FeSO\(_4\) was removed by filtration. The methanol was stripped out, and the residue left out was purified by column chromatography to obtain the pure product.

Synthesis of Deuterium Substrate (1a-d\(_2\))

To a solution of isochroman-1-one (368 μL, 3 mmol) in anhydrous THF (30 mL) under an argon atmosphere at 0 °C, was added lithium aluminum deuteride LiAlD\(_4\) (252 mg, 6 mmol). The reaction mixture was carried out at room temperature for 12 h. The mixture was then quenched with H\(_2\)O, and extracted with Et\(_2\)O. The layers were separated and the organic phase was dried (MgSO\(_4\)) and concentrated \textit{in vacuo} to afford the desired 2-(2-(hydroxymethyl-d\(_2\))phenyl)ethan-1-ol.

To a solution of 2-(2-(hydroxymethyl-d\(_2\))phenyl)ethan-1-ol (133 μL, 1 mmol) in carbon tetrachloride (10 mL), was added zinc chloride (250 mg, 1.8 mmol). The solution was refluxed for 4 h. After that, the reaction mixture was cooled, washed with water and extracted with
dichloromethane. The organic layer was dried (MgSO₄) and purified by column chromatography to obtain the pure deuterium substrate (1a-d₂).
3. General Procedure for the Photocatalytic Reaction

A 10 mL reaction tube equipped with magnetic stirring bar was charged with Acr\textsuperscript{-}Mes ClO\textsubscript{4}\textsuperscript{-} (0.025 mmol, 5 mol %), Cu(OTf)\textsubscript{2} (0.05 mmol, 10 mol %), Na\textsubscript{2}HPO\textsubscript{4} (1.0 mmol, 2 equiv.), 2 mL anhydrous acetonitrile, isochroman derivate (1.0 mmol, 2 equiv.), β-keto ester (0.5 mmol, 1 equiv.) and BrCCl\textsubscript{3} (1.0 mmol, 2 equiv.). The reaction tube was sealed and the reaction mixture was degassed by bubbling with argon for 30 minutes. The mixture was stirred and irradiated with blue LEDs (λ = 450±10 nm) for 24 h at room temperature. After that, the solution was concentrated \textit{in vacuo} and the mixture was purified by column chromatography on silica gel using hexane/ethyl acetate (15:1) as eluent to afford the desired cross coupling product, which was characterized by NMR and HRMS.
4. Cyclic voltammograms of Isochroman and BrCCl$_3$

(a)                                            (b)

Figure S1. Cyclic voltammograms of (a) Isochroman (1 mM) and (b) BrCCl$_3$ (1 mM) in deaerated MeCN containing TBAPF$_6$ (0.1 M).
5. Copies of GC-MS spectrum

**Figure S2.** Copy of GC-MS spectrum (Page 1/2)
Figure S2. Copy of GC-MS spectrum (Page 2/2)
6. Procedure for intermolecular kinetic isotope effect experiment

Intermolecular Kinetic Isotope Effect (KIE) Experiment

A 10 mL reaction tube equipped with magnetic stirring bar was charged with Acr⁺-Mes ClO₄⁻ (0.025 mmol), Cu(OTf)₂ (0.05 mmol), Na₂HPO₄ (1.0 mmol), 2 mL anhydrous acetonitrile, 1a (0.5 mmol), 1a-d₂ (0.5 mmol), 2a (0.5 mmol) and BrCCl₃ (1.0 mmol). The reaction tube was sealed and the reaction mixture was degassed by bubbling with argon for 30 minutes. The mixture was stirred and irradiated with blue LEDs (λ = 450±10 nm) for 1 h at room temperature. After that, the solution was concentrated in vacuo and purification of crude product by column chromatography on silica gel using hexane/ethyl acetate (15:1) as eluent afforded a mixture of non-deuterated (3a) and mono-deuterated (3a-d₁) products. The product ratio of 3a to 3a-d₁ was calculated by acquiring a ¹H NMR spectrum (400 MHz, CDCl₃) of the mixture.

Figure S3. ¹H NMR spectrum of mixed 3a and 3a-d₁ (up); ¹H NMR spectrum of 3a (down)
7. Characterization data of synthesized compounds

^1^H and ^1^3^C NMR spectra data of substrates:

5-methylisochromane (1b). A colorless oil: ^1^H NMR (400 MHz, CDCl\textsubscript{3}) \(\delta\) 7.12 – 7.00 (m, 2H), 6.83 (d, \(J = 7.3\) Hz, 1H), 4.76 (s, 2H), 4.01 (t, \(J = 5.8\) Hz, 2H), 2.70 (t, \(J = 5.8\) Hz, 2H), 2.23 (s, 3H); ^1^3^C NMR (100 MHz, CDCl\textsubscript{3}) \(\delta\) 136.6, 134.9, 131.9, 127.8, 125.8, 122.1, 68.4, 65.7, 26.2, 18.9.

7-methylisochromane (1c). A colorless oil: ^1^H NMR (400 MHz, CDCl\textsubscript{3}) \(\delta\) 6.99 (q, \(J = 7.9\) Hz, 2H), 6.79 (s, 1H), 4.73 (s, 2H), 3.95 (t, \(J = 5.7\) Hz, 2H), 2.81 (t, \(J = 5.7\) Hz, 2H), 2.29 (s, 3H); ^1^3^C NMR (100 MHz, CDCl\textsubscript{3}) \(\delta\) 135.6, 134.9, 130.2, 128.9, 127.3, 125.0, 68.1, 65.7, 28.1, 21.2.

7-(tert-butyl)isochromane (1d). A colorless oil: ^1^H NMR (400 MHz, CDCl\textsubscript{3}) \(\delta\) 7.21 (d, \(J = 8.0\) Hz, 1H), 7.06 (d, \(J = 8.0\) Hz, 1H), 6.99 (s, 1H), 4.77 (s, 2H), 3.97 (t, \(J = 5.7\) Hz, 2H), 2.82 (t, \(J = 5.7\) Hz, 2H), 1.30 (s, 9H); ^1^3^C NMR (100 MHz, CDCl\textsubscript{3}) \(\delta\) 149.1, 134.5, 130.4, 128.7, 123.6, 121.2, 68.4, 65.6, 34.5, 31.5, 28.1.

7-methoxyisochromane (1e). A colorless oil: ^1^H NMR (400 MHz, CDCl\textsubscript{3}) \(\delta\) 7.03 (d, \(J = 8.4\) Hz, 1H), 6.74 (dd, \(J = 8.4, 2.6\) Hz, 1H), 6.51 (d, \(J = 2.5\) Hz, 1H), 4.74 (s, 2H), 3.95 (t, \(J = 5.7\) Hz, 2H), 3.77 (s, 3H), 2.79 (t, \(J = 5.7\) Hz, 2H); ^1^3^C NMR (100 MHz, CDCl\textsubscript{3}) \(\delta\) 158.0, 136.0, 130.0, 125.4, 112.9, 109.2, 68.2, 65.8, 55.4, 27.7.

7-chloroisochromane (1f). A colorless oil: ^1^H NMR (400 MHz, CDCl\textsubscript{3}) \(\delta\) 7.13 (dd, \(J = 8.2, 2.0\) Hz, 1H), 7.04 (d, \(J = 8.2\) Hz, 1H), 6.98 (s, 1H), 4.72 (s, 2H), 3.95 (t, \(J = 5.7\) Hz, 2H), 2.81 (t, \(J = 5.7\) Hz, 2H); ^1^3^C NMR (100 MHz, CDCl\textsubscript{3}) \(\delta\) 136.8, 131.8, 131.7, 130.4, 126.7, 124.5, 67.7, 65.4, 27.9.

1,4-dihydro-2H-benzo[f]isochromene (1g). A white solid: ^1^H NMR (400 MHz, CDCl\textsubscript{3}) \(\delta\) 7.93 (d, \(J = 8.3\) Hz, 1H), 7.84 (d, \(J = 8.0\) Hz, 1H), 7.70 (d, \(J = 8.4\) Hz, 1H), 7.56 (t, \(J = 7.5\) Hz, 1H), 7.50 (t, \(J = 7.4\) Hz, 1H), 7.11 (d, \(J = 8.4\) Hz, 1H), 4.92 (s, 2H), 4.16 (t, \(J = 5.7\) Hz, 2H), 3.18 (t, \(J = 5.7\) Hz, 2H); ^1^3^C NMR (100 MHz, CDCl\textsubscript{3}) \(\delta\) 132.4, 132.2, 128.7, 128.4, 126.5, 126.4, 125.5, 123.0, 122.6,
1-(methoxymethyl)-4-methylbenzene (1h). A colorless oil: $^1$H NMR (400 MHz, CDCl$_3$) δ 7.20 (dd, $J = 27.6$, 7.9 Hz, 4H), 4.43 (s, 2H), 3.37 (s, 3H), 2.35 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 137.5, 135.3, 129.2, 128.0, 74.7, 58.1, 21.3.

Isochromane-1,1-$d_2$ (1a-$d_2$). A colorless oil: $^1$H NMR (400 MHz, CDCl$_3$) δ 7.19 – 7.09 (m, 3H), 7.01 – 6.95 (m, 1H), 3.97 (t, $J = 5.7$ Hz, 2H), 2.86 (t, $J = 5.7$ Hz, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 134.9, 133.4, 129.0, 126.5, 126.1, 124.5, 65.5, 28.5.

$^1$H and $^{13}$C NMR spectra and HRMS data of products:

**Ethyl 2-(isochroman-1-yl)-3-oxobutanoate (3a).** A colorless oil: observed as two diastereomers in $^1$H NMR (400 MHz, CDCl$_3$) δ 7.20 – 7.08 (m, 3H), 7.01 (d, $J = 7.4$ Hz, 1H), 5.49 (d, $J = 6.8$ Hz, aH), 5.46 (d, $J = 5.5$ Hz, bH)[a+b=1], 4.25 – 4.08 (m, 3H), 4.04 (d, $J = 5.5$ Hz, cH), 3.95 (d, $J = 6.8$ Hz, dH) [c+d=1], 3.83 – 3.70 (m, 1H), 3.09 – 2.92 (m, 1H), 2.75 – 2.65 (m, 1H), 2.24 (d, $J = 18.2$ Hz, 3H), 1.25 (t, $J = 7.1$ Hz, eH), 1.10 (t, $J = 7.1$ Hz, fH)[e+f=1]; $^{13}$C NMR (100 MHz, CDCl$_3$) δ 202.1, 201.9, 168.4, 167.5, 135.2, 135.0, 134.5, 134.0, 129.3, 129.1, 127.3, 127.0, 126.5, 126.4, 124.8, 124.6, 74.5, 74.3, 65.7, 65.6, 64.0, 63.6, 61.7, 61.2, 30.1, 29.5, 28.7, 28.6, 14.1, 14.0; MS (HRESI): m/z calcd for C$_{15}$H$_{18}$O$_4$ [M+Na]$^+$ 285.1097, found 285.1087.

**Ethyl 2-(isochroman-1-yl)-4-methyl-3-oxopentanoate (3b).** A colorless oil: observed as two diastereomers in $^1$H NMR (400 MHz, CDCl$_3$) δ 7.21 – 7.08 (m, 3H), 7.04 – 6.93 (m, 1H), 5.55 – 5.49 (m, 1H), 4.27 – 4.12 (m, 4H), 3.82 – 3.77 (m, 1H), 3.05 – 2.92 (m, 1H), 2.81 – 2.61 (m, 2H), 1.23 (t, $J = 7.1$ Hz, aH), 1.18 (t, $J = 7.1$ Hz, bH)[a+b=3], 1.12 – 0.95 (m, 6H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 207.5, 207.3, 168.4, 167.4, 135.9, 135.5, 134.3, 134.2, 129.2, 129.1, 127.2, 126.4, 126.3, 125.3, 124.8, 75.0, 74.1, 63.8, 63.4, 63.2, 61.6, 61.4, 41.5, 41.4, 28.9, 28.8, 18.3, 18.2, 17.8, 14.1; MS (HRESI): m/z calcd for C$_{17}$H$_{22}$O$_4$ [M+Na]$^+$ 313.1410, found 313.1401.

**Isopropyl 2-(isochroman-1-yl)-3-oxobutanoate (3c).** A colorless oil: observed as two
diastereomers in $^1$H NMR (400 MHz, CDCl$_3$) δ 7.18 – 7.11 (m, 3H), 7.02 (t, $J = 6.7$ Hz, 1H), 5.49 (d, $J = 6.9$ Hz, aH), 5.45 (d, $J = 5.4$ Hz, bH)[a+b=1], 5.10 (dt, $J = 12.5$, 6.3 Hz, cH), 4.95 (dt, $J = 12.5$, 6.3 Hz, dH)[c+d=1], 4.22 – 4.11 (m, 1H), 4.00 (d, $J = 5.4$ Hz, eH), 3.92 (d, $J = 6.9$ Hz, fH)[e+f=1], 3.81 – 3.73 (m, 1H), 3.09 – 2.93 (m, 1H), 2.78 – 2.64 (m, 1H), 2.25 (d, 3H), 1.26 – 1.08 (m, 6H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 202.3, 202.0, 168.0, 167.2, 135.4, 135.2, 134.5, 134.0, 129.3, 129.1, 127.3, 127.0, 126.4, 124.9, 124.7, 74.6, 74.4, 69.4, 68.8, 66.0, 65.7, 64.0, 63.6, 30.0, 29.4, 28.8, 28.7, 21.7, 21.6, 21.5; MS (HRESI): m/z calcd for C$_{16}$H$_{20}$O$_4$ [M+Na]$^+$ 299.1254, found 299.1246.

**Ethyl 2-(isochroman-1-yl)-4,4-dimethyl-3-oxopentanoate (3d).** A colorless oil: observed as two diastereomers in $^1$H NMR (400 MHz, CDCl$_3$) δ 7.21 – 6.84 (m, 4H), 5.62 (d, $J = 9.4$ Hz, aH), 5.56 (d, $J = 8.4$ Hz, bH)[a+b=1], 4.50 (d, $J = 9.4$ Hz, cH), 4.38 (d, $J = 8.4$ Hz, dH)[c+d=1], 4.27 – 4.06 (m, 3H), 3.89 – 3.68 (m, 1H), 3.03 – 2.67 (m, 2H), 1.29 – 0.99 (m, 12H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 207.5, 207.4, 167.7, 166.9, 135.6, 134.6, 133.8, 129.1, 129.0, 127.4, 127.1, 126.2, 126.1, 125.1, 75.5, 74.5, 63.4, 61.9, 61.6, 61.5, 60.2, 59.2, 46.0, 45.8, 29.1, 28.6, 26.3, 25.9, 14.1, 14.0; MS (HRESI): m/z calcd for C$_{18}$H$_{24}$O$_4$ [M+Na]$^+$ 327.1567, found 327.1560.

**tert-butyl 2-(isochroman-1-yl)-3-oxobutanoate (3e).** A colorless oil: observed as two diastereomers in $^1$H NMR (400 MHz, CDCl$_3$) δ 7.21 – 7.10 (m, 3H), 7.08 – 7.01 (m, 1H), 5.47 (d, $J = 6.8$ Hz, aH), 5.42 (d, $J = 5.2$ Hz, bH)[a+b=1], 4.23 – 4.11 (m, 1H), 3.93 (d, $J = 5.3$ Hz, cH), 3.88 (d, $J = 6.8$ Hz, dH)[c+d=1], 3.82 – 3.73 (m, 1H), 3.08 – 2.94 (m, 1H), 2.78 – 2.63 (m, 1H), 2.25 (d, $J = 28.0$ Hz, eH), 1.38 (d, $J = 63.8$ Hz, 9H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 202.6, 202.3, 167.6, 166.8, 135.7, 135.4, 134.4, 134.0, 129.3, 129.1, 127.2, 126.9, 126.4, 126.3, 125.0, 124.7, 82.5, 81.7, 74.5, 66.8, 66.3, 64.0, 63.6, 30.0, 29.3, 28.7, 28.0, 27.8; MS (HRESI): m/z calcd for C$_{17}$H$_{22}$O$_4$ [M+Na]$^+$ 313.1410, found 313.1400.

**Ethyl 2-(isochroman-1-yl)-3-oxo-3-phenylpropanoate (3f).** A colorless oil: observed as two diastereomers in $^1$H NMR (400 MHz, CDCl$_3$) δ 8.00 – 7.91 (m, 2H), 7.55 (q, $J = 7.5$ Hz, 1H), 7.47 – 7.41 (m, 2H), 7.18 – 7.02 (m, 4H), 5.87 – 5.67 (m, 1H), 4.95 (d, $J = 7.7$ Hz, aH), 4.90 (d, $J = 7.1$ Hz, bH)[a+b=1], 4.23 – 4.01 (m, 3H), 3.89 – 3.68 (m, 1H), 3.02 – 2.85 (m, 1H), 2.78 (dt, $J = 16.3$,
Methyl 3-(4-chlorophenyl)-2-(isochroman-1-yl)-3-oxopropanoate (3g). A colorless oil: observed as two diastereomers in $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.90 (d, $J = 8.6$ Hz, 1H), 7.84 (d, $J = 8.6$ Hz, 1H), 7.42 – 7.39 (m, 2H), 7.22 – 6.94 (m, 4H), 5.73 (t, $J = 6.9$ Hz, 1H), 4.88 (d, $J = 7.7$ Hz, aH), 4.81 (d, $J = 7.2$ Hz, bH)[$a+b=1$], 4.23 – 3.98 (m, 1H), 3.88 – 3.66 (m, 4H), 3.00 – 2.83 (m, 1H), 2.77 (dt, $J = 16.3$, 4.7 Hz, cH), 2.67 (dt, $J = 16.2$, 3.8 Hz, dH)[$c+d=1$]; $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 192.2, 192.0, 168.4, 167.4, 164.1, 163.8, 136.2, 135.9, 134.6, 134.0, 131.2, 129.7, 129.1, 127.2, 127.1, 126.3, 125.4, 125.2, 114.1, 113.9, 74.7, 74.1, 63.7, 63.5, 61.5, 60.4, 52.9, 28.9, 28.8; MS (HRESI): m/z calcd for C$_{19}$H$_{17}$ClO$_4$ [M+Na]$^+$ 367.0708, found 367.0701.

Ethyl 2-(isochroman-1-yl)-3-(4-methoxyphenyl)-3-oxopropanoate (3h). A colorless oil: observed as two diastereomers in $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.99 (d, $J = 8.9$ Hz, 1H), 7.93 (d, $J = 8.2$ Hz, cH), 4.82 (d, $J = 7.4$ Hz, dH)[$c+d=1$], 4.26 – 4.00 (m, 3H), 3.90 – 3.68 (m, 4H), 2.70 (dt, $J = 16.2$, 4.2 Hz, eH)[$c+d=1$], 1.21 – 1.10 (m, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 191.6, 191.5, 168.6, 167.4, 164.1, 163.8, 136.2, 135.9, 134.6, 134.0, 131.2, 129.7, 129.1, 127.2, 127.1, 126.3, 125.4, 125.2, 114.1, 113.9, 74.7, 74.1, 63.4, 61.7, 61.6, 60.3, 55.7, 55.6, 29.0, 28.8, 14.1; MS (HRESI): m/z calcd for C$_{21}$H$_{22}$O$_5$ [M+Na]$^+$ 377.1359, found 377.1353.

3-(isochroman-1-yl)pentane-2,4-dione or 4-hydroxy-3-(isochroman-1-yl)pent-3-en-2-one (3i). A colorless oil: observed as two isomers in $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 17.27 (s, aH), 7.18 – 7.12 (m, 3H), 6.92 (t, $J = 7.8$ Hz, 1H), 5.64 (s, cH), 5.53 (d, $J = 6.9$ Hz, dH)[$c+d=1$], 4.36 – 4.10 (m, (1+b)H)[$a+b=1$], 3.96 – 3.74 (m, 1H), 3.25 – 2.93 (m, 1H), 2.78 – 2.64 (m, 1H), 2.39 – 1.68 (m, 6H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 203.6, 203.0, 138.0, 135.3, 133.9, 133.8, 129.5, 129.0, 127.4, 127.0, 126.8, 126.7, 124.9, 124.7, 112.4, 75.1, 74.2, 66.2, 63.7, 31.0, 29.1, 28.6; MS
2-(isochroman-1-yl)-2-nitro-1-phenylethan-1-one (3j). A colorless oil: observed as two isomers in $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.86 (d, $J = 8.0$ Hz, aH), 7.72 (d, $J = 8.0$ Hz, bH)[a+b=2], 7.64 – 7.53 (m, 1H), 7.45 (t, $J = 7.8$ Hz, cH), 7.37 (t, $J = 7.8$ Hz, dH)[c+d=2], 7.26 – 6.97 (m, 4H), 6.53 (d, $J = 7.2$ Hz, eH), 6.38 (d, $J = 5.1$ Hz, fH)[e+f=1], 5.92 (d, $J = 5.0$ Hz, gH), 5.88 (d, $J = 7.2$ Hz, hH)[g+h=1], 4.28 – 3.99 (m, 1H), 3.89 – 3.64 (m, 1H), 3.05 – 2.52 (m, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 187.5, 187.3, 135.3, 135.0, 134.9, 134.8, 134.7, 134.2, 132.8, 131.3, 129.4, 129.1, 128.9, 128.8, 128.0, 127.2, 126.7, 125.5, 124.7, 93.6, 92.7, 74.8, 74.2, 64.1, 63.4, 28.6; MS (HRESI): m/z calcd for C$_{17}$H$_{14}$O$_3$ [M+Na]$^+$ 320.0893, found 320.0887.

Ethyl 2-(5-methylisochroman-1-yl)-3-oxobutanoate (3k). A colorless oil: observed as two diastereomers in $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.09 – 7.01 (m, 2H), 6.88 – 6.85 (m, 1H), 5.50 (d, $J = 6.9$ Hz, aH), 5.46 (d, $J = 5.7$ Hz, bH)[a+b=1], 4.26 – 4.07 (m, 3H), 4.05 (d, $J = 5.7$ Hz, cH), 3.97 (d, $J = 6.9$ Hz, dH)[c+d=1], 3.86 – 3.75 (m, 1H), 2.88 – 2.76 (m, 1H), 2.67 – 2.57 (m, 1H), 2.27 – 2.22 (m, 6H), 1.26 (t, $J = 7.1$ Hz, eH), 1.11 (d, $J = 7.1$ Hz, fH)[e+f=3]; $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 202.2, 202.0, 168.6, 167.6, 136.8, 136.5, 135.1, 134.9, 133.0, 132.5, 128.8, 128.5, 126.1, 125.9, 122.4, 122.3, 74.8, 74.6, 65.8, 65.7, 63.8, 63.5, 61.7, 61.2, 30.2, 29.5, 26.2, 19.2, 14.2, 14.01; MS (HRESI): m/z calcd for C$_{16}$H$_{20}$O$_4$ [M+Na]$^+$ 299.1254, found 299.1247.

Ethyl 2-(7-methylisochroman-1-yl)-3-oxobutanoate (3l). A colorless oil: observed as two diastereomers in $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.03 – 6.95 (m, 2H), 6.82 (s, 1H), 5.46 (d, $J = 6.8$ Hz, aH), 5.42 (d, $J = 5.4$ Hz, bH)[a+b=1], 4.27 – 4.08 (m, 3H), 4.02 (d, $J = 5.5$ Hz, cH), 3.94 (d, $J = 6.8$ Hz, dH)[c+d=1], 3.79 – 3.71 (m, 1H), 3.02 – 2.90 (m, 1H), 2.71 – 2.61 (m, 1H), 2.27 – 2.23 (m, 6H), 1.27 (t, $J = 7.1$ Hz, eH), 1.11 (t, $J = 7.1$ Hz, fH)[e+f=3]; $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 202.2, 202.0, 168.6, 167.6, 136.1, 135.9, 135.1, 134.9, 131.5, 130.9, 129.2, 129.0, 128.2, 127.9, 125.3, 125.2, 74.6, 74.3, 65.8, 65.7, 64.1, 63.8, 61.7, 61.2, 30.1, 29.5, 28.4, 28.3, 21.3, 14.2, 14.01; MS (HRESI): m/z calcd for C$_{16}$H$_{20}$O$_4$ [M+Na]$^+$ 299.1254, found 299.1248.

Ethyl 2-(7-(tert-butyl)isochroman-1-yl)-3-oxobutanoate (3m). A colorless oil: observed as two
diastereomers in $^1$H NMR (400 MHz, CDCl$_3$) δ 7.24 – 7.19 (m, 1H), 7.10 – 7.01 (m, 2H), 5.51 (d, $J = 7.4$ Hz, aH), 5.47 (d, $J = 5.8$ Hz, bH)[a+b=1], 4.26 – 4.09 (m, 3H), 4.07 (d, $J = 6.2$ Hz, cH), 3.98 (d, $J = 7.4$ Hz, dH)[a+b=1], 3.81 – 3.75 (m, 1H), 3.03 – 2.87 (m, 1H), 2.79 – 2.62 (m, 1H), 2.25 (d, $J = 4.0$ Hz, 3H), 1.27 – 1.08 (m, 12H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 202.2, 201.8, 168.5, 167.6, 149.5, 149.3, 134.6, 131.4, 130.9, 129.0, 128.8, 124.5, 124.1, 121.7, 121.6, 74.8, 66.1, 65.8, 64.0, 63.6, 61.7, 61.2, 34.6, 31.5, 31.4, 30.3, 29.4, 28.3, 28.2, 14.2, 14.0; MS (HRESI): m/z calcd for C$_{19}$H$_{26}$O$_4$ [M+Na]$^+$ 341.1723, found 341.1713.

**Ethyl 2-(7-(tert-butyl)isochroman-1-yl)-4-methyl-3-oxopentanoate (3n).** A colorless oil: observed as two diastereomers in $^1$H NMR (400 MHz, CDCl$_3$) δ 7.23 – 7.19 (m, 1H), 7.08 – 6.96 (m, 2H), 5.53 (t, $J = 7.0$ Hz, 1H), 4.29 – 4.09 (m, 4H), 3.83 – 3.71 (m, 1H), 3.00 – 2.87 (m, 1H), 2.84 – 2.62 (m, 2H), 1.27 – 1.17 (m, 12H), 1.12 – 0.92 (m, 6H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 207.4, 207.3, 168.4, 167.5, 149.3, 135.4, 135.0, 131.3, 131.1, 128.9, 128.8, 124.3, 122.2, 121.5, 75.3, 74.4, 64.0, 63.9, 63.5, 63.3, 61.6, 61.4, 41.5, 41.3, 34.6, 31.4, 28.5, 28.3, 18.3, 18.2, 17.8, 14.2, 14.1; MS (HRESI): m/z calcd for C$_{21}$H$_{30}$O$_4$ [M+Na]$^+$ 369.2036, found 369.2027.

**Ethyl 2-(7-(tert-butyl)isochroman-1-yl)-3-oxo-3-phenylpropanoate (3o).** A colorless oil: observed as two diastereomers in $^1$H NMR (400 MHz, CDCl$_3$) δ 7.95 – 7.92 (m, 2H), 7.57 – 7.51 (m, 1H), 7.46 – 7.39 (m, 2H), 7.25 – 6.97 (m, 3H), 5.84 – 5.69 (m, 1H), 4.98 (d, $J = 8.5$ Hz, aH), 4.92 (d, $J = 7.4$ Hz, bH)[a+b=1], 4.24 – 3.99 (m, 3H), 3.91 – 3.67 (m, 1H), 2.94 – 2.62 (m, 2H), 1.28 (s, 3H), 1.24 – 1.14 (m, 4H), 1.09 (s, 5H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 193.5, 193.4, 168.1, 167.2, 149.3, 149.2, 137.5, 137.0, 135.2, 135.1, 133.6, 133.2, 131.5, 130.9, 128.8, 128.7, 128.6, 124.3, 124.2, 122.4, 121.9, 75.2, 74.8, 63.5, 63.1, 61.7, 61.4, 60.5, 34.6, 34.4, 31.4, 31.2, 28.5, 28.3, 14.1; MS (HRESI): m/z calcd for C$_{24}$H$_{28}$O$_4$ [M+Na]$^+$ 403.1880, found 403.1868.

**Ethyl 2-(1,4-dihydro-2H-benzo[f]isochromen-4-yl)-3-oxobutanoate (3p).** A white solid: observed as two diastereomers $^1$H NMR (400 MHz, CDCl$_3$) δ 7.94 (d, $J = 8.3$ Hz, 1H), 7.82 (d, $J = 7.9$ Hz, 1H), 7.69 – 7.66 (m, 1H), 7.58 – 7.46 (m, 2H), 7.15 (d, $J = 8.6$ Hz, 1H), 5.67 (d, $J = 6.6$ Hz, aH), 5.63 (d, $J = 5.3$ Hz, bH)[a+b=1], 4.41 – 4.30 (m, 1H), 4.26 (q, $J = 7.1$ Hz, 1H), 4.14 – 4.04 (m, 2H), 3.97 – 3.89 (m, 1H), 3.31 – 3.20 (m, 1H), 3.18 – 3.09 (m, 1H), 2.27 (d, $J = 28.6$ Hz,
3H), 1.27 (t, $J = 7.1$ Hz, cH), 1.04 (t, $J = 7.1$ Hz, dH) [c+d=3]; $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$

202.0, 201.6, 168.6, 167.6, 132.6, 132.5, 132.4, 132.3, 132.1, 132.0, 130.3, 129.8, 128.7, 126.9, 126.8, 126.7, 126.6, 126.1, 126.0, 123.0, 122.8, 74.9, 74.7, 65.9, 65.6, 63.6, 63.3, 61.7, 61.2, 30.2, 29.4, 25.5, 25.3, 14.2, 14.0; MS (HRESI): m/z calcd for C$_{19}$H$_{20}$O$_4$ [M+Na]$^+$ 335.1254, found 335.1247.
8. Copies of $^1$H and $^{13}$C NMR spectra for synthesized compounds