Supporting Information

Electrophotocatalytic Undirected C–H Trifluoromethylations of (Het)Arenes

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General Remarks
Catalytic reactions were carried out in undivided electrochemical cells (10 mL) using pre-dried glassware, if not noted otherwise. Substrates, CF₃SO₂Na and solvents were obtained from commercial sources. Platinum electrodes (10 mm × 15 mm × 0.25 mm, 99.9%; obtained from ChemPur® Karlsruhe, Germany) and graphite felt electrodes (10 mm × 15 mm × 6 mm, SIGRACELL® GFA 6 EA, obtained from SGL Carbon, Wiesbaden, Germany) were connected using stainless steel adapters. Electrocatalysis was conducted using an AXIOMET AX-3003P potentiostat in constant current mode. For reactions in flow an Ismatec REGLO Digital MS-2/12 (ISM 596) peristaltic pump was employed. The ¹⁹F and ¹H NMR spectroscopy experiments in flow were performed on a Magritek Spinsolve 60ULTRA (from Magritek GmbH, Germany). Cyclic Voltammetry studies were performed using a Metrohm Autolab PGSTAT204 workstation and Nova 2.1 software. Yields refer to isolated compounds, estimated to be >95% pure as determined by ¹H-NMR. Chromatography was carried out on Merck silica gel 60 (40–63 µm). NMR spectra were recorded on a Varian Mercury VX 300, Inova 500 or Bruker Avance III 300, Avance III 400 and Avance III HD 500 in the solvent indicated; chemical shifts (δ) are given in ppm relative to the residual solvent peak. All IR spectra were recorded on a Bruker FT-IR Alpha-P device. EI-MS was recorded on Jeol AccuTOF at 70eV, ESI-MS on Bruker MicrOTOF and maXis. GC-MS was recorded on Agilent 7890B and Agilent 5977B. M. p.: Stuart melting point apparatus SMP3, Barloworld Scientific, values are uncorrected. Headspace analysis of the reaction mixture was performed on a Shimadzu S2014 GC System using a Thermal Conductivity Detector and a 5Å MS column.
Optimization of the Electrophotochemical C–H Trifluoromethylation

**Table S-1: Optimization of the electrophotochemical C–H trifluoromethylation.**

| Entry | Photocatalyst | Additive | Solvent | Yield (%)<sup>b</sup> | Ratio (%)<sup>b</sup> |
|-------|---------------|----------|---------|------------------------|----------------------|
| 1     | [Mes-Acr]<sup>+</sup>[ClO<sub>4</sub>] | KOAc     | CH<sub>3</sub>CN | 48                     | 93/7                 |
| 2     | [Mes-Acr]<sup>+</sup>[ClO<sub>4</sub>] | TBAPF<sub>6</sub> | CH<sub>3</sub>CN | 10                     | -                    |
| 3     | [Mes-Acr]<sup>+</sup>[ClO<sub>4</sub>] | LiClO<sub>4</sub> | CH<sub>3</sub>CN | 85                     | 93/7                 |
| 4     | [Mes-Acr]<sup>+</sup>[ClO<sub>4</sub>] | LiClO<sub>4</sub> | DCE     | 38                     | 94/6                 |
| 5     | [Mes-Acr]<sup>+</sup>[ClO<sub>4</sub>] | LiClO<sub>4</sub> | TFE     | 45                     | 80/20                |
| 6     | [Mes-Acr]<sup>+</sup>[ClO<sub>4</sub>] | LiClO<sub>4</sub> | HFIP    | 68                     | 62/38                |
| 7     | [Ru(bpy)]<sub>3</sub>[PF<sub>6</sub>]<sub>2</sub> | LiClO<sub>4</sub> | CH<sub>3</sub>CN | 88                     | 78/22                |
| 8     | Eosin Y      | LiClO<sub>4</sub> | CH<sub>3</sub>CN | 75                     | 83/17                |
| 9<sup>c</sup> | [Mes-Acr]<sup>+</sup>[ClO<sub>4</sub>] | LiClO<sub>4</sub> | CH<sub>3</sub>CN | 5                      | -                    |
| 10<sup>d</sup> | [Mes-Acr]<sup>+</sup>[ClO<sub>4</sub>] | LiClO<sub>4</sub> | CH<sub>3</sub>CN | 8                      | -                    |
| 11<sup>e</sup> | [Ru(bpy)]<sub>3</sub>[PF<sub>6</sub>]<sub>2</sub> | LiClO<sub>4</sub> | CH<sub>3</sub>CN | trace                  | -                    |
| 12<sup>d</sup> | [Ru(bpy)]<sub>3</sub>[PF<sub>6</sub>]<sub>2</sub> | LiClO<sub>4</sub> | CH<sub>3</sub>CN | 7                      | -                    |
| 13<sup>c</sup> | [Mes-Acr]<sup>+</sup>[ClO<sub>4</sub>] | LiClO<sub>4</sub> | CH<sub>3</sub>CN | 4                      | -                    |
| 14<sup>e</sup> | [Ru(bpy)]<sub>3</sub>[PF<sub>6</sub>]<sub>2</sub> | LiClO<sub>4</sub> | CH<sub>3</sub>CN | 3                      | -                    |
| 15    | -            | LiClO<sub>4</sub> | CH<sub>3</sub>CN | 9                      | -                    |
| 16    | [Mes-Acr]<sup>+</sup>[ClO<sub>4</sub>] | -         | CH<sub>3</sub>CN | 55                     | 92/8                 |
| 17<sup>f</sup> | [Mes-Acr]<sup>+</sup>[ClO<sub>4</sub>] | LiClO<sub>4</sub> | CH<sub>3</sub>CN | 70                     | 92/8                 |
| 18<sup>g</sup> | [Mes-Acr]<sup>+</sup>[ClO<sub>4</sub>] | LiClO<sub>4</sub> | CH<sub>3</sub>CN | 23                     | -                    |
| 19    | [Mes-Acr]<sup>+</sup>[ClO<sub>4</sub>] | -         | CH<sub>3</sub>CN | 55                     | 92/8                 |
| 10    | [Ru(bpy)]<sub>3</sub>[PF<sub>6</sub>]<sub>2</sub> | -         | CH<sub>3</sub>CN | 60                     | 80/20                |
| 21    | [Ru(bpy)]<sub>3</sub>[Cl<sub>2</sub>6H<sub>2</sub>O] | -         | CH<sub>3</sub>CN | 10                     | -                    |
| 22<sup>b</sup> | [Ru(bpy)]<sub>3</sub>[PF<sub>6</sub>]<sub>2</sub> | LiClO<sub>4</sub> | CH<sub>3</sub>CN | 75                     | 86/14                |
| 23<sup>i</sup> | [Mes-Acr]<sup>+</sup>[ClO<sub>4</sub>] | LiClO<sub>4</sub> | CH<sub>3</sub>CN | 52                     | 87/13                |

[a] Undivided cell, graphite felt (GF) anode, Pt cathode, constant current = 4.0 mA, 1 (0.25 mmol), 2 (0.50 mmol), photocatalyst (2.0 or 5.0 mol %), additive (0.1 M), solvent (4.0 mL), 23 °C, blue LED, under N<sub>2</sub>, 8 h. [b] Yields determined by <sup>1</sup>H NMR with CH<sub>2</sub>Br<sub>2</sub> as internal standard, and ratio is mono-/bis- CF<sub>3</sub> substituents. [c] Without electricity under N<sub>2</sub> after degassing. [d] Without blue light. [e] Without electricity in air. [f] Additive: H<sub>2</sub>O (2.0 equiv). [g] Additive: TFA (2.0 equiv). [h] 2 (1.5 equiv). [i] Nickel foam as cathode. Standard condition A: [Mes-Acr]<sup>+</sup>[ClO<sub>4</sub>] (5.0 mol %) as catalyst (Faradaic yield: 36%); standard condition B: [Ru(bpy)]<sub>3</sub>[PF<sub>6</sub>]<sub>2</sub> (2.0 mol %) as catalyst (Faradaic yield: 37%).
Figure S-1. Set-up of experiments
**General Procedure A for the Electrophotochemical C–H Trifluoromethylation**

The electrophotocatalysis was carried out in an undivided cell with a GF anode (10 mm × 15 mm × 6 mm) and a Pt cathode (10 mm × 15 mm × 0.25 mm). Substrate 1 or 4 (0.25 mmol, 1.0 equiv), CF₃SO₂Na 2 (78 mg, 0.50 mmol, 2.0 equiv), LiClO₄ (42 mg, 0.40 mmol) and [Mes-Acr⁺]ClO₄⁻ (5.1 mg, 5.0 mol %) were dissolved in CH₃CN (4.0 mL) under N₂. The electrophotocatalysis was performed at 23 °C with a constant current of 4.0 mA maintained for 8-16 h under visible light irradiation (2 × Kessil A360N lamp). The GF anode was washed with CH₂Cl₂ (3 × 10 mL) in an ultrasonic bath. Evaporation of the solvent and subsequent column chromatography on silica gel afforded the corresponding products.

**General Procedure B for the Electrophotochemical C–H Trifluoromethylation**

The electrophotocatalysis was carried out in an undivided cell with a GF anode (10 mm × 15 mm × 6 mm) and a Pt cathode (10 mm × 15 mm × 0.25 mm). Substrate 1 or 4 (0.25 mmol, 1.0 equiv), CF₃SO₂Na 2 (78 mg, 0.50 mmol, 2.0 equiv), LiClO₄ (42 mg, 0.40 mmol) and [Ru(bpy)₃](PF₆)₂ (4.3 mg, 2.0 mol %) were dissolved in CH₃CN (4.0 mL) under N₂. The electrophotocatalysis was performed at 23 °C with a constant current of 4.0 mA maintained for 8-16 h under visible light irradiation (2 × Kessil A360N). The GF anode was washed with CH₂Cl₂ (3 × 10 mL) in an ultrasonic bath. Evaporation of the solvent and subsequent column chromatography on silica gel afforded the corresponding products.
Characterization Data of Products.

\[ \text{3a} \]

1,3,5-Trimethyl-2-(trifluoromethyl)benzene (3a)

The general procedure A was followed using 1a (30 mg, 0.25 mmol) at 23 °C for 8 h. Purification by column chromatography on silica gel (pentane) yielded 3a (37 mg, 79%) as a colorless oil. \(^1\)H-NMR (400 MHz, CDCl\(_3\)): \(\delta = 6.88\) (s, 2H), 2.44–2.40 (m, 6H), 2.27 (s, 3H). \(^1^3\)C-NMR (100 MHz, CDCl\(_3\)): \(\delta = 140.8\) (C\(_{q}\)), 137.3 (q, \(^3\)J\(_{C-F}\) = 2.2 Hz, C\(_{q}\)), 130.8 (CH), 126.2 (q, \(^1\)J\(_{C-F}\) = 275.8 Hz, C\(_{q}\)), 124.8 (q, \(^2\)J\(_{C-F}\) = 28.0 Hz, C\(_{q}\)), 21.31 (q, \(^4\)J\(_{C-F}\) = 4.1 Hz, CH\(_3\)), 20.9 (CH\(_3\)). \(^1^9\)F-NMR (376 MHz, CDCl\(_3\)): \(\delta = 53.7\) (s). IR (ATR): 2925, 2854, 1459, 1379, 1294, 1152, 1115 cm\(^{-1}\). MS (EI) m/z (relative intensity): 188 (100) [M]\(^+\). HR-MS (EI) m/z calc. for C\(_{10}\)H\(_{11}\)F\(_3\) [M]\(^+\): 188.0807, found: 188.0815. The analytical data correspond with those reported in the literature.\(^{[1]}\)

\[ \text{3b} \]

1,3,5-Triethyl-2-(trifluoromethyl)benzene (3b)

The general procedure A was followed using 1b (41 mg, 0.25 mmol) at 23 °C for 16 h. Purification by column chromatography on silica gel (pentane) yielded 3b (38 mg, 65%) as a colorless oil. \(^1\)H-NMR (300 MHz, CDCl\(_3\)): \(\delta = 6.99\) (s, 2H), 2.88–2.76 (m, 4H), 2.65 (q, \(J = 7.6\) Hz, 2H), 1.27 (t, \(J = 7.6\) Hz, 3H), 1.26 (t, \(J = 7.4\) Hz, 6H). \(^1^3\)C-NMR (100 MHz, CDCl\(_3\)): \(\delta = 147.3\) (C\(_{q}\)), 143.9 (q, \(^3\)J\(_{C-F}\) = 1.9 Hz, C\(_{q}\)), 128.5 (CH), 126.2 (q, \(^1\)J\(_{C-F}\) = 276.2 Hz, C\(_{q}\)), 123.7 (q, \(^2\)J\(_{C-F}\) = 28.4 Hz, C\(_{q}\)), 28.4 (CH\(_2\)), 27.9 (q, \(^4\)J\(_{C-F}\) = 3.8 Hz, CH\(_2\)), 16.6 (q, \(^5\)J\(_{C-F}\) = 1.6 Hz, CH\(_3\)), 15.1 (CH\(_3\)). \(^1^9\)F-NMR (282 MHz, CDCl\(_3\)): \(\delta = -52.3\) (s). IR (ATR): 2968, 2936, 2880, 1609, 1575, 1458, 1294, 1143, 1106, 1037 cm\(^{-1}\). MS (EI) m/z (relative intensity): 230 (30) [M]\(^+\), 215 (100) [M-CH\(_3\)]\(^+\). HR-MS (EI) m/z calc. for C\(_{13}\)H\(_{17}\)F\(_3\) [M]\(^+\): 230.1277, found: 230.1279.
1,4-Diisopropyl-2-(trifluoromethyl)benzene (3c)

The general procedure B was followed using 1c (41 mg, 0.25 mmol) at 23 °C for 16 h. Purification by column chromatography on silica gel (pentane) yielded 3c (39 mg, 67%) as a colorless oil. $^1$H-NMR (400 MHz, CDCl$_3$): $\delta$ = 7.42–7.39 (m, 1H), 7.37 (d, $J$ = 8.2 Hz, 1H), 7.35–7.31 (m, 1H), 3.37–3.23 (m, 1H), 2.90 (hept, $J$ = 7.0 Hz, 1H), 1.23 (d, $J$ = 7.0 Hz, 6H), 1.23 (d, $J$ = 6.8 Hz, 6H). $^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ = 146.2 (C$_q$), 145.3 (q, $^3$J$_{C\text{-}F}$ = 1.4 Hz, C$_q$), 130.0 (CH), 127.2 (CH), 127.1 (q, $^2$J$_{C\text{-}F}$ = 28.4 Hz, C$_q$), 124.8 (q, $^1$J$_{C\text{-}F}$ = 272.3 Hz, C$_q$), 123.5 (q, $^3$J$_{C\text{-}F}$ = 5.9 Hz, CH), 33.6(CH), 28.9 (q, $^4$J$_{C\text{-}F}$ = 1.8 Hz, CH), 24.3 (CH$_3$), 23.8 (CH$_3$). $^{19}$F-NMR (376 MHz, CDCl$_3$): $\delta$ = –58.9 (s). IR (ATR): 2960, 2926, 1462, 1315, 1148, 1122, 1054 cm$^{-1}$. MS (EI) m/z (relative intensity): 230 (30) [M]$^+$, 215 (100) [M-CH$_3$]$^+$. HR-MS (EI) m/z calc. for C$_{13}$H$_{17}$F$_3$ [M]$^+$: 230.1277, found: 230.1282.

4-(tert-Butyl)-1-methoxy-2-(trifluoromethyl)benzene (3d)

The general procedure B was followed using 1d (41 mg, 0.25 mmol) at 23 °C for 8 h. Purification by column chromatography on silica gel (n-hexane) yielded 3d (41 mg, 71%) as a colorless oil. $^1$H-NMR (500 MHz, CDCl$_3$): $\delta$ = 7.57–7.52 (m, 1H), 7.51–7.44 (m, 1H), 6.92 (d, $J$ = 8.6 Hz, 1H), 3.87 (s, 3H), 1.29 (s, 9H). $^{13}$C-NMR (125 MHz, CDCl$_3$): $\delta$ = 155.2 (q, $^3$J$_{C\text{-}F}$ = 1.6 Hz, C$_q$), 142.9 (C$_q$), 129.9 (CH), 123.9 (q, $^3$J$_{C\text{-}F}$ = 5.3 Hz, CH), 123.9 (q, $^1$J$_{C\text{-}F}$ = 272.4 Hz, C$_q$), 118.0 (q, $^2$J$_{C\text{-}F}$ = 30.2 Hz, C$_q$), 111.7 (CH), 56.0 (CH$_3$), 34.2 (C$_q$), 31.3 (CH$_3$). $^{19}$F-NMR (470 MHz, CDCl$_3$): $\delta$ = –62.1 (s). IR (ATR): 2963, 2910, 1620, 1509, 1325, 1281, 1254, 1127, 1058, 1028 cm$^{-1}$. MS (EI) m/z (relative intensity): 232 (30) [M]$^+$, 217 (100) [M-CH$_3$]$^+$. HR-MS (EI) m/z calc. for C$_{12}$H$_{15}$F$_3$O [M]$^+$: 232.1070, found: 232.1069. The analytical data correspond with those reported in the literature.$^{[1]}$
1,4-Dimethoxy-2-(trifluoromethyl)benzene (3e)

The mono/bis ratio was determined to be 3:1 by $^1$H-NMR analysis of the crude reaction mixture. The general procedure B was followed using 1e (35 mg, 0.25 mmol) at 23 °C for 16 h. Purification by column chromatography on silica gel ($n$-hexane/EtOAc = 50:1) yielded 3e (33 mg, 63%) as a colorless oil. $^1$H-NMR (300 MHz, CDCl$_3$): $\delta$ = 7.17–7.11 (m, 1H), 7.08–7.01 (m, 1H), 6.97 (d, $J =$ 9.0 Hz, 1H), 3.88 (s, 3H), 3.82 (s, 3H). $^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ = 152.9 (C$_q$), 151.6 (q, $^3J_{C-F}$ = 1.7 Hz, C$_q$), 123.4 (q, $^1J_{C-F}$ = 272.5 Hz, C$_q$), 119.4 (q, $^2J_{C-F}$ = 31.0 Hz, C$_q$), 118.1 (CH), 113.6 (CH), 112.8 (q, $^3J_{C-F}$ = 5.4 Hz, CH), 56.6 (CH$_3$), 55.9 (CH$_3$). $^{19}$F-NMR (470 MHz, CDCl$_3$): $\delta$ = –62.4 (s). IR (ATR): 2954, 2921, 1504, 1415, 1306, 1122, 1043 cm$^{-1}$. MS (EI) $m/z$ (relative intensity): 206 (90) [M]$^+$, 191 (100) [M-CH$_3$]$^+$. HR-MS (EI) $m/z$ calc. for C$_9$H$_9$F$_3$O$_2$ [M]$^+$: 206.0549, found: 206.0552. The analytical data correspond with those reported in the literature.[2]

1,3,5-Trimethoxy-2-(trifluoromethyl)benzene (3f)

The general procedure A was followed using 1f (42 mg, 0.25 mmol) at 23 °C for 8 h. Purification by column chromatography on silica gel ($n$-hexane/EtOAc = 10:1) yielded 3f (43 mg, 73%) as a white solid. M. p.: 64–65 °C. $^1$H-NMR (400 MHz, CDCl$_3$): $\delta$ = 6.11 (s, 2H), 3.82 (s, 6H), 3.82 (s, 3H). $^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ = 163.5 (C$_q$), 160.4 (q, $^3J_{C-F}$ = 1.4 Hz, C$_q$), 124.3 (q, $^1J_{C-F}$ = 273.3 Hz, C$_q$), 100.4 (q, $^2J_{C-F}$ = 30.2 Hz, C$_q$), 91.2 (CH), 56.2 (CH$_3$), 55.4 (CH$_3$). $^{19}$F-NMR (376 MHz, CDCl$_3$): $\delta$ = –54.2 (s). IR (ATR): 2951, 2920, 1594, 1460, 1417, 1276, 1204, 1090, 1025 cm$^{-1}$. MS (ESI) $m/z$ (relative intensity): 259 (20) [M+Na]$^+$, 237 (100) [M+H]$^+$. HR-MS (ESI) $m/z$ calc. for C$_{10}$H$_{12}$F$_3$O$_3$ [M+H]$^+$: 237.0733, found: 237.0735. The analytical data correspond with those reported in the literature.[2]
Methyl 3,4,5-trimethoxy-2-(trifluoromethyl)benzoate (3g)

The general procedure A was followed using 1g (57 mg, 0.25 mmol) at 23 °C for 16 h. Purification by column chromatography on silica gel (n-hexane/EtOAc = 5:1) yielded 3ag (46 mg, 62%) as a colorless oil. \( ^1 \)H-NMR (400 MHz, CDCl\(_3\)): \( \delta = 6.73 \) (s, 1H), 3.93 (s, 3H), 3.89 (s, 3H), 3.87 (s, 3H), 3.87 (s, 3H). \( ^{13} \)C-NMR (100 MHz, CDCl\(_3\)): \( \delta = 168.4 \) (C\(_q\)), 155.9 (C\(_q\)), 153.0 (q, \( J_{C-F} = 1.6 \) Hz, C\(_q\)), 144.2 (C\(_q\)), 128.4 (q, \( J_{C-F} = 2.8 \) Hz, C\(_q\)), 123.0 (q, \( J_{C-F} = 273.1 \) Hz, C\(_q\)), 114.6 (q, \( J_{C-F} = 31.0 \) Hz, C\(_q\)), 106.9 (CH), 61.9 (CH\(_3\)), 60.9 (CH\(_3\)), 56.2 (CH\(_3\)), 53.0 (CH\(_3\)). \( ^{19} \)F-NMR (376 MHz, CDCl\(_3\)): \( \delta = 56.9 \) (s). IR (ATR): 2952, 1735, 1580, 1457, 1404, 1342, 1300, 1222, 1034 cm\(^{-1}\). MS (ESI) m/z (relative intensity): 317 (100) [M+Na]\(^+\). HR-MS (ESI) m/z calc. for C\(_{12}\)H\(_{13}\)F\(_3\)O\(_5\)Na [M+Na]\(^+\): 317.0607, found: 317.0611. The analytical data correspond with those reported in the literature.\(^{[3]}\)

1,3,5-Trichloro-2-(trifluoromethyl)benzene (3h)

The general procedure B was followed using 1h (45 mg, 0.25 mmol) at 23 °C for 16 h. Purification by column chromatography on silica gel (pentane) yielded 3h (31 mg, 50%) as a colorless oil. \( ^1 \)H-NMR (400 MHz, CDCl\(_3\)): \( \delta = 7.44–7.42 \) (m, 2H). \( ^{13} \)C-NMR (100 MHz, CDCl\(_3\)): \( \delta = 138.0 \) (C\(_q\)), 135.3 (q, \( J_{C-F} = 1.3 \) Hz, C\(_q\)), 130.6 (CH), 124.9 (q, \( J_{C-F} = 31.3 \) Hz, C\(_q\)), 122.2 (q, \( J_{C-F} = 276.2 \) Hz, C\(_q\)). \( ^{19} \)F-NMR (376 MHz, CDCl\(_3\)): \( \delta = -55.7 \) (s). IR (ATR): 2956, 2925, 1580, 1567, 1375, 1283, 1209, 1142, 1114, 1030 cm\(^{-1}\). MS (EI) m/z (relative intensity): 248 (100) [M]\(^+\). HR-MS (EI) m/z calc. for C\(_7\)H\(_2\)\(^{35}\)Cl\(_3\)F\(_3\) [M]\(^+\): 247.9169, found: 247.9178. The analytical data correspond with those reported in the literature.\(^{[1]}\)
Methyl 5-(trifluoromethyl)furan-2-carboxylate (5a)

The general procedure B was followed using 4a (32 mg, 0.25 mmol) at 23 °C for 8 h. Purification by column chromatography on silica gel (n-hexane/EtOAc = 50:1) yielded 5a (38 mg, 77%) as a colorless oil. $^1$H-NMR (400 MHz, CDCl$_3$): $\delta$ = 7.18 (dq, $J$ = 3.6, 0.9 Hz, 1H), 6.86 (dq, $J$ = 3.6, 1.1 Hz, 1H), 3.92 (s, 3H). $^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ = 158.1 (C$_q$), 146.3 (q, $^4$J$_{C-F}$ = 1.4 Hz, C$_q$), 144.6 (q, $^2$J$_{C-F}$ = 43.3 Hz, C$_q$), 118.3 (q, $^1$J$_{C-F}$ = 268.2 Hz, C$_q$), 117.6 (CH), 112.8 (q, $^3$J$_{C-F}$ = 2.7 Hz, CH), 52.5 (CH$_3$). $^{19}$F-NMR (376 MHz, CDCl$_3$): $\delta$ = 64.5 (s). IR (ATR): 2957, 2923, 1740, 1461, 1378, 1309, 1147 cm$^{-1}$. MS (ESI) m/z (relative intensity): 217 (20) [M+Na]$^+$, 195 (100) [M+H]$^+$. HR-MS (ESI) m/z calc. for C$_7$H$_5$F$_3$O$_3$Na [M+Na]$^+$: 217.0083, found: 217.0086. The analytical data correspond with those reported in the literature.$^{[1]}$

Methyl 3-methyl-5-(trifluoromethyl)furan-2-carboxylate (5b)

The general procedure B was followed using 4b (35 mg, 0.25 mmol) at 23 °C for 16 h. Purification by column chromatography on silica gel (n-hexane/DCM = 1:1) yielded 5b (37 mg, 71%) as a colorless oil. $^1$H-NMR (400 MHz, CDCl$_3$): $\delta$ = 6.74–6.69 (m, 1H), 3.90 (s, 3H), 2.36 (s, 3H). $^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ = 159.1 (C$_q$), 143.0 (q, $^2$J$_{C-F}$ = 43.0 Hz, C$_q$), 141.7 (q, $^4$J$_{C-F}$ = 1.5 Hz, C$_q$), 130.8 (C$_q$), 118.4 (q, $^1$J$_{C-F}$ = 268.3 Hz, C$_q$), 115.7 (q, $^3$J$_{C-F}$ = 2.6 Hz, CH), 52.0 (CH$_3$), 11.4 (CH$_3$). $^{19}$F-NMR (376 MHz, CDCl$_3$): $\delta$ = −64.6 (s). IR (ATR): 2954, 2924, 1747, 1460, 1377, 1261, 1105 cm$^{-1}$. MS (ESI) m/z (relative intensity): 231 (30) [M+Na]$^+$, 209 (10) [M+H]$^+$. HR-MS (ESI) m/z calc. for C$_8$H$_9$F$_3$O$_3$ [M+H]$^+$: 209.0420, found: 209.0418.

Methyl 2-methyl-5-(trifluoromethyl)furan-3-carboxylate (5c)

The general procedure B was followed using 4c (35 mg, 0.25 mmol) at 23 °C for 16 h. Purification by column chromatography on silica gel (n-hexane/DCM = 1:1) yielded 5c...
(33 mg, 64%) as a colorless oil.  

\[ \delta = 7.06 \text{ (s, 1H), 3.88 \text{ (s, 3H), 2.66 \text{ (s, 3H)}} \].  

\[ \mathrm{H}^1\text{-NMR (400 MHz, CDCl}_3\mathrm{): } \delta = 163.2 \text{ (C,q), 161.5 \text{ (C,q), 139.8 \text{ (q, } J_{C-F} = 43.4 \text{ Hz, C,q), 118.7 \text{ (q, } J_{C-F} = 267.0 \text{ Hz, C,q), 114.4 \text{ (C,q), 112.6 \text{ (q, } J_{C-F} = 2.8 \text{ Hz, CH), 51.7 (CH}_3\text{), 13.8 (CH}_3\text{).}}} \]

\[ \mathrm{C}^13\text{-NMR (100 MHz, CDCl}_3\mathrm{): } \delta = 163.2 \text{ (C,q), 161.5 \text{ (C,q), 139.8 (q, } J_{C-F} = 43.4 \text{ Hz, C,q), 118.7 (q, } J_{C-F} = 267.0 \text{ Hz, C,q), 114.4 \text{ (C,q), 112.6 (q, } J_{C-F} = 2.8 \text{ Hz, CH), 51.7 (CH}_3\text{), 13.8 (CH}_3\text{).}}} \]

\[ \mathrm{F}\text{-NMR (376 MHz, CDCl}_3\mathrm{): } \delta = -64.5 \text{ (s). IR (ATR): 2956, 2925, 1730, 1621, 1448, 1255, 1135, 1063 cm}^{-1\text). MS (ESI) m/z \text{ (relative intensity): 231 (5) [M+Na]^{+}, 209 (20) [M+H]^{+}. HR-MS (ESI) m/z \text{ calc. for C}_8\text{H}_8\text{F}_3\text{O}_3 \text{[M+H]}^{+}: 209.0420, found: 209.0426.} \]

\[ 3,6\text{-Dimethyl-2-(trifluoromethyl)-4,5,6,7-tetrahydrobenzofuran (5d)} \]

The general procedure A was followed using 4d (38 mg, 0.25 mmol) at 23 °C for 16 h. Purification by column chromatography on silica gel (pentane) yielded 5d (36 mg, 65%) as a colorless oil.  

\[ \delta = 2.75–2.64 \text{ (m, 1H), 2.45–2.27 (m, 2H), 2.25–2.15 (m, 1H), 2.06 (q, } J = 2.0 \text{ Hz, 3H), 2.02–1.91 (m, 1H), 1.91–1.83 (m, 1H), 1.45–1.32 (m, 1H), 1.11 \text{ (d, } J = 6.7 \text{ Hz, 3H). 13C-NMR (100 MHz, CDCl}_3\mathrm{): } \delta = 152.4 \text{ (q, } J_{C-F} = 1.4 \text{ Hz, C,q), 134.9 (q, } J_{C-F} = 39.9 \text{ Hz, C,q), 122.5 (q, } J_{C-F} = 2.4 \text{ Hz, C,q), 120.7 (q, } J_{C-F} = 266.9 \text{ Hz, C,q), 119.0 \text{ (C,q), 31.1 (CH}_2\text{), 30.8 (CH}_2\text{), 29.4 (CH), 21.3 (CH}_3\text{), 19.5 (CH}_2\text{), 7.9 (CH}_3\text{). 19F-NMR (282 MHz, CDCl}_3\mathrm{): } \delta = -61.2 \text{ (s). IR (ATR): 2927, 1590, 1424, 1368, 1355, 1113, 1045 cm}^{-1\text). MS (EI) m/z \text{ (relative intensity): 218 (30) [M]^{+}. HR-MS (EI) m/z \text{ calc. for C}_{11}\text{H}_{13}\text{F}_3\text{O [M]}^{+}: 218.0913, found: 218.0923.} \]

\[ N\text{-Methyl-5-(trifluoromethyl)furan-2-carboxamide (5e)} \]

The general procedure B was followed using 4e (31 mg, 0.25 mmol) at 23 °C for 16 h. Purification by column chromatography on silica gel (n-hexane/EtOAc = 2:1) yielded 5e (33 mg, 69%) as a white solid. M. p.: 78–80 °C.  

\[ \delta = 7.16–7.09 \text{ (m, 1H), 6.89–6.83 (m, 1H), 6.45 (brs, 1H), 2.99 \text{ (d, } J = 5.0 \text{ Hz, 3H). 13C-NMR (125 MHz, CDCl}_3\mathrm{): } \delta = 157.8 \text{ (C,q), 149.7 (q, } J_{C-F} = 1.3 \text{ Hz, C,q), 142.4 (q, } J_{C-F} = 43.2 \text{ Hz, C,q), 118.4 (q, 5-11}} \]
$^{1}J_{C-F} = 267.8$ Hz, C$_{q}$), 114.0 (CH), 113.4 (q, $^{3}J_{C-F} = 2.7$ Hz, CH), 26.0 (CH$_{3}$). $^{19}$F-NMR (470 MHz, CDCl$_{3}$): $\delta = -64.3$ (s). IR (ATR): 3294, 2953, 2922, 1574, 1309, 1178, 1107, 1017 cm$^{-1}$. MS (ESI) m/z (relative intensity): 216 (100) [M+Na]$^{+}$, 194 (45) [M+H]$^{+}$. HR-MS (ESI) m/z calc. for C$_{7}$H$_{5}$F$_{3}$NO$_{2}$ [M+H]$^{+}$: 210.0195, found: 210.0190.

![5f](image)

**Ethyl (5-(trifluoromethyl)furan-2-carbonyl)glycinate (5f)**

The general procedure B was followed using 4f (49 mg, 0.25 mmol) at 23 °C for 16 h. Purification by column chromatography on silica gel (n-hexane/EtOAc = 2:1) yielded 5f (46 mg, 70%) as a white solid. M. p.: 66–68 °C. $^{1}$H-NMR (400 MHz, CDCl$_{3}$): $\delta = 7.15$ (dq, $J = 3.6, 0.9$ Hz, 1H), 6.90 (s, 1H), 6.87 (dq, $J = 3.6, 1.1$ Hz, 1H), 4.24 (q, $J = 7.2$ Hz, 2H), 4.19 (d, $J = 5.4$ Hz, 2H), 1.29 (t, $J = 7.2$ Hz, 3H). $^{13}$C-NMR (100 MHz, CDCl$_{3}$): $\delta = 169.3$ (C$_{q}$), 157.1 (C$_{q}$), 149.0 (q, $^{4}J_{C-F} = 1.3$ Hz, C$_{q}$), 142.9 (q, $^{2}J_{C-F} = 43.3$ Hz, C$_{q}$), 118.3 (d, $^{1}J_{C-F} = 267.9$ Hz, C$_{q}$), 114.8 (CH), 113.4 (q, $^{3}J_{C-F} = 2.7$ Hz, CH), 61.8 (CH$_{2}$), 41.1 (CH$_{2}$), 14.1 (CH$_{3}$).

$^{19}$F-NMR (376 MHz, CDCl$_{3}$): $\delta = -64.3$ (s). IR (ATR): 3329, 2988, 2943, 1744, 1665, 1572, 1307, 1182, 1109, 1019 cm$^{-1}$. MS (ESI) m/z (relative intensity): 288 (100) [M+Na]$^{+}$, 266 (10) [M+H]$^{+}$. HR-MS (ESI) m/z calc. for C$_{10}$H$_{11}$F$_{3}$NO$_{2}$ [M+H]$^{+}$: 266.0635, found: 266.0634.

![5g](image)

**N-Methyl-5-(trifluoromethyl)thiophene-2-carboxamide (5g)**

The general procedure B was followed using 4g (35 mg, 0.25 mmol) at 23 °C for 16 h. Purification by column chromatography on silica gel (n-hexane/EtOAc = 2:1) yielded 5g (38 mg, 73%) as a white solid. M. p.: 130–132 °C. $^{1}$H-NMR (400 MHz, CDCl$_{3}$): $\delta = 7.38$ (dq, $J = 3.9, 1.1$ Hz, 1H), 7.36 (dq, $J = 3.9, 0.9$ Hz, 1H), 6.24 (brs, 1H), 2.99 (d, $J = 4.9$ Hz, 3H). $^{13}$C-NMR (100 MHz, CDCl$_{3}$): $\delta = 161.4$ (C$_{q}$), 142.6 (C$_{q}$), 134.9 (q, $^{2}J_{C-F} = 38.7$ Hz, C$_{q}$), 128.6 (q, $^{3}J_{C-F} = 3.7$ Hz, CH), 126.6 (CH), 121.9 (q, $^{1}J_{C-F} = 269.6$ Hz, C$_{q}$), 26.9 (CH$_{3}$). $^{19}$F-NMR (376 MHz, CDCl$_{3}$): $\delta = -56.0$ (s). IR (ATR): 3276, 2986, 1734, 1373, 1239, 1045, 913 cm$^{-1}$. MS (ESI) m/z (relative intensity): 232 (100) [M+Na]$^{+}$, 210 (30) [M+H]$^{+}$. HR-MS (ESI) m/z calc. for C$_{7}$H$_{5}$F$_{3}$NOS [M+H]$^{+}$: 210.0195, found: 210.0190.
2-Butyl-5-(trifluoromethyl)thiophene (5h)

The ratio of two mono-substituted products was determined to be 10:1 by $^1$H-NMR analysis of the crude reaction mixture. The general procedure A was followed using 4h (35 mg, 0.25 mmol) at 23 °C for 16 h. Purification by column chromatography on silica gel (n-hexane) yielded 5h (34 mg, 65%) as a colorless oil. $^1$H-NMR (300 MHz, CDCl$_3$): $\delta = 7.28$–$7.25$ (m, 1H), 6.78–6.73 (m, 1H), 2.85 (t, $J = 7.6$ Hz, 2H), 1.75–1.64 (m, 2H), 1.49–1.35 (m, 2H), 0.97 (t, $J = 7.3$ Hz, 3H). $^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta = 150.3$ (q, $^4J_{C-F} = 1.3$ Hz, C$_q$), 128.4 (q, $^3J_{C-F} = 3.8$ Hz, CH), 128.3 (q, $^2J_{C-F} = 38.2$ Hz, C$_q$), 123.8 (CH), 122.6 (q, $^1J_{C-F} = 268.1$ Hz, C$_q$), 33.6 (CH$_2$), 29.7 (CH$_2$), 22.1 (CH$_2$), 13.7 (CH$_3$). $^{19}$F-NMR (282 MHz, CDCl$_3$): $\delta = -55.1$ (s). IR (ATR): 2957, 2924, 1481, 1378, 1299, 1154, 1125, 1051 cm$^{-1}$. MS (EI) $m/z$ (relative intensity): 208 (30) [M]$^+$, 165 (100). HR-MS (EI) $m/z$ calc. for C$_9$H$_{11}$F$_3$S [M]$^+$: 208.0534, found: 208.0526.

4,6-Dimethoxy-5-(trifluoromethyl)pyrimidine (5i)

The general procedure B was followed using 4i (35 mg, 0.25 mmol) at 23 °C for 15 h. Purification by column chromatography on silica gel (n-hexane/EtOAc = 30:1) yielded 5i (32 mg, 62%) as a white solid. M. p.: 94–96 °C. $^1$H-NMR (400 MHz, CDCl$_3$): $\delta = 8.45$ (s, 1H), 4.02 (s, 6H). $^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta = 167.9$ (C$_q$), 158.9 (CH), 122.8 (q, $^1J_{C-F} = 272.9$ Hz, C$_q$), 95.4 (q, $^2J_{C-F} = 33.8$ Hz, C$_q$), 55.0 (CH$_3$). $^{19}$F-NMR (376 MHz, CDCl$_3$): $\delta = -56.9$ (s). IR (ATR): 2954, 2924, 1573, 1476, 1386, 1244, 1099, 1034 cm$^{-1}$. MS (ESI) $m/z$ (relative intensity): 231 (50) [M+Na]$^+$, 209 (100) [M+H]$^+$. HR-MS (ESI) $m/z$ calc. for C$_7$H$_8$F$_3$N$_2$O$_2$ [M+H]$^+$: 209.0538, found: 209.0540. The analytical data correspond with those reported in the literature.$^{[1]}$
3-Methyl-2-(trifluoromethyl)benzofuran (5j)

The general procedure A was followed using 4j (33 mg, 0.25 mmol) at 23 °C for 8 h. Purification by column chromatography on silica gel (n-hexane) yielded 5j (36 mg, 72%) as a colorless oil. $^1$H-NMR (400 MHz, CDCl$_3$): $\delta = 7.59$ (d, $J = 7.8$ Hz, 1H), 7.52–7.48 (m, 1H), 7.45–7.39 (m, 1H), 7.31 (ddd, $J = 7.8$, 7.2, 1.0 Hz, 1H), 2.39 (q, $J = 2.1$ Hz, 3H). $^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta = 154.0$ (C$_q$), 138.5 (q, $^{2}J_{C-F} = 39.8$ Hz, C$_q$), 128.4 (C$_q$), 126.9 (CH), 123.3 (CH), 120.6 (CH), 120.5 (q, $^{1}J_{C-F} = 267.0$ Hz, C$_q$), 118.2 (q, $^{3}J_{C-F} = 2.7$ Hz, C$_q$), 111.9 (CH), 7.7 (q, $^{4}J_{C-F} = 1.0$ Hz, CH$_3$). $^{19}$F-NMR (376 MHz, CDCl$_3$): $\delta = 62.0$ (s). IR (ATR): 2956, 2925, 1635, 1454, 1385, 1302, 1129, 1083, 1041 cm$^{-1}$. MS (EI) m/z (relative intensity): 200 (100) [M]$^+$.

HR-MS (EI) m/z calc. for C$_{10}$H$_7$F$_3$O [M]$^+$: 200.044, found: 200.0443. The analytical data correspond with those reported in the literature.$^{[1]}$

![Image](image-url)

5j

3-Methyl-2-(trifluoromethyl)benzo[b]thiophene (5k)

The general procedure A was followed using 4k (37 mg, 0.25 mmol) at 23 °C for 8 h. Purification by column chromatography on silica gel (n-hexane) yielded 5k (35 mg, 65%) as a colorless oil. $^1$H-NMR (400 MHz, CDCl$_3$): $\delta = 7.86–7.81$ (m, 1H), 7.80–7.76 (m, 1H), 7.48–7.41 (m, 2H), 2.55 (q, $J = 1.8$ Hz, 3H). $^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta = 139.6$ (C$_q$), 138.5 (q, $^{4}J_{C-F} = 1.0$ Hz, C$_q$), 134.7 (q, $^{3}J_{C-F} = 3.3$ Hz, C$_q$), 126.5 (CH), 124.9 (q, $^{2}J_{C-F} = 31.4$ Hz, C$_q$), 124.8 (CH), 123.2 (q, $^{1}J_{C-F} = 270.5$ Hz, C$_q$), 123.0 (CH), 122.6 (CH), 119 (CH$_3$). $^{19}$F-NMR (282 MHz, CDCl$_3$): $\delta = -54.1$ (s). IR (ATR): 2957, 2928, 1579, 1438, 1359, 1290, 1120, 989 cm$^{-1}$. MS (EI) m/z (relative intensity): 216 (100) [M]$^+$.

HR-MS (EI) m/z calc. for C$_{10}$H$_7$F$_3$O [M]$^+$: 216.0215, found: 216.0212. The analytical data correspond with those reported in the literature.$^{[1]}$

![Image](image-url)

5l

1,2-Dimethyl-3-(trifluoromethyl)-1H-indole (5l)

The general procedure A was followed using 4l (36 mg, 0.25 mmol) at 23 °C for 16 h. Purification by column chromatography on silica gel (n-hexane/EtOAc = 30:1) yielded 5l
(30 mg, 57%) as a colorless oil. \(^1\)H-NMR (400 MHz, CDCl\(_3\)): \(\delta = 7.72-7.67\) (m, 1H), 7.30–7.26 (m, 1H), 7.25–7.20 (m, 1H), 7.19–7.14 (m, 1H), 3.67 (s, 3H), 2.52 (q, \(J = 1.4\) Hz, 3H).

\(^1^3\)C-NMR (100 MHz, CDCl\(_3\)): \(\delta = 137.2\) (q, \(^3\)J\(_{C-F}\) = 3.8 Hz, C\(_q\)), 136.1 (C\(_q\)), 125.5 (q, \(^1\)J\(_{C-F}\) = 266.7 Hz, C\(_q\)), 124.4 (q, \(^3\)J\(_{C-F}\) = 1.8 Hz, C\(_q\)), 122.0 (CH), 121.0 (CH), 119.0 (CH), 109.2 (CH), 102.6 (q, \(^2\)J\(_{C-F}\) = 35.2 Hz, C\(_q\)), 29.5 (CH\(_3\)), 10.9 (q, \(^4\)J\(_{C-F}\) = 1.8 Hz, CH\(_3\)).

\(^1^9\)F-NMR (376 MHz, CDCl\(_3\)): \(\delta = 53.7\) (s). IR (ATR): 2949, 2926, 1617, 1558, 1475, 1416, 1283, 1226, 1076 cm\(^{-1}\). MS (ESI) m/z (relative intensity): 236 (100) [M+Na]\(^+\), 214 (40) [M+H]\(^+\). HR-MS (ESI) m/z calc. for C\(_{11}\)H\(_{11}\)F\(_3\)N [M+H]\(^+\): 214.0838, found: 214.0833. The analytical data correspond with those reported in the literature.\(^2\)

1-(1-Benzyl-2-(trifluoromethyl)-1H-indol-3-yl)ethan-1-one (5m)

The general procedure B was followed using 4m (62 mg, 0.25 mmol) at 23 °C for 16 h. Purification by column chromatography on silica gel (n-hexane/EtOAc = 15:1) yielded 5m (45 mg, 57%) as a colorless oil. \(^1\)H-NMR (400 MHz, CDCl\(_3\)): \(\delta = 7.94\) (d, \(J = 8.0\) Hz, 1H), 7.39–7.27 (m, 6H), 7.07–7.00 (m, 2H), 5.6 (s, 2H), 2.7 (s, 3H). \(^1^3\)C-NMR (100 MHz, CDCl\(_3\)): \(\delta = 196.8\) (C\(_q\)), 137.0 (C\(_q\)), 136.0 (C\(_q\)), 128.9 (CH), 127.8 (CH), 125.8 (CH), 125.8 (CH), 125.3 (d, \(^2\)J\(_{C-F}\) = 37.5 Hz), 124.8 (C\(_q\)), 122.8 (CH), 121.9 (CH), 121.1 (q, \(^1\)J\(_{C-F}\) = 268.9 Hz, C\(_q\)), 120.4 (q, \(^3\)J\(_{C-F}\) = 2.7 Hz, C\(_q\)), 111.0 (CH). 48.8 (q, \(^4\)J\(_{C-F}\) = 2.9 Hz, CH\(_2\)), 32.0 (q, \(^5\)J\(_{C-F}\) = 3.0 Hz, CH\(_3\)). \(^1^9\)F-NMR (282 MHz, CDCl\(_3\)): \(\delta = -53.4\) (s). IR (ATR): 2956, 2925, 1680, 1541, 1416, 1352, 1249, 1226, 1164, 1117, 1089 cm\(^{-1}\). MS (ESI) m/z (relative intensity): 340 (100) [M+Na]\(^+\), 318 (30) [M+H]\(^+\). HR-MS (ESI) m/z calc. for C\(_{18}\)H\(_{13}\)F\(_3\)NO [M+H]\(^+\): 318.1100, found: 318.1097.

4-Methyl-2-(trifluoromethyl)quinoline (5n)
The ratio of two mono-substituted products was determined to be 20:1 by $^1$H-NMR analysis of the crude reaction mixture, while the exact substituent position in the minor component could not be identified. The general procedure A was followed using 4n (36 mg, 0.25 mmol) at 23 °C for 15 h. Purification by column chromatography on silica gel ($n$-hexane/EtOAc = 10:1) yielded 5n (29 mg, 55%) as a colorless oil. $^1$H-NMR (500 MHz, CDCl$_3$): $\delta$ = 8.92 (d, $J$ = 4.4 Hz, 1H), 8.20 (dd, $J$ = 8.4, 0.8 Hz, 1H), 8.06 (ddq, $J$ = 7.4, 1.5, 0.8 Hz, 1H), 7.60 (ddd, $J$ = 8.4, 7.4, 0.8 Hz, 1H), 7.32 (dq, $J$ = 4.4, 1.0 Hz, 1H), 2.73 (d, $J$ = 1.0 Hz, 3H). $^{13}$C-NMR (125 MHz, CDCl$_3$): $\delta$ = 150.9 (CH), 144.6 (q, $^3$J$_{C-F}$ = 3.2 Hz, C$_q$), 144.6 (C$_q$), 128.8 (C$_q$), 128.4 (q, $^4$J$_{C-F}$ = 0.8 Hz, CH), 128.2 (q, $^2$J$_{C-F}$ = 29.2 Hz, C$_q$), 127.6 (q, $^1$J$_{C-F}$ = 5.7 Hz, CH), 124.8 (CH), 124.2 (q, $^1$J$_{C-F}$ = 273.4 Hz, C$_q$), 122.7 (CH), 19.0 (CH$_3$), 109.2 cm$^{-1}$. MS (ESI) m/z (relative intensity): 234 (95) [M+Na]$^+$, 212 (100) [M+H]$^+$. HR-MS (ESI) m/z calc. for C$_{11}$H$_9$F$_3$N$_2$ [M+H]$^+$: 212.0682, found: 212.0682.

1,3,7-Trimethyl-8-(trifluoromethyl)-3,7-dihydro-1H-purine-2,6-dione (6)

The general procedure A was followed using caffeine (49 mg, 0.25 mmol) at 23 °C for 8 h. Purification by column chromatography on silica gel ($n$-hexane/EtOAc = 3:1) yielded 6 (46 mg, 70%) as a white solid. M. p.: 128–130 °C. $^1$H-NMR (400 MHz, CDCl$_3$): $\delta$ = 4.13 (q, $J$ = 1.2 Hz, 3H), 3.56 (s, 3H), 3.39 (s, 3H). $^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ = 155.4 (C$_q$), 151.3 (C$_q$), 146.5 (C$_q$), 138.9 (q, $^2$J$_{C-F}$ = 40.0 Hz, C$_q$), 118.2 (q, $^1$J$_{C-F}$ = 271.3 Hz, C$_q$), 109.6 (C$_q$), 33.2 (q, $^4$J$_{C-F}$ = 1.9 Hz, CH$_3$), 29.9 (CH$_3$), 28.2 (CH$_3$). $^{19}$F-NMR (376 MHz, CDCl$_3$): $\delta$ = -62.4 (s). IR (ATR): 2957, 2927, 1708, 1662, 1548, 1460, 1428, 1243, 1141, 1098 cm$^{-1}$. MS (ESI) m/z (relative intensity): 285 (80) [M+Na]$^+$, 263 (100) [M+H]$^+$. HR-MS (ESI) m/z calc. for C$_9$H$_{10}$F$_3$N$_4$O$_2$ [M+H]$^+$: 263.0750, found: 263.0751. The analytical data correspond with those reported in the literature.[2]
3,7-Dimethyl-1-(5-oxohexyl)-8-(trifluoromethyl)-3,7-dihydro-1H-purine-2,6-dione (7)

The general procedure A was followed using Pentoxifylline (70 mg, 0.25 mmol) at 23 °C for 16 h. Purification by column chromatography on silica gel (n-hexane/EtOAc = 1:1) yielded 7 (63 mg, 72%) as a colorless oil. \(^1\)H-NMR (400 MHz, CDCl\(_3\)): \(\delta = 4.11\) (q, \(J = 1.2\) Hz, 3H), 3.98 (t, \(J = 8.0\) Hz, 2H), 3.54 (s, 3H), 2.46 (t, \(J = 6.9\) Hz, 2H), 2.10 (s, 3H), 1.67–1.56 (m, 4H). \(^13\)C-NMR (100 MHz, CDCl\(_3\)): \(\delta = 208.5\) (C\(_q\)), 155.3 (C\(_q\)), 151.0 (C\(_q\)), 146.5 (C\(_q\)), 138.9 (q, \(^2\)J\(_{C-F}\) = 40.1 Hz, C\(_q\)), 118.2 (q, \(^1\)J\(_{C-F}\) = 271.4 Hz, C\(_q\)), 109.6 (C\(_q\)), 43.0 (CH\(_2\)), 41.1 (CH\(_2\)), 33.1 (q, \(^4\)J\(_{C-F}\) = 2.0 Hz, CH\(_2\)), 29.9 (CH\(_3\)), 29.8 (CH\(_3\)). \(^19\)F-NMR (376 MHz, CDCl\(_3\)): \(\delta = -62.4\) (s). IR (ATR): 2957, 1708, 1661, 1609, 1547, 1462, 1334, 1247, 1130, 1098 cm\(^{-1}\). MS (ESI) \(m/z\) (relative intensity): 369 (100) [M+Na]\(^+\), 347 (20) [M+H]\(^+\). HR-MS (ESI) \(m/z\) calc. for C\(_{14}\)H\(_{18}\)F\(_3\)N\(_4\)O\(_3\) [M+H]\(^+\): 347.1326, found: 347.1320. The analytical data correspond with those reported in the literature.\(^{[2]}\)

7-((1,3-Dioxolan-2-yl)methyl)-1,3-dimethyl-8-(trifluoromethyl)-3,7-dihydro-1H-purine-2,6-dione (8)

The general procedure A was followed using Doxofylline (67 mg, 0.25 mmol) at 23 °C for 16 h. Purification by column chromatography on silica gel (n-hexane/EtOAc = 2:1) yielded 8 (55 mg, 65%) as a colorless oil. \(^1\)H-NMR (400 MHz, CDCl\(_3\)): \(\delta = 5.31\) (t, \(J = 4.3\) Hz, 1H), 4.65 (dd, \(J = 4.3, 1.0\) Hz, 2H), 3.96–3.83 (m, 4H), 3.57 (s, 3H), 3.39 (s, 3H). \(^13\)C-NMR (100 MHz, CDCl\(_3\)): \(\delta = 155.3\) (C\(_q\)), 151.3 (C\(_q\)), 146.7 (C\(_q\)), 139.1 (q, \(^2\)J\(_{C-F}\) = 40.0 Hz, C\(_q\)), 118.2 (q, \(^1\)J\(_{C-F}\) = 271.6 Hz, C\(_q\)), 109.5 (C\(_q\)), 100.9 (CH), 65.3 (CH\(_2\)), 48.6 (q, \(^4\)J\(_{C-F}\) = 1.5 Hz, CH\(_2\)), 29.9 (CH\(_3\)), 28.3 (CH\(_3\)). \(^19\)F-NMR (376 MHz, CDCl\(_3\)): \(\delta = -62.4\) (s). IR (ATR): 2957, 2896, 1710, 1661, 1612, 1545, 1455, 1346, 1267, 1128, 1038 cm\(^{-1}\). MS (ESI) \(m/z\) (relative intensity): 357
3,7-Dimethyl-8-(trifluoromethyl)-3,7-dihydro-1H-purine-2,6-dione (9)

The general procedure A was followed using Theobromine (45 mg, 0.25 mmol) at 23 °C for 16 h. Purification by column chromatography on silica gel (n-hexane/EtOAc = 1:1) yielded 9 (28 mg, 45%) as a white solid. M. p.: 206–208 °C (dark, decomposed). 1H-NMR (500 MHz, CDCl3): δ = 8.45 (s, 1H), 4.12 (q, J = 1.2 Hz, 3H), 3.53 (s, 3H). 13C-NMR (125 MHz, CDCl3): δ = 154.6 (Cq), 150.5 (Cq), 148.4 (Cq), 139.5 (q, 2JCF = 40.3 Hz, Cq), 118.0 (q, 1JCF = 271.4 Hz, Cq), 109.9 (Cq), 33.3 (q, 4JCF = 1.9 Hz, CH3), 29.2 (CH3). 19F-NMR (470 MHz, CDCl3): δ = –62.5 (s). IR (ATR): 3169, 2958, 2924, 1701, 1548, 1351, 1247, 1194, 1141, 1102 cm⁻¹. MS (ESI) m/z (relative intensity): 271 (30) [M+Na]+, 249 (100) [M+H]+. HR-MS (ESI) m/z calc. for C8H8F3N4O2 [M+H]+: 249.0594, found: 249.0602. The analytical data correspond with those reported in the literature.\(^4\)

\[10\] (ratio: 3/1)

(8R,9S,13S,14S)-3-Methoxy-13-methyl-2-(trifluoromethyl)-6,7,8,9,11,12,13,14,15,16-decahydro-17H-cyclopenta[a]phenanthren-17-one (10)

The ratio of two mono-substituted products was determined to be 3:1 by 1H-NMR analysis of the crude reaction mixture. The general procedure B was followed using Methyl Estrone (71 mg, 0.25 mmol) at 23 °C for 16 h. Purification by column chromatography on silica gel (n-hexane) yielded 10 (48 mg, 55%) as a yellow oil. The ratio was determined to be 10:1 by 1H-NMR analysis after column. 1H-NMR (400 MHz, CDCl3): δ = 7.44 (s, 1H), 6.69 (s, 1H), 3.84 (s, 3H), 2.96–2.87 (m, 2H), 2.54–2.45 (m, 1H), 2.43–2.37 (m, 1H), 2.29–2.22 (m, 1H), 2.13 (dt, J = 18.8, 8.7 Hz, 1H), 2.08–2.00 (m, 2H), 1.98–1.93 (m, 1H), 1.67–1.55 (m, 2H),
1.54–1.41 (m, 4H), 0.89 (s, 3H). \(^{13}\)C-NMR (100 MHz, CDCl\(_3\)): \(\delta = 220.5\) (C\(_q\)), 155.2 (q, \(^3\)J\(_{C-F}\) = 1.4 Hz, C\(_q\)), 142.1 (C\(_q\)), 131.5 (C\(_q\)), 124.1 (q, \(^3\)J\(_{C-F}\) = 5.2 Hz, CH), 124.0 (q, \(^1\)J\(_{C-F}\) = 272.0 Hz, C\(_q\)), 116.2 (q, \(^2\)J\(_{C-F}\) = 30.5 Hz, C\(_q\)), 112.3 (CH), 55.9 (CH\(_3\)), 50.3 (CH), 47.9 (C\(_q\)), 43.7 (CH), 38.1 (CH), 35.8 (CH\(_2\)), 31.4 (CH\(_2\)), 29.8 (CH\(_2\)), 26.2 (CH\(_2\)), 25.8 (CH\(_2\)), 21.5 (CH\(_2\)), 13.8 (CH\(_3\)). \(^{19}\)F-NMR (376 MHz, CDCl\(_3\)): \(\delta = -61.8\) (s). IR (ATR): 2933, 1737, 1621, 1507, 1465, 1416, 1255, 1117, 1051 cm\(^{-1}\). MS (ESI) \(m/z\) (relative intensity): 375 (100) [M+Na]\(^+\), 353 (30) [M+H]\(^+\). HR-MS (ESI) \(m/z\) calc. for C\(_{20}\)H\(_{24}\)F\(_3\)O\(_2\) [M+H]\(^+\): 353.1723, found: 353.1717. The analytical data correspond with those reported in the literature.\(^{[21]}\)

![Methyl (S)-2-acetamido-3-(1-(pyrimidin-2-yl)-2-(trifluoromethyl)-1H-indol-3-yl)propanoate (11)](image)

Methyl (S)-2-acetamido-3-(1-(pyrimidin-2-yl)-2-(trifluoromethyl)-1H-indol-3-yl)propanoate (11)

The general procedure B was followed using Tryptophan derivative (85 mg, 0.25 mmol) at 23 °C for 16 h. Purification by column chromatography on silica gel (n-hexane/EtOAc = 1:1) yielded 11 (65 mg, 64%) as a colorless oil. \(^1\)H-NMR (300 MHz, CDCl\(_3\)): \(\delta = 8.88\) (d, \(J = 4.8\) Hz, 2H), 8.01 (dt, \(J = 8.5, 1.0\) Hz, 1H), 7.84 (d, \(J = 7.6\) Hz, 1H), 7.42 (ddd, \(J = 8.5, 7.1, 1.2\) Hz, 1H), 7.36–7.27 (m, 2H), 6.22 (d, \(J = 7.9\) Hz, 1H), 5.02 (dt, \(J = 7.9, 6.4\) Hz, 1H), 3.68 (s, 3H), 3.59–3.50 (m, 2H), 2.01 (s, 3H). \(^{13}\)C-NMR (100 MHz, CDCl\(_3\)): \(\delta = 172.0\) (C\(_q\)), 169.8 (C\(_q\)), 158.5 (CH), 157.2 (C\(_q\)), 137.0 (C\(_q\)), 127.7 (C\(_q\)), 126.6 (CH), 124.2 (q, \(^2\)J\(_{C-F}\) = 36.4 Hz, C\(_q\)), 122.7 (CH), 121.8 (q, \(^1\)J\(_{C-F}\) = 268.0 Hz, C\(_q\)), 120.3 (CH), 118.9 (q, \(^3\)J\(_{C-F}\) = 2.7 Hz, C\(_q\)), 118.8 (CH), 113.2 (CH), 52.43 (CH), 52.37 (CH\(_3\)), 27.6 (q, \(^4\)J\(_{C-F}\) = 1.8 Hz, CH\(_2\)), 23.1 (CH\(_3\)). \(^{19}\)F-NMR (282 MHz, CDCl\(_3\)): \(\delta = -52.9\) (s). IR (ATR): 3290, 3056, 2955, 1744, 1657, 1567, 1423, 1287, 1087 cm\(^{-1}\). MS (ESI) \(m/z\) (relative intensity): 429 (100) [M+Na]\(^+\), 407 (15) [M+H]\(^+\). HR-MS (ESI) \(m/z\) calc. for C\(_{19}\)H\(_{18}\)F\(_3\)N\(_4\)O\(_3\) [M+H]\(^+\): 407.1326, found: 407.1321.
Some inert examples

A: \([\text{Mes-Acr}^-]\text{ClO}_4^-

B: [\text{Ru(bpy)}_3]\text{[PF}_6\text{]}_2

LiClO_4, \text{CH}_2\text{CN}, \text{rt}, 16 \text{ h}

blue LED, N_2

CCE at 4.0 \text{ mA}

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General Procedure for the Electrophotochemical C–H Trifluoromethylation in Flow

A 15 mL-Schlenk tube was charged with Substrate 1a (60 mg, 0.5 mmol, 1.0 equiv), \(\text{CF}_3\text{SO}_2\text{Na} \) 2 (156 mg, 1.0 mmol, 2.0 equiv), LiClO_4 (85 mg, 0.80 mmol) and [Mes-Acr]+ClO_4− (5.1 mg, 5.0 mol %) and CH_3CN (10.0 mL) under N_2. The tube was sealed with a septum and connected to a balloon filled with N_2. The solution was passed through the electroflow reactor and a following transparent FEP tube (ID 0.5 mm, OD 1/16”) by a peristaltic pump with a flow speed of 1.0 mL/min. Ca. 20 cm of the FEP tube were irradiated. The electrophocatalysis was performed at 23 °C with a constant current of 4.0 mA maintained for 12 h under visible light irradiation (2 × Kessil A360N lamp). Graphite felt was washed by pumping through additional 10 mL of methanol. After dismantling the reactor, the graphite felt anode was washed with CH_2Cl_2 (3 × 20 mL) in an ultrasonic bath. Evaporation of the solvents and subsequent column chromatography on silica gel (pentane) afforded the corresponding products 3a (71 mg, 76%). With 2 mol % of [Ru(bipy)_3](PF_6)_2 (B) as the catalyst, 3a was obtained in 15% yield.

Description of the employed electro-flow-reactor:

Electrocatalysis in flow was designed based on a commercial IKA ElectraSyn flow. The nickel cathode A and gasket D were used directly. Turbulence promoter B and anode slot E for the graphite felt anode C were made from polytetrafluoroethylene (PTFE).

**Flow Reactor Compartments:** A: nickel cathode (Teflon base); B: turbulence promoter; C: graphite felt (1.9 cm × 5.9 cm × 0.6 cm); D: gasket; E: slot for graphite felt (Teflon base).
3D-explosion drawing of the flow cell setup:

**Dimensions of B**: length: 5.7 cm, width: 1.9 cm; thickness: 0.2 cm (0.1 cm).

For further details of the electro-flow-reactor components, please see our recently published work. [5]
On-Line NMR Monitoring in Flow

The $^{19}$F and $^1$H NMR spectroscopy experiments in flow were performed on a Magritek Spinsolve 60\textsuperscript{ULTRA} (from Magritek GmbH, Germany) with the reaction monitoring kit supplied by the manufacturer. For pumping the solution to the spectrometer, an Ismatec REGLO Digital MS-2/12 (ISM 596) peristaltic pump was employed. The flow rate was 0.4 mL/min.

Reaction A: A 15 mL-Schlenk tube was charged with Substrate 1a (60 mg, 0.375 mmol, 1.0 equiv), CF$_3$SO$_2$Na 2 (156 mg, 0.75 mmol, 2.0 equiv), LiClO$_4$ (63 mg, 0.59 mmol) and [Mes-Acr$^+$]ClO$_4^-$ (5.1 mg, 5.0 mol %) and CH$_3$CN (8.0 mL) under N$_2$. The tube was sealed with a septum and connected to a balloon filled with N$_2$. The solution was pumped to the NMR spectrometer by a peristaltic pump with a flow speed of 0.4 mL/min. The electrophotocatalysis was performed at 23 °C with a constant current of 4.0 mA maintained for 12 h under visible light irradiation (2 × Kessil A360N lamp). Subsequently the reaction yield was determined by $^1$H NMR with CH$_2$Br$_2$ as internal standard and the obtained value employed for calibration of the NMR spectra recorded in flow.

![Figure S-2](image-url)  
Figure S-2 Reaction profile of reaction A determined by $^{19}$F NMR spectroscopic monitoring in flow.
**Figure S-3** $^{19}$F NMR spectra recorded in flow from reaction mixture A at selected times (★: Product, ✪: Intermediate, ✡: NaSO$_2$CF$_3$).

**Reaction B:** In a second experiment a 15 mL-Schlenk tube was charged with Substrate 1a (60 mg, 0.5 mmol, 1.0 equiv), CF$_3$SO$_2$Na 2 (156 mg, 1.0 mmol, 2.0 equiv), LiClO$_4$ (84.4 mg, 0.80 mmol) and [Mes-Acr$^+$]ClO$_4^-$ (5.1 mg, 5.0 mol %) and CH$_3$CN (8.0 mL) under N$_2$. The tube was sealed with a septum and connected to a balloon filled with N$_2$. The solution was pumped to the NMR spectrometer by a peristaltic pump with a flow speed of 0.4 mL/min. The electrophotocatalysis was performed at 23 °C with a constant current of 4.0 mA maintained for 12 h under visible light irradiation (2 × Kessil A360N lamp). Subsequently the reaction yield was determined by $^1$H NMR with CH$_2$Br$_2$ as internal standard and the obtained value employed for calibration of the NMR spectra recorded in flow.
Figure S-4 Reaction profile of reaction B determined by $^{19}$F NMR spectroscopic monitoring in flow.

Figure S-5 Reaction profile of reaction B determined by $^1$H NMR spectroscopic monitoring in flow.
Figure S-6 $^1$H NMR spectra recorded in flow from reaction mixture B at selected times (★: Bis-CF$_3$-Product, ☆: Product, ♦: Mesitylene, ♣: Intermediate).
Radical trap experiments

The electrophotochemical reaction was carried out in an undivided cell, with a GF anode (10 mm × 15 mm × 6 mm) and a Pt cathode (10 mm × 15 mm × 0.25 mm). 1a (30 mg, 0.25 mmol), CF₃SO₂Na (2, 78 mg, 0.50 mmol), LiClO₄ (42 mg, 0.40 mmol), [Mes-Acr⁺][ClO₄⁻] (5.1 mg, 5.0 mol %) and BHT (110 mg, 0.50 mmol) were dissolved in CH₃CN (4.0 mL) under N₂. The electrophotocatalysis was performed at 23 °C with a constant current of 4.0 mA maintained for 16 h under visible light irradiation (2 × Kessil A360N). The GF anode was washed with CH₂Cl₂ (3 × 10 mL) in an ultrasonic cleaner. Evaporation of the solvent and subsequent column chromatography on silica gel afforded the corresponding products 12 (52 mg, 36% yield based on 2) as a colorless oil, 13 (9.3 mg, 11%) as a white solid. M. p.: 133–135 °C, and 3a (9.4 mg, 20%) (eluent: n-hexane → n-hexane/EtOAc = 25:1).

2,6-Di-tert-butyl-4-(2,2,2-trifluoroethyl)phenol (12)

¹H-NMR (400 MHz, CDCl₃): δ = 7.04 (s, 1H), 5.20 (s, 1H), 3.25 (q, J = 11.0 Hz, 2H), 1.42 (s, 18H). ¹³C-NMR (100 MHz, CDCl₃): δ = 153.6 (C₆), 136.1 (CH), 126.0 (q, ¹JC-F = 276.9 Hz, C₆), 126.8 (C₆), 120.9 (q, ³JC-F = 2.9 Hz, C₆), 40.0 (q, ²JC-F = 29.4 Hz, CH₂), 34.3 (C₆), 30.2 (CH₃). ¹⁹F-NMR (376 MHz, CDCl₃): δ = -66.2 (s). IR (ATR): 3644, 2955, 2924, 1460, 1436, 1359, 1258, 1134, 1086 cm⁻¹. MS (EI) m/z (relative intensity): 288 (30) [M⁺, 273 (100) [M-
CH$_3]^+$. HR-MS (EI) m/z calc. for C$_{16}$H$_{23}$F$_3$O [M]$^+$: 288.1696, found: 288.1700. The analytical data correspond with those reported in the literature.[6]

2,6-Di-tert-butyl-4-(2,4,6-trimethylbenzyl)phenol (13)

$^1$H-NMR (400 MHz, CDCl$_3$): $\delta$ = 6.86 (s, 2H), 6.83 (s, 2H), 4.97 (s, 1H), 3.90 (s, 2H), 2.27 (s, 3H), 2.24 (s, 6H), 1.36 (s, 18H). $^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ = 151.6 (C$_q$), 136.8 (C$_q$), 135.6 (C$_q$), 135.2 (C$_q$), 134.6, (C$_q$) 130.5 (C$_q$), 128.8 (CH), 124.4 (CH), 34.5 (CH$_2$), 34.2 (C$_q$), 30.3 (CH$_3$), 20.9 (CH$_3$), 20.2 (CH$_3$). IR (ATR): 3645, 2955, 2915, 1614, 1434, 1361, 1232, 1153, 1120, 1026 cm$^{-1}$. MS (ESI) m/z (relative intensity): 337 (100) [M-H]$^+$. HR-MS (ESI) m/z calc. for C$_{24}$H$_{33}$O [M-H]$^+$: 337.2526, found: 337.2525. The analytical data correspond with those reported in the literature.[7]
Light on/off experiments

![Reaction Scheme]

| Time (h) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|---|---|---|---|---|---|---|---|---|---|----|
| Light on/off | 0 | on | off | on | off | on | off | on | off | on | off |
| Yield (%) | 0 | 23 | 23 | 26 | 26 | 28 | 28 | 29 | 29 | 30 | 30 |

Figure S-7. Light on/off experiments

The electrophotocatalysis was carried out in an undivided cell, with a GF anode (10 mm × 15 mm × 6 mm) and a Pt cathode (10 mm × 15 mm × 0.25 mm). 1a (30 mg, 0.25 mmol), CF<sub>3</sub>SO<sub>2</sub>Na (2, 78 mg, 0.50 mmol), LiClO<sub>4</sub> (42 mg, 0.40 mmol), and [Mes-Acr<sup>+</sup>]ClO<sub>4</sub>− (5.1 mg, 5.0 mol %) were dissolved in CH<sub>3</sub>CN (4.0 mL) under N<sub>2</sub>. The electrophotocatalysis was performed at 23 °C with a constant current of 4.0 mA under visible light irradiation (2 × Kessil A360N) at given time intervals. The yield of 3a was determined by GC/MS analysis of the crude mixture with n-dodecane as the internal standard.
Electricity on/off experiments

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\end{array} \quad \overset{\text{[Mes-Acr}^+\text{]}\text{ClO}_4^- (5\text{ mol %})}{\text{LiClO}_4, \text{CH}_3\text{CN, rt}} \quad \begin{array}{c}
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| Time (h) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|---|---|---|---|---|---|---|---|---|---|----|
| Electricity on/off | 0 | on | off | on | off | on | off | on | off | on | off |
| Yield (%) | 0 | 23 | 25 | 36 | 38 | 45 | 46 | 54 | 54 | 64 | 64 |

Figure S-8. Electricity on/off experiments

The electrophotocatalysis was carried out in an undivided cell, with a GF anode (10 mm × 15 mm × 6 mm) and a Pt cathode (10 mm × 15 mm × 0.25 mm). 1a (30 mg, 0.25 mmol), CF$_3$SO$_2$Na (2, 78 mg, 0.50 mmol), LiClO$_4$ (42 mg, 0.40 mmol), and [Mes-Acr$^+$]ClO$_4^-$ (5.1 mg, 5.0 mol %) were dissolved in CH$_3$CN (4.0 mL) under N$_2$. The electrophotocatalysis was performed at 23 °C with a constant current of 4.0 mA under visible light irradiation (2 × Kessil A360N) at given time intervals. The yield of 3a was determined by GC/MS analysis of the crude mixture with $n$-dodecane as the internal standard.
**Estimation of quantum yield**

The quantum yield $\Phi$ is defined as the ratio between the number or rate of desired photochemical transformations and the number or rate of absorbed photons. In our reaction, the reaction velocity $v_r$ is driven by electric current, which for a 2-electron process at ideally 100% faradaic yield corresponds to a maximum value of:

$$v_r = \frac{4mA}{2F} = \frac{0.004 \, C \, s^{-1}}{2 \times 96485 \, C \, mol^{-1}} \leq 2.07 \times 10^{-8} \, mol \, s^{-1}$$

The photon flux was determined using the well-established Hatchard-Parker actinometer.\[^7\]

Two solutions were prepared for the quantification of Fe(II) produced by photochemical decomposition of potassium ferrioxalate:

*Ferrioxalate solution F*: 124 mg (0.25 mmol) of commercially obtained $K_3[Fe(C_2O_4)_3]$ were dissolved in approx. 20 mL of distilled water. Subsequently, 250 mg conc. $H_2SO_4$ (2.5 mmol) were added and the solution was topped with distilled water to a total volume of 25 mL.

*Phenanthroline buffer P*: 150 mg (0.83 mmol) phenanthroline and 2.050 g (25 mmol) NaOAc were dissolved in approx. 40 mL of distilled water. Subsequently, 0.50 mL $H_2SO_4$ (9 mmol) were added and the solution was topped with distilled water to a total volume of 50 mL.

The measurement was performed in the typical reaction setup: A Schlenk-tube, equipped with a magnetic stirring bar and a rubber septum with electrode inlets was charged with 4 mL of solution $F$. The sample was irradiated with blue light for 20 s ($2 \times Kessil A360N$). Subsequently, a 1/40 aliquot (100 µL) was taken and dissolved in 10 mL of solution $P$ to obtain complex solution $C_1$. This procedure was repeated with a non-irradiated sample to obtain complex solution $C_0$.

The quantification of Fe(II) amount relies on the phenanthroline complex, which possesses an absorptivity $\varepsilon$ of 11000 L·mol$^{-1}$·cm$^{-1}$ at 510 nm. UV absorbance $A$ of $C_0$ was recorded as a blank. The absorbance of $C_1$ at 510 nm was 0.58. According to the Lambert-Beer law, this corresponds at an optical path length of $l = 1$ cm to a concentration of:

$$c = \frac{A}{\varepsilon l} = \frac{0.58}{11000 \, L \, mol^{-1} \, cm^{-1} \times 1 \, cm} = 5.3 \times 10^{-5} \, mol \, L^{-1}$$

Given a dilution factor of 100 and a quantum yield of 0.86 of potassium ferrioxalate at 436 nm, the total amount of photons absorbed per second $v_p$ in the sample is:
\[ v_p = \frac{5.3 \times 10^{-5} \text{mol} \text{L}^{-1} \times 100 \times 0.004 \text{L}}{0.86 \times 20 \text{s}} = 1.23 \times 10^{-6} \text{mol s}^{-1} \]

The ratio between \( v_r \) and \( v_p \) is the estimated quantum yield:

\[ \Phi = \frac{v_r}{v_p} = \frac{2.07 \times 10^{-8} \text{mol s}^{-1}}{1.23 \times 10^{-6} \text{mol s}^{-1}} \leq 1.7 \times 10^{-2} (1.7\%) \]
**Fluorescence Quenching Experiments**

Sample solutions were prepared in a MeCN/H$_2$O 9:1 mixture with concentrations of $10^{-4}$ M for [Mes-Acr$^+$]ClO$_4^-$, $10^{-5}$ M for [Ru(bpy)$_3$](PF$_6$)$_2$ and varying concentrations of quencher (1a or 2). The sample solutions were degassed prior to measurement by N$_2$-bubbling. Stern-Volmer experiments were conducted with fixed excitation wavelengths of 450 nm for [Ru(bpy)$_3$](PF$_6$)$_2$ and 400 nm for [Mes-Acr$^+$]ClO$_4^-$ and detection at the emission maximum of the respective analyte. Plotting of the $I_0/I$ value against the concentration of the potential quencher yielded the following graphs.

![Graph showing quenching data](image)

**Figure S-9.** Quenching of [Mes-Acr$^+$]ClO$_4^-$ with 1a:
Figure S-10. Quenching of $\text{[Mes-Acr}^+\text{]ClO}_4^-$ with 2:

\[
\frac{I_0}{I} = (75.5 \pm 1.7) \times [2] \times (\text{mol/L})^{-1} + 1
\]

Figure S-11. Quenching of $\text{[Ru(bpy)}_3\text{](PF}_6\text{)}_2$ with 1a:
Figure S-12. Quenching of [Ru(bpy)$_3$](PF$_6$)$_2$ with 2:
In a Schlenk tube equipped with GF anode (10 mm × 10 mm × 6 mm) and a platinum cathode (20 mm × 10 mm × 0.25 mm), 1a (30 mg, 0.25 mmol), CF₃SO₂Na 2 (78 mg, 0.50 mmol), LiClO₄ (42 mg, 0.40 mmol) and [Ru(bpy)₃]([PF₆]₂) (4.3 mg, 2.0 mol %) were dissolved in CH₃CN (4.0 mL). The atmosphere was exchanged to N₂ and the stopcock has been closed. The electrophotocatalysis was performed at 23 °C with a constant current of 4.0 mA under visible light irradiation (2 × Kessil A360N). After 8 h, 1.0 mL of the headspace volume was taken for GC analysis.
Cyclic Voltammetry

The cyclic voltammetry was carried out with a Metrohm Autolab PGSTAT204 potentiostat and Nova 2.1 software. For all experiments, a glassy carbon working electrode (disk, diameter: 3 mm), a platinum wire counter electrode and a saturated calomel reference electrode (SCE) were employed. The voltammograms were recorded in MeCN at a substrate concentration of 5.0 mmol/L and with 0.1 mol/L LiClO$_4$ as supporting electrolyte. All solutions were saturated with nitrogen gas prior to measurement. The scan rate was 100 mV/s. Blue light irradiation was accomplished by one Kessil A360N lamp, mounted in 10 cm distance from the electrochemical cell, turned up to highest intensity and lowest wave length.

Figure S-13. Cyclic voltammograms at 100 mVs$^{-1}$, substrates (5 mmol/L) and LiClO$_4$ (100 mmol/L) in MeCN: blank (black), 1a (red), 3a (blue).
**Figure S-14.** Cyclic voltammograms at 100 mVs$^{-1}$, substrates (5 mmol/L) and LiClO$_4$ (100 mmol/L) in MeCN: PC (black), 2 (red), PC + 2 (blue).
Figure S-15. Cyclic voltammograms at 100 mVs$^{-1}$, substrates (5.0 mmol/L) and LiClO$_4$ (100 mmol/L) in MeCN: PC + 2 (black), PC + 2 after being irradiated for 10 minutes with blue light (red).
Plausible mechanism with [Ru(bpy)$_3$](PF$_6$)$_2$ as catalyst

Scheme S-1. Plausible mechanism
References

[1] Y. Ouyang, X.-H. Xu, F.-L. Qing, *Angew. Chem. Int. Ed.* **2018**, *57*, 6926–6929.

[2] K. Natte, R. V. Jagadeesh, L. He, J. Rabeah, J. Chen, C. Taeschler, S. Ellinger, F. Zaragoza, H. Neumann, A. Brückner, M. Beller, *Angew. Chem. Int. Ed.* **2016**, *55*, 2782–2786.

[3] Y. Deng, F. Lu, S. You, T. Xia, Y. Zheng, C. Lu, G. Yang, Z. Chen, M. Gao, A. Lei, *Chin. J. Chem.* **2019**, *37*, 817–820.

[4] J. Lin, Z. Li, J. Kan, S. Huang, W. Su, Y. Li, *Nat. Commun.* **2017**, *8*, 14353.

[5] W.-J. Kong, L. H. Finger, A. M. Messinis, R. Kuniyil, J. C. A. Oliveira, L. Ackermann, *J. Am. Chem. Soc.* **2019**, *141*, 17198–17206.

[5] J. Wang, K. Sun, X. Chen, T. Chen, Y. Liu, L. Qu, Y. Zhao, B. Yu, *Org. Lett.* **2019**, *21*, 1863–1867.

[6] I. G. Arzamanova, I. P. Romm, Y. K. Tovbin, E. N. Gur'yanova, E. A. Gurvich, A. I. Rybak, *Zh. Org. Khim.* **1979**, *49*, 672–675.

[7] a) C. A. Parker, *Proc. R. Soc. Lond. A* **1953**, *220*, 104–116; b) C. G. Hatchard, C. A. Parker, *Proc. R. Soc. Lond. A* **1956**, *235*, 518–536.
$^1$H-, $^{13}$C- and $^{19}$F-NMR Spectra

3a
(400 MHz, CDCl$_3$)

3a
(100 MHz, CDCl$_3$)
3a
(376 MHz, CDCl\textsubscript{3})

3b
(300 MHz, CDCl\textsubscript{3})
$3c$
(376 MHz, CDCl$_3$)

$3d$
(500 MHz, CDCl$_3$)
3d (125 MHz, CDCl₃)

3d (470 MHz, CDCl₃)
3e
(470 MHz, CDCl₃)

3f
(400 MHz, CDCl₃)
$\text{3f} \\
(100 \text{ MHz, CDCl}_3)$

$\text{3f} \\
(376 \text{ MHz, CDCl}_3)$
3g (376 MHz, CDCl₃)

3h (400 MHz, CDCl₃)
3h
(100 MHz, CDCl₃)

3h
(376 MHz, CDCl₃)
5a
(400 MHz, CDCl₃)

5a
(100 MHz, CDCl₃)
$\text{MeO}_2\text{C} - \text{CF}_3$

**5a**
(376 MHz, CDCl$_3$)

$\text{Me} - \text{CF}_3$

**5b**
(400 MHz, CDCl$_3$)
5b
(100 MHz, CDCl$_3$)

5b
(376 MHz, CDCl$_3$)
$5c$

(376 MHz, CDCl$_3$)

$5d$

(400 MHz, CDCl$_3$)
5d
(376 MHz, CDCl₃)
$5e$

$(500 \text{ MHz, CDCl}_3)$

$(125 \text{ MHz, CDCl}_3)$
$5e$

(470 MHz, CDCl$_3$)

$5f$

(400 MHz, CDCl$_3$)
$5f$
(100 MHz, CDCl$_3$)

$5f$
(376 MHz, CDCl$_3$)
**5g**
(376 MHz, CDCl₃)

5h (ratio: 10/1)
(400 MHz, CDCl₃)
**5h (ratio: 10/1)**
(100 MHz, CDCl₃)

**5h (ratio: 10/1)**
(282 MHz, CDCl₃)
$5i$
*(400 MHz, CDCl$_3$)*

$5i$
*(100 MHz, CDCl$_3$)*
5i
(376 MHz, CDCl₃)

5j
(400 MHz, CDCl₃)
5j
(100 MHz, CDCl₃)

5j
(376 MHz, CDCl₃)
5k
(400 MHz, CDCl₃)

5k
(100 MHz, CDCl₃)
$\text{O-Me}$

$\text{CF}_3$

$\text{Bn}$

**5m**

(400 MHz, CDCl$_3$)

---

$\text{O-Me}$

$\text{CF}_3$

$\text{Bn}$

**5m**

(100 MHz, CDCl$_3$)
$5m$ (282 MHz, CDCl$_3$)

$5n$ (ratio: 20/1) (500 MHz, CDCl$_3$)
5n (ratio: 20/1)  
(125 MHz, CDCl₃)
6
(400 MHz, CDCl₃)

6
(100 MHz, CDCl₃)
6
(376 MHz, CDCl₃)

7
(400 MHz, CDCl₃)
7
(100 MHz, CDCl₃)

7
(376 MHz, CDCl₃)
8
(400 MHz, CDCl₃)

8
(100 MHz, CDCl₃)
8
(376 MHz, CDCl$_3$)

9
(500 MHz, CDCl$_3$)
$^9$ (125 MHz, CDCl$_3$)

$^9$ (470 MHz, CDCl$_3$)
10 (ratio: 10/1)  
(400 MHz, CDCl₃)

10 (ratio: 10/1)  
(100 MHz, CDCl₃)
10 (ratio: 10/1)  
(376 MHz, CDCl₃)

11  
(300 MHz, CDCl₃)
12
(376 MHz, CDCl₃)

13
(400 MHz, CDCl₃)
13
(100 MHz, CDCl$_3$)