Supporting Information

Diverse reaction behaviors of artificial ubiquinones in mitochondrial respiratory complex I

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Figure S1
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Michaelis-Menten-type curves for the NADH-UQ oxidoreductase activity with the native (in SMPs) (A) and the isolated (B) complex I. Circles, squares, and triangles represent UQ$_2$, pUQ$_{m-1}$, and pUQ$_{p-1}$, respectively. The experimental conditions are the same as those in Figure 3.
Figure S3

Effects of pUQs on the membrane potential generated by ATP hydrolysis in SMPs. The membrane potential generated by ATP hydrolysis by ATPase in SMPs was determined via following changes in absorbance of oxonol IV (an optical indicator of the membrane potential) at 601-minus-630 nm with a Shimadzu UV-3000 instrument in dual-wavelength mode. SMPs (60 μg of protein/mL) were suspended in the reaction medium (2.0 mL) containing 0.25 M sucrose, 1.0 mM MgCl₂, 0.80 μM antimycin A, 4.0 mM KCN, 0.10 μM nigericin, 1.0 μM oxonol VI, and 50 mM phosphate buffer (pH 7.4). The reaction was initiated by adding 1.0 mM ATP, then 2.0 μM (final) of UQ₂ (left), pUQ₉₋₁ (middle), or pUQ₉₋₁ (right) was added (each arrow). Finally, the membrane potential was dissipated by adding an uncoupler SF6847 (0.20 μM).
HPLC analyses of the reaction products of the NADH-UQ oxidoreduction assay. (A) The products with native complex I in SMPs (60 µg of protein/mL) was monitored by reverse-phase HPLC. The concentrations of pUQs and NADH were 100 and 100 µM, respectively. The upper and lower chromatograph panels represent the results in the absence and presence of bullatacin (1.0 µM), respectively. (B) The products with the isolated complex I (7.5 µg of protein/ml) was monitored. (C) The products with the isolated complex I (300 µg of protein/mL) was monitored. A mobile phase of the HPLC analysis for pUQ$_{m-1}$ and pUQ$_{p-1}$ was composed of 87% methanol in water containing 0.1% TFA. A mobile phase for pUQ$_{m-2}$ and pUQ$_{p-2}$ was composed of 92% methanol in water containing 0.1% TFA. Data are representative of three independent experiments.
Figure S5

MALDI-TOF/TOF spectra of the peptide Phe<sup>522</sup>−Arg<sup>535</sup>. The fragment ion spectra of an ion at m/z 1682.9 (z = 1) was matched the sequence Phe<sup>522</sup>−Arg<sup>535</sup> with an ion score of 92 (a number of greater than 37 indicates identity or extensive homology, p < 0.05). Raw mass spectrometric data were deposited to jPOST repository. Project ID is JPST001456.
(https://repository.jpostdb.org/preview/43621785861ee0e6f8550c)
Figure S6

The NADH-UQ oxidoreductase assay with SMPs (60 µg of protein/mL) in the absence (control) and presence of various inhibitors. The experimental conditions are the same as those in Figure 3A. The final concentration of each inhibitor was as follows: Piericidin A (1.0 µM), Fenpyroximate (1.0 µM), Bullatacin (1.0 µM), Aminoquinazoline (1.0 µM), Rotenone (1.0 µM), and IACS-010759 (10 µM).
Determination of a ratio of the active/deactive states of the native (A) and isolated (B) complex I. SMPs (4.0 mg of protein/mL) and the isolated complex I (0.30 mg of protein/mL) were incubated in 60 µL reaction medium containing 0.25 M sucrose, 1.0 mM MgCl₂, and 50 mM phosphate buffer (pH 7.4) and medium containing 0.40 mg/mL asolectin, 0.08% CHAPS, and 20 mM Tris/HCl buffer (pH 7.5), respectively, at 37 °C for the indicated period of time. Then, the samples were cooled on ice for 5 min and incubated with (closed circles) or without (open circles) 4.0 mM N-ethylmaleimide on ice for 10 min (34, 35). A portion of the samples was subjected to the NADH-UQ₁ oxidoreduction assay (NADH: 50 µM, UQ₁: 50 µM).

Figure S7
Figure S8

The photoaffinity labeling of complex I in the pseudoactive state by $[^{125}\text{I}]p\text{UQs}$. (A) SMPs as prepared (4.0 mg of protein/mL) were cross-linked by $[^{125}\text{I}]p\text{UQs}$ (10 nM each) and resolved by the same procedure described in Figure 4C. The complex I as isolated (0.60 mg of protein/mL) was cross-linked by $[^{125}\text{I}]p\text{UQs}$ (4.0 nM each) and resolved by the same procedure described in Figure 5C. AAC stands for an ADP/ATP carrier. (B) Comparison of the incorporated radioactivity in the ND1 subunit between the deactive (dark gray bars, 100%) and pseudo-active (light gray bars) states of complex I. SMPs (2.0 mg of protein/ml) in the deactive or the pseudoactive state were cross-linked by $[^{125}\text{I}]p\text{UQs}$ (5.0 nM). The isolated complex I (0.30 mg of protein/ml) in the deactive or pseudoactive state was cross-linked by $[^{125}\text{I}]p\text{UQs}$ (2.0 nM). The ND1 subunit was resolved by 12.5% Laemmli-type SDS-PAGE, followed by quantification of the incorporated radioactivity. Values in graphs are means ± S.E. ($n = 3$).
Figure S9

Competition test between $[^{125}\text{I}]$pUQs and different types of inhibitors in the native (A) and isolated (B) complex I in the pseudoactive state. SMPs as prepared (2.0 mg of protein/ml) and the complex I as isolated (0.30 mg of protein/ml) were cross-linked by 5.0 and 2.0 nM $[^{125}\text{I}]$pUQs, respectively, in the presence of excess inhibitors. The labeled complex I was analyzed by the same procedures described in Figure 11. Dark and light gray bars show the results of $[^{125}\text{I}]$pUQ$_{m-1}$ and $[^{125}\text{I}]$pUQ$_{p-1}$, respectively. The extent of labeling in the absence of inhibitor is 100%. Values in graphs are means ± S.E. ($n = 3$).
Figure S10

Localization of the labeled regions by $^{125}$I$pUQ$s in ND1 of the native (A) and isolated (B) complex I in the pseudoactive state. The ND1 subunit labeled by $^{125}$I$pUQ$s was exhaustively digested with Lys-C or Asp-N. The digests were analyzed by the same procedure described in Figure 7.
Figure S11

The regions labeled by $[^{125}\text{I}]p\text{UQ}_{m-2}$ in the ND5 and ND2 subunits. The ND2, ND4, and ND5 subunits in bovine complex I (PDB entry: 5O31) are colored in blue, purple, and yellow, respectively. The labeled regions (Tyr$^{513}$–Lys$^{564}$ and Glu$^{269}$–Lys$^{321}$ in ND5 and ND2, respectively) are shown in spheres. ND2-Lys$^{58}$ and -His$^{112}$ are shown in red spheres. The putative UQ binding area in the membrane domain (UB$_m$) is shown by a red circle.
Sequence alignment of the ND2 and NuoN subunits of *B. taurus* and *E. coli*, respectively. Alignment was conducted with Clastal Omega using the amino acid sequences of *B. taurus* (P03892) and *E. coli* (P0AFF0). *B. taurus* ND2-Lys\(^{58}\) and -His\(^{112}\) and *E. coli* NuoN-Lys\(^{158}\) and -His\(^{224}\) were shadowed.

|          | B. taurus | E. coli |
|----------|-----------|---------|
| Sequence | 49 NPRATEASTKYFLTQSTASMLLMMA 73 | 149 QKRSLEASIKYTILSAAASSFLLF 173 |
|          | B. taurus | E. coli |
|          | 97 LMTMALAMKLGMAPFFFWVPEVTQG 121 | 209 LMIVGLGFKLSLVPFHSTPDVYG 233 |
The structures of rotenone-bound (PDB entry: 6ZKM) (A) and rotenone-non-bound (PDB entry: 6ZKE) (B) complex I. The bound phospholipids and rotenone were shown in spheres and in green spheres, respectively. The ND2, ND4, and ND5 subunits were colored in blue, purple, and yellow, respectively. The putative UQ binding area in the membrane domain (UBm, see Figure S11) was shown by a yellow circle.
**General procedures for the syntheses**

All moisture- and air-sensitive reactions were performed in oven-dried glassware under nitrogen or argon atmosphere with dry solvents under anhydrous conditions using standard syringe septum techniques. $^1$H-NMR spectra were recorded at 400 or 500 MHz with Bruker AVANCE III 400 or 500 spectrometers, respectively, using tetramethylsilane (TMS) as the internal standard. $^{13}$C-NMR spectra were recorded at 100 or 125 MHz. $^{19}$F-NMR spectra were recorded at 470 MHz. Chemical shifts (δ) were given in ppm relative to TMS with coupling constants (J) in Hz. The mass spectra were recorded on a Shimadzu LCMS-8040 with ESI source. Thin-layer chromatography (TLC) was performed on Merk TLC plate Silica-gel 60F254, and the spot was detected by iodine, anis, phosphomolybdic acid, or UV absorbance. Dry solvents were either used as purchased or freshly distilled using common practices where appropriate. HPLC purification was carried out with a Shimadzu LC-10 AS. Elution profiles were monitored at 254 nm with a Shimadzu SPD-10A.

**Abbreviations**

AcCl, acetyl chloride; BTI, [bis(trifluoroacetoxy)iodo]benzene; n-BuLi, n-butyl lithium; DIAD, diisopropyl azodicarboxylate; DMAP, 4-dimethylaminopyridine; DMF, dimethylformamide; Et₂O, diethyl ether; EtOAc, ethyl acetate; HMPA, hexamethylphosphoric triamide; KPi, potassium phosphate; MOM, methoxymethyl; PPh₃, triphenylphosphine; rt, room temperature; TEA, triethylamine; THF, tetrahydrofuran; TLC, thin-layer chromatography; p-TsCl, para-toluenesulfonyl chloride.
Outline of the syntheses of pUQs

The synthetic procedures of pUQs and [$^{125}$I]pUQs are outlined in Schemes S1 and S2. We used 4-bromophenol and 3-bromophenol as starting materials for meta- and para-substituted pUQs, respectively. MOM protection of 4-bromophenol and 3-bromophenol gave S1 and S12, respectively. The bromobenzene derivatives were subjected to lithiation by n-BuLi, followed by reaction with the ethyl trifluoroacetate gave trifluoroacetyl derivatives. Wolf-Kishner reaction of S2 and S13 provided hydrazone derivatives, followed by the tosylation gave S3 and S14, respectively. The diazirine compounds S5 and S16 were prepared according to the procedures described in ref. 80. Iodination of the diazirine compounds was succeeded by the method of Hashimoto et al. [81]. The deprotection of MOM group provided key intermediate S7 and S18. They were subjected to the conjugation with appropriate ubiquinone analogues (S8 and S9) in the presence of DIAD and PPh₃ to provide corresponding pUQs. [$^{125}$I]pUQ_m-1, [$^{125}$I]pUQ_m-2, [$^{125}$I]pUQ_p-1, and [$^{125}$I]pUQ_p-2 were prepared by the catalysis of chloramine T [25] using tin-precursors S10, S11, S19, and S20, respectively.

Scheme S1

Reagents and conditions: (a) MOMCl, NaH, DMF, 0 °C, 1 h, 97%; (b) ethyl trifluoroacetate, n-BuLi, THF, rt, 2 h; (c) i) NH₂OH-HCl, pyridine, 80 °C, 12 h; ii) p-TsCl, TEA, DMAP, CH₂Cl₂, rt, 3 h, 62% (2 steps); (d) liq. NH₃, Et₂O, rt, 12 h; (e) I₂, TEA, CH₂Cl₂, rt, 15 min, 88% (2 steps); (f) I₂, BTI, CH₃CN, -10 °C, 5 h, 52%; (g) AcCl/MeOH (1:9), CH₂Cl₂, 35 °C, 7 h, 70%; (h) DIAD, PPh₃, toluene, rt, 2–4 h, 26–40%; (i) Bu₆Sn₂, Pd(CH₂CN)₂Cl₂, HMPA, rt, 6 h, 20–26%; (j) [$^{125}$I]NaI, chloramine T, KPi aq. (pH 7.4), rt, 10 min, 4–6%.
**Scheme S2**

Reagents and conditions: (a) MOMCl, NaH, DMF, 0 °C, 1 h, 98%; (b) ethyl trifluoroacetate, n-BuLi, THF, rt, 1 h, 87%; (c) i) NH₂OH-HCl, pyridine, 80 °C, 5 h; ii) p-TsCl, TEA, DMAP, CH₂Cl₂, rt, 3 h, 80%; (d) liq. NH₃, Et₂O, rt, 12 h; (e) i) TEA, CH₂Cl₂, rt, 15 min, 87% (2 steps); (f) i) I₂, BTI, CH₃CN, -20 °C, 5 h; (g) AcCl/MeOH (1:9), CH₂Cl₂, 35 °C, 7 h, 30%, (2 steps); (h) DIAD, PPh₃, toluene, rt, 2 h, 21-24%; (i) Bu₆Sn₂, Pd(CH₃CN)₂Cl₂, HMPA, rt, 6 h, 24-32%; (j) [¹²⁵I]NaI, chloramine T,KP i aq. (pH 7.4), rt, 10 min, 8–20%.

**Synthesis of S1**

To a solution of 4-bromophenol (10.0 g, 57.8 mmol) in anhydrous DMF (50 mL), NaH (2.54 g, 60% in mineral oil, 63.6 mmol) was added in several portions at 0 °C under N₂ atmosphere. After the mixture was stirred for 10 min at 0 °C, MOM-Cl (5.1 g, 63.6 mmol) was added to the mixture, and the mixture was stirred for 1 h at 0 °C. The reaction mixture was quenched with saturated aqueous NH₄Cl, extracted with Et₂O and dried over anhydrous MgSO₄. The crude product was purified by silica gel column chromatography (Wako gel® C-200, 10% EtOAc/n-hexane) to provide S1 as a colorless oil (12.2 g, 56.2 mmol, 97%): ¹H-NMR (400 MHz, CDCl₃): δ 7.38 (d, J = 9.0 Hz, 2H), 6.92 (d, J = 9.0 Hz, 2H), 5.14 (s, 2H). 3.46 (s, 3H); ¹³C-NMR (100 MHz, CDCl₃): δ 156.57, 132.53 (2C), 118.31(2C), 114.43, 94.73, 94.73, 56.24.

**Synthesis of S2**

To a solution of S1 (3.0 g, 13.8 mmol) in anhydrous THF (20 mL), n-BuLi (6.64 mL, 2.5 M solution in hexane, 16.6 mmol) was added at -78 °C under N₂ atmosphere. After the mixture was
stirred at -78 °C for 1 h, ethyl trifluoroacetate (2.16 g, 15.2 mmol) was added to the mixture. After stirring for 10 min at -78 °C, the mixture was allowed to warm to rt and stirred for further 2 h. The reaction mixture was quenched with saturated aqueous NH₄Cl, extracted with Et₂O and dried over anhydrous MgSO₄. The crude product was purified by silica gel column chromatography (Wako gel® C-200, 15% EtOAc/n-hexane) to provide S2 as a colorless oil (2.55 g, crude).

Synthesis of S3

To a solution of S2 (2.55 g, crude) in pyridine (20 mL), NH₂OH-HCl (1.49 g, 21.5 mmol) was added, and the mixture was heated at 80 °C for 12 h. The mixture was concentrated in vacuo to remove pyridine. The residue was diluted with Et₂O, washed with 0.10 M aqueous HCl, and dried over anhydrous MgSO₄. The organic layer was concentrated in vacuo. The resulting mixture was diluted with CH₂Cl₂ and cooled at 0 °C. Then, TEA (4.6 mL, 32.7 mmol), DMAP (664 mg, 5.45 mmol), and p-TsCl (2.49 g, 13.1 mmol) were added, and the mixture was allowed to warm to rt and stirred for 3 h. The reaction mixture was quenched with H₂O, extracted with CH₂Cl₂, and dried over anhydrous MgSO₄. The crude product was purified by silica gel column chromatography (Wako gel® C-200, 15% EtOAc/n-hexane) to provide S3 as a colorless oil (3.44 g, 8.53 mmol, 62%, 2 steps) as a mixture of E/Z-isomers: ¹H-NMR (400 MHz, CDCl₃): δ 7.90/7.89 (d, J = 8.4 Hz, 1.0/1.0H), 7.43-7.35 (m, 4H), 7.11/7.05 (d, J = 9.0 Hz, 1.0/1.0H), 5.22/5.20 (s, 1.0/1.0H), 3.49/3.47 (s, 1.5/1.5H), 2.48/2.46 (s, 1.5/1.5H); ¹³C-NMR (100 MHz, CDCl₃): δ 160.34/159.94, 153.92/153.36, 146.26/146.09, 130.83/130.78, 130.06, 129.50/129.34, 116.48, 94.33, 56.50/56.46, 21.99/21.98. ESI-MS (m/z): 402.1 [M-H].

Synthesis of S4

Anhydrous ammonia was condensed at -78 °C (~5 mL) in a sealed tube. A solution of S3 (3.12 g, 7.73 mmol) in Et₂O (3 mL) was added at -78 °C, and the mixture was allowed to warm to rt and stirred for 12 h. The solution was cooled again to -78 °C and the excess ammonia was evaporated by gently warming to rt. The crude mixture was diluted with H₂O and extracted with Et₂O and dried over anhydrous MgSO₄. The crude product was purified by silica gel column chromatography (Wako gel® C-200, 30% EtOAc/n-hexane) to provide S4 as a white solid (2.33 g, crude): ¹H-NMR (400 MHz, CDCl₃): δ 7.54 (d, J = 8.6 Hz, 2H), 7.07 (d, J = 8.9 Hz, 2H), 5.19 (s, 2H), 3.48 (s, 3H), 2.76 (d, J = 8.5 Hz, 1H), 2.17 (d, J = 8.7 Hz, 1H); ¹³C-NMR (100 MHz, CDCl₃): δ 158.71, 129.73 (2C), 125.15, 123.81 (q, J_CF = 276 Hz), 116.54 (2C), 94.46, 57.86 (q, J_CF = 36 Hz), 56.33. ESI-MS (m/z): 249.1 [M+H]⁺.
**Synthesis of S5**

To a solution of S4 (2.33 g, crude) in CH₂Cl₂ (20 mL) and TEA (3.3 mL, 24 mmol), solid I₂ was added at 0 ℃ until the solution turned brown. After stirring for 15 min, the reaction mixture was quenched by 1.0 M aqueous NaOH, extracted with CH₂Cl₂ and dried over anhydrous MgSO₄. The crude product was purified by silica gel column chromatography (Wako gel® C-200, 10% EtOAc/n-hexane) to provide S5 as a yellow oil (1.69 g, 6.84 mmol, 88%, 2 steps): ¹H-NMR (500 MHz, CDCl₃): δ 7.15 (d, J = 7.0 Hz, 2H), 7.05 (d, J = 7.1 Hz, 2H), 5.17 (s, 2H), 3.46 (s, 3H); ¹³C-NMR (125 MHz, CDCl₃): δ 158.49, 128.35 (2C), 122.44 (q, J_CF = 274 Hz), 122.34, 116.75 (2C), 94.44, 56.33, 28.43 (q, J_CF = 40 Hz).

**Synthesis of S6**

To a solution of S5 (160 mg, 0.65 mmol) in CH₃CN (9 mL), I₂ (940 mg, 3.9 mmol) and BTI (3.25 g, 7.8 mmol) were added at -10 ℃. After the mixture was stirred at -10 ℃ for 5 h, the reaction was quenched with 1.0 M aqueous NaOH. The mixture was extracted with Et₂O and dried over anhydrous MgSO₄. The crude product was purified by silica gel column chromatography (Wako gel® C-200, 5% EtOAc/n-hexane) to provide S6 as a yellow oil (126 mg, 0.34 mmol, 52%): ¹H-NMR (500 MHz, CDCl₃): δ 7.58 (d, J = 2.3 Hz, 1H), 7.19 (dd, J = 2.2, 8.7 Hz, 1H), 7.07 (d, J = 8.7 Hz, 1H), 5.25 (s, 1H), 3.49 (s, 1H); ¹³C-NMR (125 MHz, CDCl₃): δ 157.48, 137.98, 128.47, 124.14, 122.18 (q, J_CF = 294 Hz), 114.60, 95.04, 87.48, 56.75, 27.69 (q, J_CF = 41 Hz); ¹⁹F-NMR (470 MHz, CDCl₃): δ -65.57; ESI-MS (m/z): 327.0 [M-H]⁻.

**Synthesis of S7**

To a solution of S6 (126 mg, 0.34 mmol) in CH₂Cl₂ (3 mL), AcCl (0.5 mL, 10% (v/v) solution in MeOH) was added at 0 ℃. After stirring at 35 ℃ for 7 h, the reaction mixture was diluted with H₂O. The crude solution was extracted with Et₂O and dried over anhydrous MgSO₄. The crude product was purified by silica gel column chromatography (Wako gel® C-200, 10-20% EtOAc/n-hexane) to provide S7 as a yellow oil (78 mg, 0.24 mmol, 70%): ¹H-NMR (500 MHz, CDCl₃): δ 7.47 (d, J = 2.2 Hz, 1H), 7.17 (dd, J = 2.1, 8.6 Hz, 1H), 6.99 (d, J = 8.6 Hz, 1H), 5.53 (s, 1H); ¹³C-NMR (125 MHz, CDCl₃): δ 156.49, 136.95, 129.23, 123.17, 122.19 (q, J_CF = 273 Hz), 115.54, 86.08, 27.67 (q, J_CF = 41 Hz); ¹⁹F-NMR (470 MHz, CDCl₃): δ -65.57; ESI-MS (m/z): 327.0 [M-H]⁻.

**Synthesis of S8 and S9**

These compounds were synthesized in 5 steps according to the procedures described in ref. 25.
using commercially available 1,3-propanediol and 1,8-octanediol as a starting material, respectively.

**S8**: $^1$H-NMR (400 MHz, CDCl$_3$): δ 4.00 (s, 3H), 3.99 (s, 3H), 3.61 (t, J = 6.0 Hz, 2H), 2.59 (t, J = 7.4 Hz, 2H), 2.05 (s, 3H), 1.69 (tt, J = 6.0, 7.4 Hz, 2H); $^{13}$C-NMR (100 MHz, CDCl$_3$): δ 184.88, 184.62, 144.69, 144.45, 142.45, 139.71, 66.03, 61.83, 61.38, 31.54, 22.56, 12.09.

**S9**: $^1$H-NMR (400 MHz, CDCl$_3$): δ 3.99 (s, 3H), 3.98 (s, 3H), 3.64 (t, J = 6.6 Hz, 2H), 2.45 (br t, J = 7.3 Hz, 2H), 2.01 (s, 3H), 1.56 (m, 2H), 1.44-1.27 (m, 10H); $^{13}$C-NMR (100 MHz, CDCl$_3$): δ 184.91, 184.37, 144.51 (2C), 143.24, 138.90, 63.21, 61.35 (2C), 32.93, 29.92, 29.49, 29.45, 28.88, 26.57, 25.89, 12.11; ESI-MS (m/z): 311.2 [M+H$^+$].

**Synthesis of pUQ$_{m1}$**

To a solution of S8 (30 mg, 0.128 mmol) and S7 (42 mg, 0.128 mmol) in toluene (0.4 mL), PPh$_3$ (66 mg, 0.252 mmol) was added at rt. After the mixture was stirred for 10 min, DIAD (1.9 M in toluene, 132 µL, 0.232 mmol) was added and the reaction mixture was stirred for 4 h at rt. After removing the solvent in vacuo, the crude product was purified by silica gel column chromatography (Wako gel® C-200, 10-15% EtOAc/n-hexane) to provide pUQ$_{m1}$ as a yellow solid (28 mg, 0.051 mmol, 40%): $^1$H-NMR (500 MHz, CDCl$_3$): δ 7.57 (d, J = 2.2 Hz, 1H), 7.20 (dd, J = 2.0, 8.6 Hz, 1H), 6.75 (d, J = 8.7 Hz, 1H), 4.04 (t, J = 5.6 Hz, 2H), 3.99 (s, 3H), 3.93 (s, 3H), 2.75 (t, J = 7.7 Hz, 2H), 2.08 (s, 3H), 2.01-1.95 (m, 2H); $^{13}$C-NMR (125 MHz, CDCl$_3$): δ 184.76, 184.37, 158.66, 144.72, 144.60, 141.84, 139.89, 137.89, 128.66, 123.08, 122.20 (q, J$_{CF}$ = 274 Hz), 111.62, 86.87, 69.57, 61.38, 61.29, 28.25, 27.69 (q, J$_{CF}$ = 41 Hz), 23.72, 12.35; $^{19}$F-NMR (470 MHz, CDCl$_3$): δ -65.58.

**Synthesis of pUQ$_{m2}$**

To a solution of S9 (25 mg, 0.081 mmol) and S7 (30 mg, 0.081 mmol) in toluene (0.2 mL), PPh$_3$ (43 mg, 0.162 mmol) was added at rt. After the mixture was stirred for 10 min, DIAD (1.9 M in toluene, 85 µL, 0.162 mmol) was added and the reaction mixture was stirred for 2 h at rt. After removing the solvent in vacuo, the crude product was purified by silica gel column chromatography (Wako gel® C-200, 10% EtOAc/n-hexane) to provide pUQ$_{m2}$ as a yellow oil (13 mg, 0.021 mmol, 26%): $^1$H-NMR (500 MHz, CDCl$_3$): δ 7.57 (d, J = 1.6 Hz, 1H), 7.19 (dd, J = 1.6, 8.7 Hz, 1H), 6.76 (d, J = 8.7 Hz, 1H), 4.01 (t, J = 6.4 Hz, 2H), 3.99 (s, 3H), 3.93 (s, 3H), 2.45 (t, J = 7.2 Hz, 2H), 2.01 (s, 3H), 1.83 (m, 2H), 1.52 (m, 2H), 1.45-1.33 (m, 8H); $^{13}$C-NMR (125 MHz, CDCl$_3$): δ 184.89, 184.35, 159.05, 144.51, 144.50, 143.20, 138.90, 137.83, 128.49, 122.69, 122.21 (q, J$_{CF}$ = 273 Hz), 111.75, 87.10, 69.57, 61.34 (2C), 29.89, 29.42, 29.26, 29.06, 28.88, 27.70 (q, J$_{CF}$ = 41 Hz), 26.57, 26.16, 12.35; $^{19}$F-NMR (470 MHz, CDCl$_3$): δ -65.60.
**Synthesis of S10**

To a solution of pUQ$_{m-1}$ (16 mg, 0.029 mmol) in anhydrous HMPA (1.0 mL), Bu$_6$Sn$_2$ (90 mg, 0.155 mmol) and Pd(CH$_3$CN)$_2$Cl$_2$ (3 mg, 0.012 mmol) were added under Ar atmosphere, and the mixture was stirred at rt for 6 h. The reaction mixture was quenched by addition of H$_2$O and Et$_2$O, extracted with Et$_2$O, and dried over anhydrous MgSO$_4$. The crude product was purified by silica gel column chromatography (Wako gel® C-200, 2-5% EtOAc/n-hexane) to provide S10 as an orange oil (5.3 mg, 7.4 µmol, 26\%): $^1$H-NMR (500 MHz, CDCl$_3$): δ 7.23-7.13 (m, 1H), 7.10 (dd, $J = 2.0, 6.8$ Hz, 1H), 6.76 (d, $J = 8.6$ Hz, 1H), 4.00 (s, 3H), 3.94 (t, $J = 6.4$ Hz, 2H), 2.64 (t, $J = 7.7$ Hz, 2H), 2.02 (s, 3H), 1.89 (m, 2H), 1.34-1.24 (m, 6H), 0.87 (t, $J = 7.3$ Hz, 9H); $^{13}$C-NMR (125 MHz, CDCl$_3$): δ 184.63, 164.21, 144.64, 144.63, 144.62, 141.85, 139.69, 135.39, 131.70, 128.78, 122.75 (q, $J_{CF} = 228$ Hz), 121.46, 109.75, 67.69, 67.70, 67.71, 67.72, 29.30 (3C), 28.42, 27.54 (3C), 23.47, 13.87 (3C), 12.27, 10.19 (3C); $^{19}$F-NMR (470 MHz, CDCl$_3$): δ -65.48.

**Synthesis of S11**

To a solution of pUQ$_{m-2}$ (9 mg, 0.015 mmol) in anhydrous HMPA (0.5 mL), Bu$_6$Sn$_2$ (42 mg, 0.073 mmol) and Pd(CH$_3$CN)$_2$Cl$_2$ (1.6 mg, 0.006 mmol) were added under Ar atmosphere, and the mixture was stirred at rt for 6 h. The reaction mixture was quenched by addition of H$_2$O and Et$_2$O, extracted with Et$_2$O, and dried over anhydrous MgSO$_4$. The crude product was purified by silica gel column chromatography (Wako gel® C-200, 2-5% EtOAc/n-hexane) to provide S11 as a yellow oil (2.4 mg, 3.1 µmol, 20\%): $^1$H-NMR (500 MHz, CDCl$_3$): δ 7.22-7.12 (m, 1H), 7.10 (dd, $J = 2.0, 8.6$ Hz, 1H), 6.75 (d, $J = 8.6$ Hz, 1H), 3.99 (s, 3H), 3.90 (t, $J = 6.5$ Hz, 2H), 2.45 (t, $J = 7.3$ Hz, 2H), 2.01 (s, 3H), 1.76 (m, 2H), 1.55-1.42 (m, 8H), 1.40-1.24 (m, 14H), 1.11-1.06 (m, 6H), 0.87 (t, $J = 7.3$ Hz, 9H); $^{13}$C-NMR (125 MHz, CDCl$_3$): δ 184.92, 184.15, 164.21, 144.64, 144.63, 141.85, 139.69, 135.39, 131.70, 128.78, 122.75 (q, $J_{CF} = 228$ Hz), 121.46, 109.75, 67.69, 67.70, 67.71, 67.72, 29.30 (3C), 28.93, 27.55 (3C), 26.60, 26.33, 13.88 (3C), 12.11, 10.12 (3C) (2 carbon couldn’t be seen); $^{19}$F-NMR (470 MHz, CDCl$_3$): δ -65.51.

**Synthesis of $^{125}$I-pUQ$_{m-1}$**

To a solution of S10 (1.0 mM in EtOH, 20 µL) in a screw-capped 1.5 mL plastic tube, $[^{125}$I]NaI (Perkin-Elmer, NEZ 033A, 1 mCi, 2000 Ci/mmol, 10 µL) was added. The radio-iodination was initiated by adding freshly prepared aqueous chloramine T (3.0 mM in 1.0 M KPi buffer (pH 7.4), 10 µL), and the mixture was incubated for 10 min at rt. The reaction was quenched with 5% (w/v)
aqueous NaHSO₃ (50 μL) and extracted with CHCl₃ (100 μL × 3 times). Then, the mixture was subjected to HPLC (Shimadzu LC-10AS, Kyoto, Japan) purification using a C18 column (COSMOSIL 5C18-MSII, 4.6 mm x 150 mm, Nacalai Tesque, Kyoto, Japan) at a flow rate of 0.80 mL/min with MeOH/0.01% aqueous TFA as an eluent.

The column was eluted with isocratic 87% MeOH in 15 min. The fraction was collected every 30 s (400 μL) and the radioactivity and radiochemical purity were assessed by γ-counting system (COBRA™ II, Packard) and radio-TLC analysis. The radioactive fractions, corresponding to the retention time of cold pUQ₉₋₁ (7.5 min), were combined and the solvent was evaporated by a vacuum-centrifugal evaporator. [¹²⁵I]pUQ₉₋₁ was stored as an ethanoic solution (1 mCi/mL) at 4 °C. The radiochemical yield of [¹²⁵I]pUQ₉₋₁ from the initial [¹²⁵I]NaI was 6.1%. The radiochemical purity and the specific activity were > 99% and 2,000 Ci/mmol, respectively (judged from HPLC and radio-TLC).

**Synthesis of [¹²⁵I]pUQ₉₋₂**

[¹²⁵I]pUQ₉₋₂ was prepared from S₁₁ according to the procedure described for [¹²⁵I]pUQ₉₋₁. The radiochemical yield of [¹²⁵I]pUQ₉₋₂ from the initial [¹²⁵I]NaI was 4.1%. The radiochemical purity and the specific activity were > 99% and 2,000 Ci/mmol, respectively (judged from HPLC and radio-TLC). [¹²⁵I]pUQ₉₋₂ was stored as an ethanoic solution (1 mCi/mL) at 4°C.

**Synthesis of S₁₂**

To a solution of m-bromophenol (2.5 g, 14.5 mmol) in anhydrous DMF (25 mL), NaH (0.64 g, 60% in mineral oil, 16.0 mmol) was added in several portions at 0 °C under N₂ atmosphere. After the mixture was stirred for 10 min at 0 °C, MOM-Cl (1.28 g, 16.0 mmol) was added to the mixture, and the mixture was allowed to rt and stirred for 1 h. The reaction mixture was quenched with saturated aqueous NH₄Cl, extracted with Et₂O and dried over anhydrous MgSO₄. The crude product was purified by silica gel column chromatography (Wako gel® C-200, 5% EtOAc/n-hexane) to provide S₁₂ as a colorless oil (3.07 g, 14.2 mmol, 98%): ¹H-NMR (500 MHz, CDCl₃): δ 7.22 (m, 1H), 7.16-7.12 (m, 2H), 6.97 (m, 1H), 5.15 (s, 2H), 3.47 (s, 3H); ¹³C-NMR (125 MHz, CDCl₃): δ 158.21, 130.76, 125.19, 122.91, 119.84, 115.27, 94.67, 56.32.

**Synthesis of S₁₃**

To a solution of S₁₂ (1.5 g, 6.91 mmol) in anhydrous THF (10 mL), n-BuLi (4.75 mL, 2.5 M solution in hexane, 7.60 mmol) was added at -78 °C under N₂ atmosphere. After the mixture was
stirred for 45 min at -78 °C, ethyl trifluoroacetate (1.08 g, 7.60 mmol) was added to the mixture. After stirring for 30 min at -78 °C, the mixture was allowed to warm to rt and stirred for further 1 h. The reaction mixture was quenched with saturated aqueous NH₄Cl, extracted with Et₂O and dried over anhydrous MgSO₄. The crude product was purified by silica gel column chromatography (Wako gel® C-200, 10% EtOAc/n-hexane) to provide S13 as a colorless oil (1.41 g, 6.02 mmol, 87%): ¹H-NMR (500 MHz, CDCl₃): δ 7.73-7.69 (m, 2H), 7.47 (dd, J = 7.9, 8.1 Hz, 1H), 7.39 (ddd, J = 1.0, 2.5, 8.2 Hz, 1H), 5.23 (s, 2H), 3.48 (s, 3H); ¹³C-NMR (125 MHz, CDCl₃): δ 180.46 (q, J_CF = 35 Hz), 157.85, 131.77, 130.41, 129.70, 123.91, 123.84 (q, J_CF = 2.5 Hz), 117.50, 94.64, 56.43; ¹⁹F-NMR (470 MHz, CDCl₃): δ -71.28.

Synthesis of S14

To a solution of S13 (1.40 g, 5.98 mmol) in pyridine (15 mL), NH₂OH-HCl (827 mg, 11.9 mmol) was added, and the mixture was heated at 80 °C for 5 h. The mixture was concentrated in vacuo to remove pyridine. The residue was diluted with Et₂O, washed with 0.1 M aqueous HCl, and dried over anhydrous MgSO₄. The organic layer was concentrated in vacuo. The resulting mixture was diluted with CH₂Cl₂ (15 mL) and cooled at 0 °C. Then, TEA (2.5 mL, 17.9 mmol), DMAP (365 mg, 2.99 mmol), and p-TsCl (1.37 g, 7.17 mmol) were added, and the mixture was allowed to warm to rt and stirred for 1 h. The reaction mixture was quenched with H₂O, extracted with CH₂Cl₂, and dried over anhydrous MgSO₄. The crude product was purified by silica gel column chromatography (Wako gel® C-200, 15% EtOAc/n-hexane) to provide S14 as a colorless oil (1.94 g, 4.78 mmol, 80%) as a mixture of E/Z-isomers: ¹H-NMR (500 MHz, CDCl₃): δ 7.91/7.89 (d, J = 8.3 Hz, 1.0/1.0H), 7.39/7.36 (d, J = 8.1 Hz, 1.0/1.0H), 7.37/7.33 (t, J = 8.0 Hz, 0.5/0.5H), 7.20 (m, 1H), 7.10-6.99 (m, 2H), 5.18/5.17 (s, 1.0/1.0H), 3.48/3.47 (s, 1.5/1.5H), 2.48/2.46 (s, 1.5/1.5H); ¹³C-NMR (125 MHz, CDCl₃): δ 157.56/157.46, 153.96 (q, J_CF = 33 Hz )/153.85 (q, J_CF = 31 Hz ), 146.34/146.21, 131.63/131.43, 130.23/130.04, 130.10 (2C), 129.47/129.37 (2C), 125.83, 122.48/121.87, 119.86/119.58, 119.74 (q, J_CF = 276 Hz)/119.71 (q, J_CF = 276 Hz), 116.94/116.91, 94.78/94.68, 56.37/56.35, 21.99/21.97; ¹⁹F-NMR (470 MHz, CDCl₃): δ -61.45/-66.80; ESI-MS (m/z): 402.1 [M-H].

Synthesis of S15

Anhydrous ammonia was condensed at -78 °C (ca.5 mL) in a sealed tube. A solution of S14 (1.93 mg, 4.78 mmol) in Et₂O (3 mL) was added at -78 °C, and the mixture was allowed to warm to rt and stirred for 12 h. The solution was cooled again to -78 °C and the excess ammonia was evaporated by gently warming to rt. The crude mixture was diluted with H₂O and extracted with Et₂O and dried over
anhydrous MgSO₄. The crude product was purified by silica gel column chromatography (Wako gel® C-200, 30% EtOAc/n-hexane) to provide S15 as a colorless oil (1.20 g, crude): ¹H-NMR (500 MHz, CDCl₃): δ 7.34 (dd, J = 7.9, 8.1 Hz, 1H), 7.29 (s, 1H), 7.26 (d, J = 6.8 Hz, 1H), 7.12 (ddd, J = 1.0, 2.5, 8.2 Hz, 1H), 5.20 (d, J = 6.9 Hz, 1H), 5.18 (d, J = 6.9 Hz, 1H), 3.48 (s, 3H), 2.79 (d, J = 8.7 Hz, 1H), 2.26 (d, J = 8.8 Hz, 1H); ¹³C-NMR (125 MHz, CDCl₃): δ 157.62, 133.29, 130.14, 123.68 (q, J CF = 276 Hz), 121.66, 118.09, 116.36, 94.68, 58.13 (q, J CF = 36 Hz), 56.33; ¹⁹F-NMR (470 MHz, CDCl₃): δ -75.41; ESI-MS (m/z): 249.1 [M+H]+.

**Synthesis of S16**

To a solution of S15 (1.20 g, crude) in CH₂Cl₂ (8 mL) and TEA (2.0 mL, 14.4 mmol), solid I₂ was added at 0 °C until the solution turned brown. After stirring for 15 min, the reaction mixture was quenched with 1.0 M aqueous NaOH, extracted with CH₂Cl₂ and dried over anhydrous MgSO₄. The crude product was purified by silica gel column chromatography (Wako gel® C-200, 10% EtOAc/n-hexane) to provide S16 as a colorless oil (1.02 g, 4.16 mmol, 87%, 2 steps): ¹H-NMR (500 MHz, CDCl₃): δ 7.30 (dd, J = 7.2, 7.3 Hz, 1H), 7.10 (m, 1H), 6.84 (d, J = 7.4 Hz, 1H), 6.83 (s, 1H), 5.17 (s, 2H), 3.47 (s, 3H); ¹³C-NMR (125 MHz, CDCl₃): δ 157.75, 130.82, 130.25, 122.30 (q, J CF = 273 Hz), 120.08, 117.51, 114.91, 94.66, 56.32, 28.59 (q, J CF = 40 Hz); ¹⁹F-NMR (470 MHz, CDCl₃): δ -65.15.

**Synthesis of S17**

To a solution of S16 (100 mg, 0.41 mmol) in CH₃CN (4 mL), I₂ (414 mg, 1.62 mmol) and BTI (1.39 g, 3.24 mmol) were added at -20 °C. After the mixture was stirred at -20 °C for 5 h, the reaction was quenched with 1.0 M aqueous NaOH. The mixture was extracted with Et₂O and dried over anhydrous MgSO₄. The crude product was purified by silica gel column chromatography (Wako gel® C-200, 2% EtOAc/n-hexane) to provide S17 as a yellow oil (79 mg, crude): ¹H-NMR (500 MHz, CDCl₃): δ 7.80 (d, J = 8.3 Hz, 1H), 6.81 (d, J = 1.9 Hz, 1H), 6.64 (d, J = 7.4 Hz, 1H), 6.83 (s, 1H), 5.17 (s, 2H), 3.51 (s, 3H); ¹³C-NMR (125 MHz, CDCl₃): δ 157.75, 130.82, 130.25, 122.30 (q, J CF = 273 Hz), 120.08, 117.51, 114.91, 94.66, 56.32, 28.59 (q, J CF = 40 Hz); ¹⁹F-NMR (470 MHz, CDCl₃): δ -65.17.

**Synthesis of S18**

To a solution of S17 (79 mg, crude) in CH₂Cl₂ (5 mL), AcCl (1.5 mL, 10% (v/v) solution in MeOH) was added at 0 °C. After stirring at 35 °C for 7 h, the reaction mixture was diluted with H₂O. The crude solution was extracted with Et₂O and dried over anhydrous MgSO₄. The crude product was purified by silica gel column chromatography (Wako gel® C-200, 10% EtOAc/n-hexane) to provide S18 as a yellow solid (40 mg, 0.122 mmol, 30%, 2 steps): ¹H-NMR (500 MHz, CDCl₃): δ 7.68 (d, J...
= 8.4 Hz, 1H), 6.80 (d, J = 1.5 Hz, 1H), 6.47 (dd, J = 1.5, 8.4 Hz, 1H), 5.50 (s, 1H); $^{13}$C-NMR (125 MHz, CDCl$_3$): $\delta$ 155.45, 138.99, 131.86, 122.06 (q, $J_{CF} = 274$ Hz), 120.32, 113.34, 113.34, 87.61, 28.30 (q, $J_{CF} = 41$ Hz); $^{19}$F-NMR (470 MHz, CDCl$_3$): $\delta$ -65.10; ESI-MS (m/z): 327.0 [M-H].

**Synthesis of pUQ$_{p-1}$**

To a solution of S8 (22 mg, 0.088 mmol) and S18 (29 mg, 0.088 mmol) in toluene (0.3 mL), PPh$_3$ (46 mg, 0.176 mmol) was added at rt. After the mixture was stirred for 10 min, DIAD (1.9 M in toluene, 93 µL, 0.176 mmol) was added and the reaction mixture was stirred for 2 h at rt. After removing the solvent in vacuo, the crude product was purified by silica gel column chromatography (Wako gel® C-200, 10-20% EtOAc/n-hexane) to provide pUQ$_{p-1}$ as an orange solid (10 mg, 0.018 mmol, 21%): $^1$H-NMR (500 MHz, CDCl$_3$): $\delta$ 7.78 (d, $J = 8.2$ Hz, 1H), 6.56 (dd, $J = 1.2$, 8.2 Hz, 1H), 6.48 (d, $J = 1.7$ Hz, 1H), 4.03 (t, $J = 5.6$ Hz, 2H), 3.99 (s, 3H), 3.95 (s, 3H), 2.76 (t, $J = 7.7$ Hz, 2H), 2.08 (s, 3H), 1.98 (m, 2H); $^{13}$C-NMR (125 MHz, CDCl$_3$): $\delta$ 184.77, 184.32, 157.78, 144.71, 144.58, 141.88, 140.07, 139.84, 130.94, 122.10 (q, $J_{CF} = 274$ Hz), 120.75, 109.42, 88.75, 68.70, 61.38, 61.30, 28.55 (q, $J_{CF} = 41$ Hz), 28.25, 23.73, 12.34; $^{19}$F-NMR (470 MHz, CDCl$_3$): $\delta$ -65.10.

**Synthesis of pUQ$_{p-2}$**

To a solution of S9 (42 mg, 0.135 mmol) and S18 (40 mg, 0.122 mmol) in toluene (0.4 mL), PPh$_3$ (64 mg, 0.244 mmol) was added at rt. After the mixture was stirred for 10 min, DIAD (1.9 M in toluene, 128 µL, 0.244 mmol) was added and the reaction mixture was stirred for 2 h at rt. After removing the solvent in vacuo, the crude product was purified by silica gel column chromatography (Wako gel® C-200, 5-10% EtOAc/n-hexane) to provide pUQ$_{p-2}$ as an orange oil (20 mg, 0.032 mmol, 24%): $^1$H-NMR (500 MHz, CDCl$_3$): $\delta$ 7.77 (d, $J = 8.2$ Hz, 1H), 6.53 (dd, $J = 0.7$, 8.3 Hz, 1H), 6.50 (s, 1H), 3.99 (t, $J = 6.2$ Hz, 2H), 3.99 (s, 3H), 3.99 (s, 3H), 2.46 (t, $J = 7.2$ Hz, 2H), 2.01 (s, 3H), 1.84 (m, 2H), 1.54-1.49 (m, 2H), 1.28 (m, 8H); $^{13}$C-NMR (125 MHz, CDCl$_3$): $\delta$ 184.88, 184.33, 158.14, 144.49, 144.48, 143.20, 140.00, 138.87, 130.75, 122.12 (q, $J_{CF} = 274$ Hz), 120.44, 109.61, 89.02, 69.51, 61.33 (2C), 29.90, 29.43, 29.28, 29.06, 28.89, 28.56 (q, $J_{CF} = 41$ Hz), 26.57, 26.17, 12.11; $^{19}$F-NMR (470 MHz, CDCl$_3$): $\delta$ -65.10.

**Synthesis of S19**

To a solution of pUQ$_{p-1}$ (8.2 mg, 0.015 mmol) in anhydrous HMPA (0.5 mL), Bu$_6$Sn$_2$ (44 mg, 0.075 mmol) and Pd(CH$_3$CN)$_2$Cl$_2$ (1.6 mg, 0.006 mmol) were added under Ar atmosphere, and the mixture was stirred at rt for 1.5 h. The reaction mixture was quenched by addition of H$_2$O and Et$_2$O,
extracted with Et₂O, and dried over anhydrous MgSO₄. The crude product was purified by silica gel column chromatography (Wako gel® C-200, 10% EtOAc/n-hexane) to provide S19 as an orange oil (2.6 mg, 3.6 µmol, 24%): ^1^H-NMR (500 MHz, CDCl₃): δ 7.42-7.32 (m, 1H), 6.77 (d, J = 7.4 Hz, 1H), 6.49-6.45 (m, 1H), 4.01 (s, 3H), 4.01 (s, 3H), 3.94 (t, J = 6.4 Hz, 2H), 2.65 (t, J = 7.8 Hz, 2H), 2.03 (s, 3H), 1.88 (m, 2H), 1.56-1.40 (m, 6H), 1.33-1.21 (m, 6H), 1.13-0.97 (m, 6H), 0.85 (t, J = 7.3 Hz, 9H); ^1^C-NMR (125 MHz, CDCl₃): δ 184.65, 184.11, 163.45, 144.67, 144.63, 141.90, 139.63, 137.78, 133.29, 130.85, 122.35 (q, J_CF = 274 Hz), 119.38, 107.22, 67.62, 61.40 (2C), 29.32 (3C), 28.82 (q, J_CF = 40 Hz), 28.40, 27.56 (3C), 23.51, 13.88 (3C), 12.25, 10.15 (3C); ^1^F-NMR (470 MHz, CDCl₃): δ -64.98.

Synthesis of S20

To a solution of pUQ_p (16 mg, 0.026 mmol) in anhydrous HMPA (0.5 mL), Bu₆Sn₂ (75 mg, 0.129 mmol) and Pd(CH₃CN)₂Cl₂ (2.7 mg, 0.010 mmol) were added under Ar atmosphere, and the mixture was stirred at rt for 1.5 h. The reaction mixture was quenched by addition of H₂O and Et₂O, extracted with Et₂O, and dried over anhydrous MgSO₄. The crude product was purified by silica gel column chromatography (Wako gel® C-200, 5% EtOAc/n-hexane) to provide S20 as an orange oil (6.5 mg, 8.3 µmol, 32%): ^1^H-NMR (500 MHz, CDCl₃): δ 7.41-7.30 (m, 1H), 6.76 (d, J = 7.3 Hz, 1H), 6.48-6.44 (m, 1H), 3.99 (s, 3H), 3.99 (s, 3H), 3.88 (t, J = 6.5 Hz, 2H), 2.46 (t, J = 7.3 Hz, 2H), 2.01 (s, 3H), 1.77 (m, 2H), 1.52-1.41 (m, 16H), 1.38-1.25 (m, 6H), 1.10-0.95 (m, 6H), 0.86 (t, J = 7.3 Hz, 9H); ^1^C-NMR (125 MHz, CDCl₃): δ 184.92, 184.35, 163.71, 144.53, 144.51, 143.22, 138.90, 137.61, 133.33, 130.76, 122.42 (q, J_CF = 273 Hz), 119.02, 106.99, 67.93, 61.36 (2C), 30.05, 29.57, 29.54, 29.49, 29.31 (3C), 28.95, 28.85 (q, J_CF = 40 Hz), 27.57 (3C), 26.61, 26.34, 13.88 (3C), 12.10, 10.09 (3C); ^1^F-NMR (470 MHz, CDCl₃): δ -64.99.

Synthesis of [¹²⁵I]pUQ_p-1

[¹²⁵I]pUQ_p-1 was prepared from S19 according to the procedure described for [¹²⁵I]pUQ_m-1. The radiochemical yield of [¹²⁵I]pUQ_p-1 from the initial [¹²⁵I]NaI was 20%. The radiochemical purity and the specific activity were > 99% and 2,000 Ci/mmol, respectively (judged from HPLC and radio-TLC). [¹²⁵I]pUQ_p-1 was stored as an ethanoic solution (1 mCi/mL) at 4 °C.

Synthesis of [¹²⁵I]pUQ_p-2

[¹²⁵I]pUQ_p-2 was prepared from S20 according to the procedure described for [¹²⁵I]pUQ_m-1. The radiochemical yield of [¹²⁵I]pUQ_p-2 from the initial [¹²⁵I]NaI was 7.8%. The radiochemical purity and
the specific activity were > 99% and 2,000 Ci/mmol, respectively (judged from HPLC and radio-TLC). \[^{125}\text{I}]\text{pUQ}_{\text{p-2}}\) was stored as an ethanoic solution (1 mCi/mL) at 4 °C.

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