Supplementary Information (SI) for Organic & Biomolecular Chemistry.
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Supporting Information-I

Constructing Chiral Bicyclo[3.2.1]octanes *via* Low-loading Organocatalysis

Etikala Ashok,[1] Pandhiti R. Lakshmi,[1] Revoju Sravanthi,[1,2] and Dhevalapally B. Ramachary[1,3,*]

[1]Catalysis Laboratory, School of Chemistry, University of Hyderabad, Hyderabad-500 046, India
[2]Department of Pharmaceutical Chemistry, GITAM School of Pharmacy, GITAM University, Visakhapatnam-530 045, India
[3]Lead contact
*Correspondence: ramsc@uohyd.ac.in and ramchary.db@gmail.com

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General Methods: The ^{1}H NMR and ^{13}C NMR spectra were recorded at 500, 400, 125 and 100 MHz, respectively. The chemical shifts are reported in ppm downfield to TMS ($\delta = 0$) for ^{1}H NMR and relative to the central $CDCl_3$ resonance ($\delta = 77.0$) for ^{13}C NMR. In the ^{13}C NMR spectra, the nature of the carbons (C, CH, CH_2, or CH_3) was determined by recording the DEPT-135 experiment and is given in parentheses. The coupling constants *J* are given in Hz. Column chromatography was performed using silica gel (particle size: 0.063−0.200 mm). High-resolution mass spectra were recorded on a micromass ESI-TOF MS. IR spectra were recorded on FT/IR-5300 and FT/IR-5700. Mass spectra were recorded on either VG7070H mass spectrometer using EI technique or Shimadzu-LCMS-2010 A mass spectrometer. The X-ray diffraction measurements were carried out at 298 K on an automated Enraf-Nonious $MACH_3$ diffractometer using graphite monochromated, Mo−Kα ($\lambda = 0.71073$ Å) radiation with CAD4 software, or the X-ray intensity data were measured at 298 K on a SMART APEX CCD area detector system equipped with a graphite monochromator and a Mo−Kα fine-focus sealed tube ($\lambda = 0.71073$ Å). For thin-layer chromatography (TLC), silica gel plates were used and compounds were visualized by irradiation with UV light and/or by treatment with a solution of *p*-anisaldehyde (23 mL), conc. H_2SO_4 (35 mL), acetic acid (10 mL), and ethanol (900 mL), followed by heating.

Materials: All solvents and commercially available chemicals were used as received. 4-isopropyl phenol and 4-tertiarybutyl phenol were utilized for the synthesis of **1a** and **1b** and nitroolefins **6a** to **6e** were prepared according to the literature procedures.[1,2]

Procedure A: Aniline-induced Cascade Three-Component Reductive Alkylation (TCRA): In an ordinary glass vial equipped with a magnetic stirring bar, to 0.6 mmol of the aldehyde **2** (2 equiv.), 0.3 mmol of 2-hydroxy-5-alkylcyclohexa-2,5-diene-1,4-diones **1** (1 equiv.), 0.6 mmol of Hantzsch ester **4** (151.97 mg, 2 equiv.) was added in 1.0 mL of DCM (0.3 M) and aniline **3c** (27.39 μL, 1.0 equiv.) was added and the reaction mixture was stirred at 0 ºC for 40 min and 25 °C for 3 h. The crude reaction mixture was directly loaded onto a silica gel column without aqueous workup and pure cascade TCRA products **5aa**–**5bl** were obtained in 52-74% yield (silica gel, mixture of hexanes/ethyl acetate).

Procedure B: **Preparation of Racemic Tandem Michael/Henry Annulation Products 10/11**: An oven-dried, round bottom flask equipped with a magnetic stirring bar was charged

with 10 mol% of achiral thiourea catalyst **3d** (5.38 mg), followed by the addition of 0.05 mL of dry toluene, 0.15 mmol of 2-hydroxy-3,5-dialkyl-1,4-quinones **5** (1 equiv.). To this solution, 0.45 mmol of nitro-olefins **6** (0.45 mL, 1.0 M in toluene, 3 equiv.) was added and the resulting reaction mixture was stirred at rt for 5-30 min, monitored by TLC. The reaction mixture was then treated with 8.0 equiv. of acetyl chloride (85 μL) followed by the sequential addition of 0.3 equiv. of conc. H_2SO_4 (2.4 μL). The reaction mixture was then allowed to stir at rt for 30 min and reaction progress is monitored by TLC. The crude reaction mixture was directly loaded onto silica gel for column chromatography without aqueous workup and pure racemic products (±)-**10/11** were obtained in 60-96% yield (silica gel, mixture of hexane/ethyl acetate).

Procedure C: **Preparation of Chiral Tandem Michael/Henry Annulation Products 10/11**: An oven-dried, round bottom flask equipped with a magnetic stirring bar was charged with chiral quinine squaramide catalyst **3g** (1.0 mol%, 0.9 mg) followed by the addition of 0.05 mL of dry toluene, 0.15 mmol of 2-hydroxy-3,5-dialkyl-1,4-quinones **5** (1 equiv.) and 0.45 mmol of nitro-olefins **6** (0.45 mL, 1.0 M in toluene, 3 equiv.). The resulting reaction mixture was stirred at rt for 1-4 h and reaction progress is monitored by TLC. The reaction mixture was then treated with 8.0 equiv. of acetyl chloride (85 μL) followed by the sequential addition of 0.3 equiv. of conc. H_2SO_4 (2.4 μL). The reaction mixture was then allowed to stir at rt for 30 min and reaction progress is monitored by TLC. The crude reaction mixture was directly loaded onto silica gel for column chromatography without aqueous workup and the pure chiral annulation products (+)-**10/11** were obtained in 60-96% yield (silica gel, mixture of hexanes/ethyl acetate).

Procedure D: **General Procedure for the Preparation of (1*R*,4*R*,5*S*,7*R*)-5-Benzyl-4-Hydroxy-3-Isopropyl-7-Methyl-7-Nitro-8-Oxobicyclo[3.2.1]oct-2-en-1-yl Acetate (12c/13c)**: In a 10 mL round-bottom flask equipped with a magnetic stirring bar, compound (+)-**10c** (115.6 mg, 0.3 mmol) was dissolved in dry MeOH (1.0 mL, 0.3 M) and then cooled to 0 ºC, followed by addition of $NaBH_4$ (17.02 mg, 1.5 equiv.) in portion wise. The reaction mixture was then stirred at the same temperature for 2 h. The crude reaction mixture was quenched with water and the the aqueous layer was extracted with ethyl acetate (3 x 20 mL). The combined organic layers were dried over Na_2SO_4, filtered and concentrated in *vacuo* to give pure products (+)-**12c/13c** in 95% yield.

Procedure E: **General Procedure for the Preparation of (1*R*,4*S*,5*S*,7*R*)-5-Benzyl-3-(*tert*-Butyl)-4-Hydroxy-7-Methyl-7-Nitro-8-Oxobicyclo[3.2.1]oct-2-en-1-yl Acetate (12p/13p)**: In a 10 mL round-bottom flask equipped with a magnetic stirring bar, (+)-**10p** (59.85 mg, 0.15 mmol) was dissolved in dry MeOH/DCM (1:1, 0.15 M, 1.0 mL) in equimolar ratio under argon atmospear and then cooled to 0 ºC, followed by addition of 2.0 equiv. of $NaBH_4$ (11.35 mg) in portion wise. The reaction mixture was then stirred at the same temperature for 4 h. The crude reaction mixture was quenched with water and the the aqueous layer was extracted with ethyl acetate (3 x 20 mL). The combined organic layers were dried over Na_2SO_4, filtered and concentrated in *vacuo* and purified by coloumn chromatography to give products (+)-**12p/13p** in 80% yield (silica gel, mixture of hexane/ethyl acetate).

Procedure F: **Preparation of Racemic 5-Hydroxy-3-Isopropyl-6-Methyl-6-Nitro-1-(2-nitropropyl)bicyclo[3.2.1]oct-3-ene-2,8-dione** (±)-**8bb**/**9bb**: An oven-dried, round bottom flask equipped with a magnetic stirring bar was charged with 10 mol% of achiral thiourea catalyst **3d** (10.8 mg), followed by the addition of 0.1 mL of dry toluene, 0.3 mmol of 2-hydroxy-5-isopropylcyclohexa-2,5-diene-1,4-dione **1a** (50 mg) and 0.9 mmol (0.9 mL, 1.0 M in toluene) of α-methylnitroethylene **6c** the resulting reaction mixture was stirred at room temperature for 20 min. The crude reaction mixture was directly loaded onto a silica gel column without aqueous workup, and pure products (±)-**8bb**/**9bb** were obtained in 39% yield (silica gel, mixture of hexane/ethyl acetate).

Procedure G: **Preparation of Chiral 5-Hydroxy-3-Isopropyl-6-Methyl-6-Nitro-1-(2-nitropropyl)bicyclo[3.2.1]oct-3-ene-2,8-dione** (+)-**8bb**/**9bb**: An oven-dried, round bottom flask equipped with a magnetic stirring bar was charged with 10 mol% of chiral quinine squaramide catalyst **3g** (18.12 mg), followed by the addition of 0.1 mL of dry toluene, 0.3 mmol of 2-hydroxy-5-isopropylcyclohexa-2,5-diene-1,4-dione **1a** (50 mg) and 0.9 mmol (0.9 mL, 1.0 M in toluene) of α-methylnitroethylene **6c** and the resulting reaction mixture was stirred at room temperature for 20 min. The crude reaction mixture was directly loaded onto a silica gel column without aqueous workup, and pure products **8bb**/**9bb** were obtained in 76% yield (silica gel, mixture of hexane/ethyl acetate).

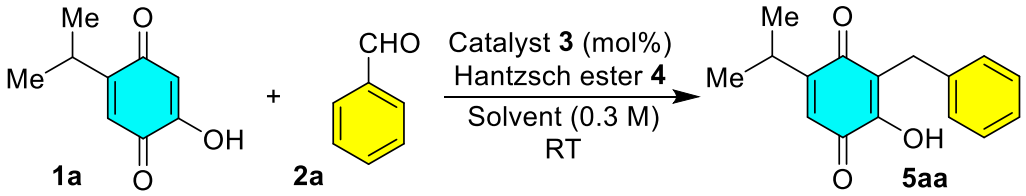
Procedure H: **Preparation of Chiral 3-Isopropyl-7-Methyl-7-Nitro-5-(2-Nitropropyl)-4,8-Dioxobicyclo[3.2.1]oct-2-en-1-yl Acetate** (+)-**10bb/11bb**: In an oven dried 10.0 mL round

bottom flask equipped with a magnetic stirring bar, to the compound (+)-**8bb/9bb** (40 mg, 0.1 mmol), in dry toluene (0.4 mL), acetyl chloride (0.936 mmol, 8.0 equiv., 67 µl) and conc. H_2SO_4 (0.0351 mmol, 30 mol%, 1.88 µl) were added. The resulting reaction mixture was stirred at room temperature for 0.5 h. The crude reaction mixture was directly loaded onto a silica gel column without aqueous workup, and pure products (+)-**10bb/11bb** were obtained in 84% yield (silica gel, mixture of hexane/ethyl acetate).

Reaction Optimization for the Reductive Alkylation of Hydroxy-*p*-quinone 1a: Initially, we synthesized **1a** from *p*-isopropylphenol and then treated it with commercially available benzaldehyde **2a** and Hantzsch ester **4** under the proline-catalysis to furnish the corresponding reductive alkylation product **5aa**. In this reaction, we have utilized proline **3a** as the catalyst and Hantzsch ester **4** as hydride source in DCM solvent at room temperature and obtained **5aa** in only 28% yield (Table S1, entry 1). The desired reductive alkylation product **5aa** was obtained when we performed reactions using benzylamine **3b** as a catalyst, but there is no considerable increase in the yield with the increase in loading of catalyst **3b**. Moreover, stirring the reaction for a longer time (>1 h) has decreased the yield as multiple spots appeared (Table S1, entries 2-4). The same alkylation reaction was then carried out using aniline **3c** as the catalyst and to our delight, the yield slightly improved to 56% (Table S1, entry 5). When the equivalence of aniline **3c** was changed from 0.2 to 0.05, the reaction took longer hours with decreased product formation of **5aa** (Table S1, entries 5-7). Screening of solvents such as THF, *n*-butanol, methanol, isopropanol, DCE, and CH_3CN, the reaction proved that only DCM and DCE are efficient, and establishing them as the most suitable solvents in this reductive alkylation reaction (Table S1, entries 8-14). Upon increasing the loading of aniline **3c** from 0.5 equiv. to 1.0 equiv, the yield of alkylation product **5aa** enhanced from 58% to 70% within 0.5 h, thus indicating it as the optimized condition for the synthesis of designed 3,5-dialkyl-2-hydroxy-*p*-quinone **5aa** (Table S1, entries 15-16).

With the established optimized reaction conditions in hand, we investigated to synthesize various substituted 3,5-dialkyl-2-hydroxy-*p*-quinones **5** in good to very good yields as shown in Tables S2-S3.

Table S1: Reaction Optimization for the Reductive Alkylation of Hydroxy-*p*-quinone **1a**.[a]

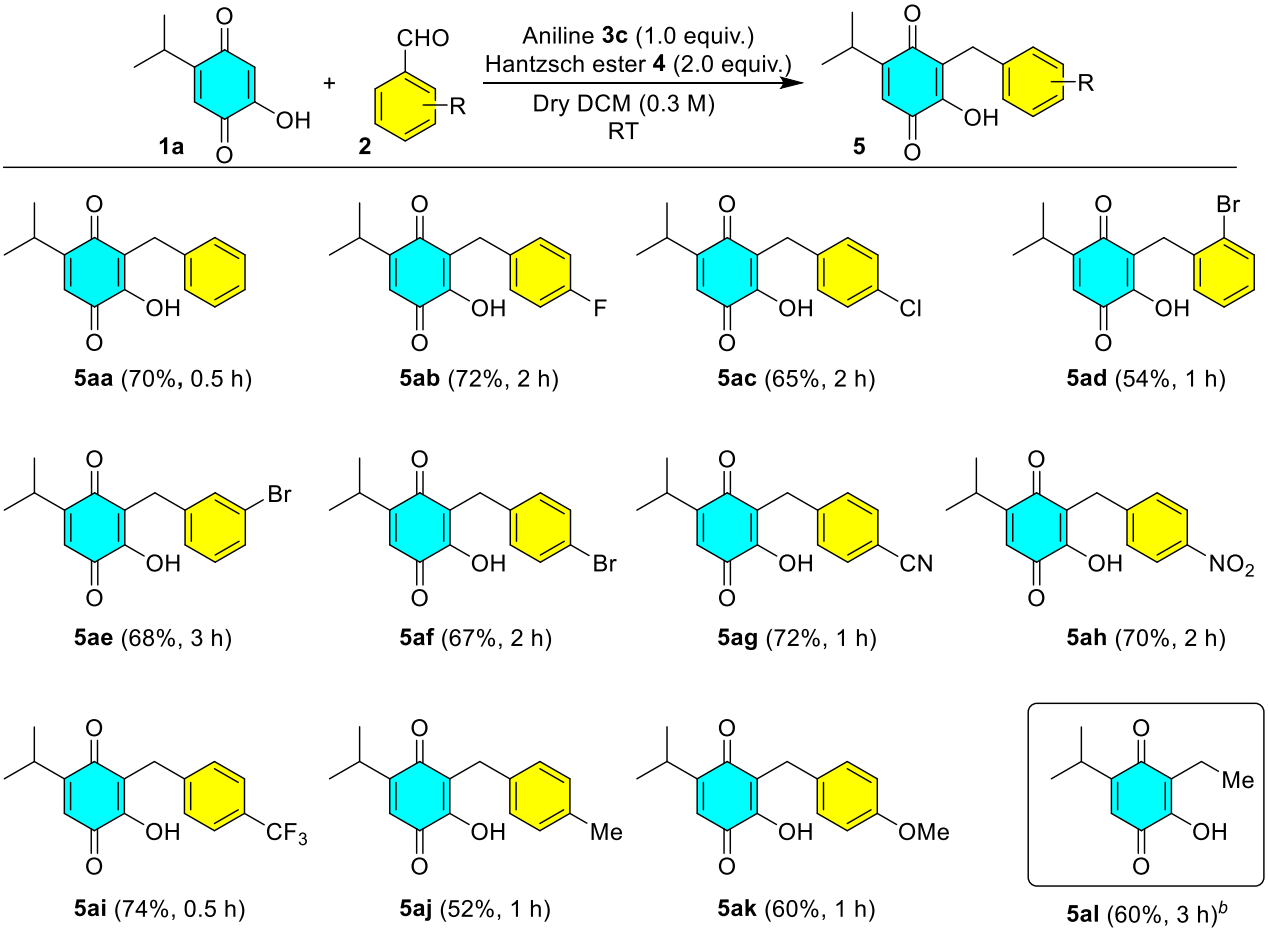


Entry	Catalyst **3** (mol%)	**2a** (equiv.)	**4** (equiv.)	Solvent (0.3 M)	Time (h)	Yield (%)[b]
1	Proline **3a** (20)	2.0	1.1	DCM	11 h	28
2	Benzylamine **3b** (5)	2.0	1.1	DCM	1.0 h	15
3	Benzylamine **3b** (10)	2.0	1.1	DCM	0.25 h	36
4	Benzylamine **3b** (20)	2.0	1.1	DCM	0.25 h	42
5	Aniline **3c** (20)	2.0	1.1	DCM	3.0 h	56
6	Aniline **3c** (10)	2.0	1.1	DCM	3.0 h	53
7	Aniline **3c** (5.0)	2.0	1.1	DCM	16 h	50
8	Aniline **3c** (20)	2.0	1.1	THF	3.0 h	45
9	Aniline **3c** (20)	2.0	1.1	n-butanol	3.0 h	56
10	Aniline **3c** (20)	2.0	1.1	DMSO	3.0 h	25
11	Aniline **3c** (20)	2.0	1.1	MeOH	3.0 h	20
12	Aniline **3c** (20)	2.0	1.1	*i*-PrOH	3.0 h	45
13	Aniline **3c** (20)	2.0	1.1	DCE	1.0 h	58
14	Aniline **3c** (20)	2.0	1.1	CH_3CN	6.0 h	33
15	Aniline **3c** (50)	2.0	2.0	DCM	1.0 h	60
16	Aniline **3c** (1.0 equiv.)	2.0	2.0	DCM	0.5 h	70

[a] Reactions were carried out in solvent (0.3 M) with 2.0 equiv. of **2a** (0.6 mmol) and 2.0 equiv. of **4** (0.6 mmol) relative to the hydroxy-*p*-quinone **1a** (0.3 mmol) in the presence of aniline **3c**. [b] Yield refers to the column-purified product.

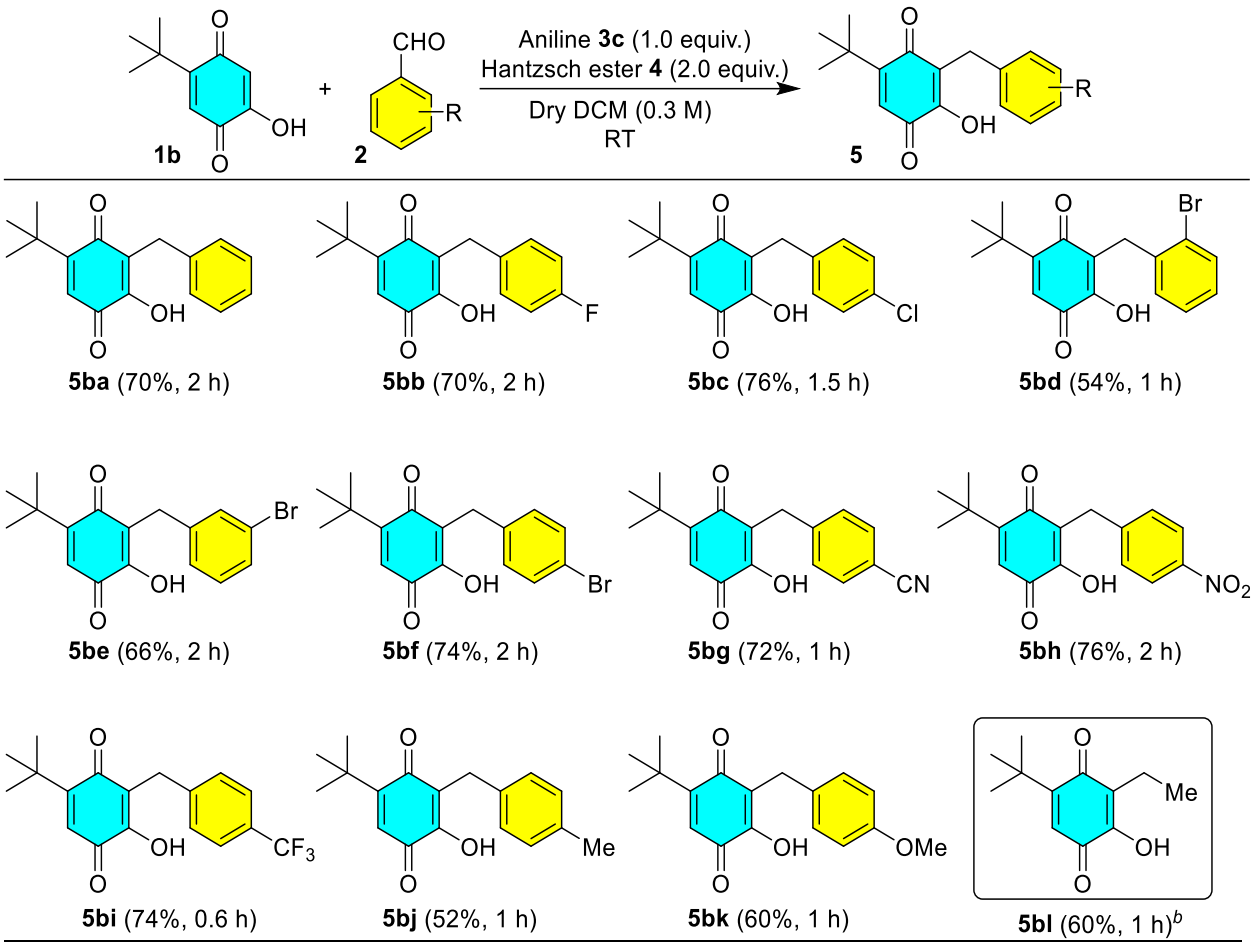
We performed the **3c**-induced reaction between **1a**, **4** and various aldehydes **2b-2l** to furnish the reductive alkylation products **5ab-5al**. The reaction of 4-fluoro and 4-chlorobenzaldehydes **2b** and **2c** with **1a** and **4** gave **5ab** and **5ac** in 72% and 65% yields, respectively within 2 h (Table S2). The reaction of **1a** with **2d-2f** went smoothly to give **5ad-5af** in moderate yields (54%, 68%, 67%) in less than 3 h, stating that steric factors are govern the reaction (Table S2). Reactions were carried out with electron-withdrawing groups (4-CN, 4-NO_2, and 4-CF_3) containing **2g-2i** with **1a** and **4** to give products **5ag-5ai** in very good yields, i.e., 72%, 70%, 74%, respectively and also with electron-donating groups of 4-methyl and 4-methoxy **2j** and **2k** also furnished the products **5aj** and **5ak** in 1 h with moderate yields of 52% and 60% respectively (Table S2). The reaction of **1a** and **4** with 5.0 equiv. of acetaldehyde **2l** at 0 °C went smoothly to give **5al** in 3 h with 60% yield (Table S2).

Table S2: Reductive Alkylation of Hydroxy-*p*-quinone **1a** with various Aldehydes **2**.[a]



[a] Reactions were performed with 1.0 equiv. of hydroxy-*p*-quinone **1a** (0.3 mmol), 2.0 equiv. of aldehyde **2** (0.6 mmol) and 2.0 equiv. of Hantzsch ester **4** (0.6 mmol) in the presence of aniline **3c** (1.0 equiv.) in DCM (0.3 M) at room temperature. [b] Reaction was performed with 5.0 equiv. of aliphatic acetaldehyde **2l** as aldehyde source at 0 °C.

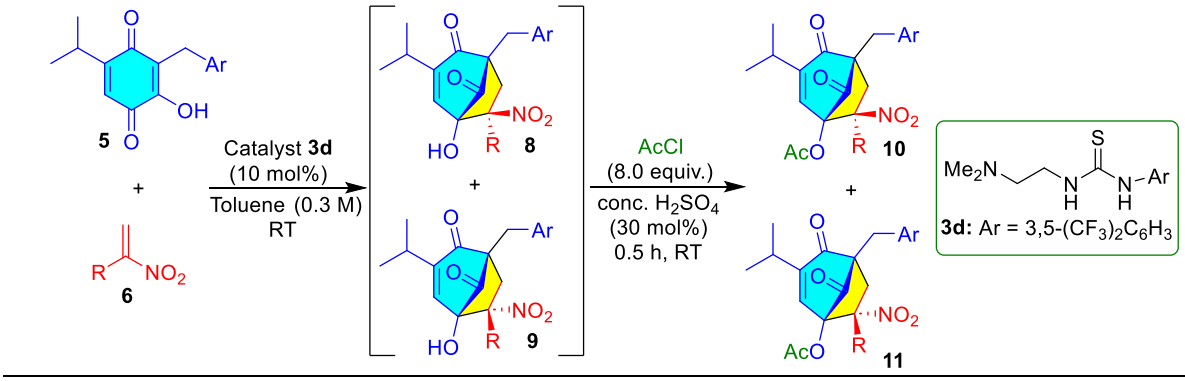
Table S3: Reductive Alkylation of Hydroxy-*p*-quinone **1b** with various Aldehydes **2**.[a]

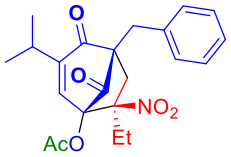


[a] Reactions were performed with 1.0 equiv. of hydroxy-*p*-quinone **1b** (0.3 mmol), 2.0 equiv. of aldehyde **2** (0.6 mmol) and 2.0 equiv. of Hantzsch ester **4** (0.6 mmol) in the presence of aniline **3c** (1.0 equiv.) in DCM (0.3 M) at room temperature. [b] Reaction was performed with 5.0 equiv. of aliphatic acetaldehyde **2l** as aldehyde source at 0 °C.

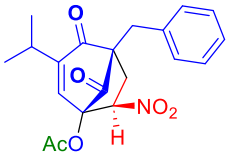
We went onto investigate the reaction scope for 2-(*tert*-butyl)-5-hydroxycyclohexa-2,5-diene-1,4-dione **1b** with various aldehydes **2** and **4** to furnish the products **5ba-5bl** (Table S3). The reaction of **1b** with aldehydes **2a-2c** resulted in the formation of products **5ba-5bc** with good yields of 70% and 76% in 2 h or less than 2 h, respectively (Table S3). Treatment of **1b** with aldehydes **2d-2f** gave products **5bd-5bf** with 54%, 66%, 74% yields respectively, which can be attributed to steric factors (Table S3). Electron-withdrawing groups containing aldehydes **2g-2i** gave the products **5bg-5bi** in less than 2 h with good yields. Same time electron-donating groups containing aldehydes **2j-2k** gave products **5bj-5bk** in 1 h with yields of 52% and 60% (Table S3). The **3c**-induced reaction of **1b** and **4** with 5.0 equiv. of acetaldehyde **2l** at 0 °C for 1.0 h furnished product **5bl** in 60% yield (Table S3).

Table S4: Organocatalytic Racemic Synthesis of Bicyclo[3.2.1]octanes **10a/11a-10o/11o**.[a-c]

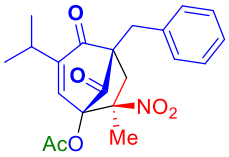




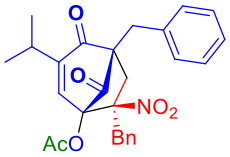
(±)-**10a** (93%)
5 min, *dr*: 2:1



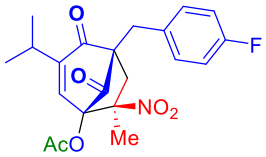
(±)-**10b** (91%)
5 min, *dr*: 4.5:1



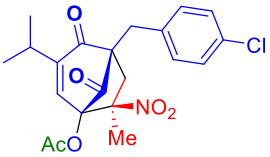
(±)-**10c** (83%)
5 min, *dr*: 2.8:1



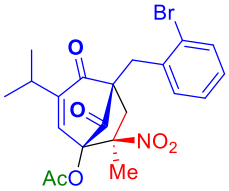
(±)-**10d** (88%)
5 min, *dr*: 17.2:1



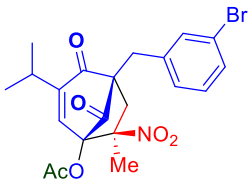
(±)-**10e** (75%)
5 min, *dr*: 3.2:1



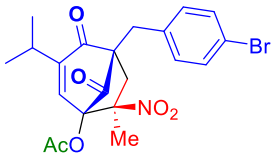
(±)-**10f** (93%)
10 min, *dr*: 4:1



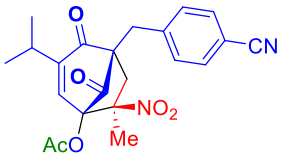
(±)-**10g** (89%)
10 min, *dr*: 3:1



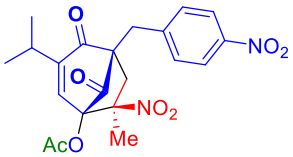
(±)-**10h** (87%)
5 min, *dr*: 2.4:1



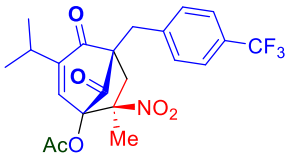
(±)-**10i** (85%)
10 min, *dr*: 3.5:1



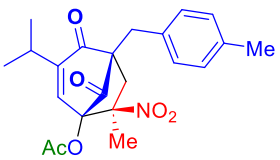
(±)-**10j** (96%)
20 min, *dr*: 2.5:1



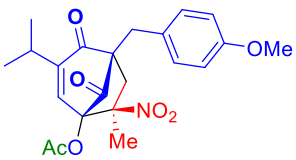
(±)-**10k** (91%)
10 min, *dr*: 5.5:1



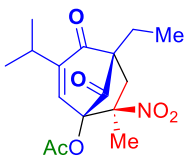
(±)-**10l** (86%)
10 min, *dr*: 3.9:1



(±)-**10m** (76%)
30 min, *dr*: 2.5:1



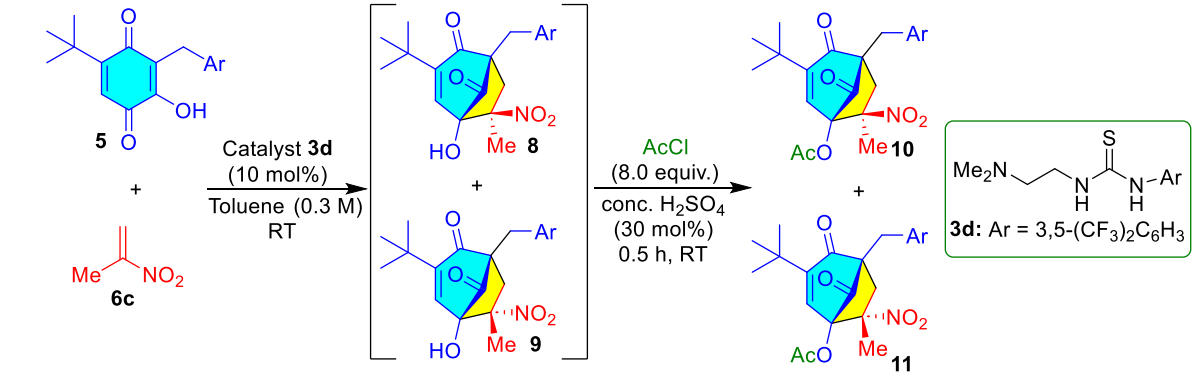
(±)-**10n** (88%)
30 min, *dr*: 2.6:1

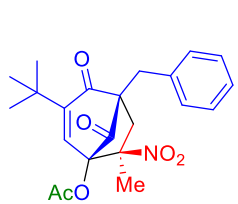


(±)-**10o** (83%)
5 min, *dr*: 2.5:1

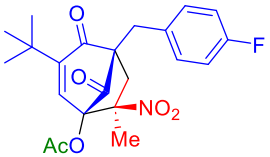
[a] Reactions were carried out in toluene (0.05 mL) with 3.0 equiv. of **6** (0.45 mL, 1.0 M in toluene) relative to **5** (0.15 mmol, 1.0 equiv.) in the presence of catalyst **3d** (5.38 mg, 10 mol%) at room temperature for 5-30 minutes followed by *in situ* protection of *tert*-hydroxy group with 8.0 equiv. of acetyl chloride (85 µL) in the presence of 30 mol% of conc.H_2SO_4 (2.4 µL). [b] Yield refers to the column-purified combined products of **10** and **11**. [c] *dr* was determined by CSP-HPLC analysis of the column-purified combined products of **10** and **11**.

Table S5: Organocatalytic Racemic Synthesis of Bicyclo[3.2.1]octanes **10p/11p-10aa/11aa**.[a-c]

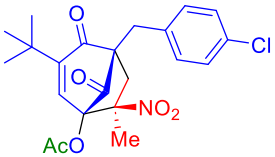




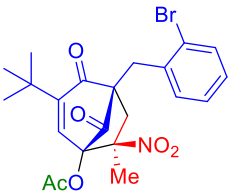
(±)-**10p** (95%)
30 min, *dr*: 4.5:1



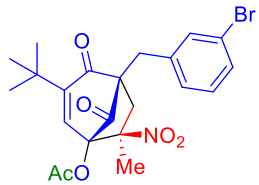
(±)-**10q** (95%)
20 min, *dr*: 3:1



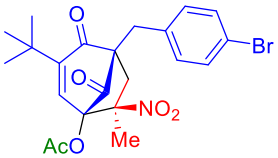
(±)-**10r** (90%)
20 min, *dr*: 3.1:1



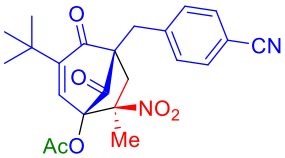
(±)-**10s** (83%)
20 min, *dr*: 3.1:1



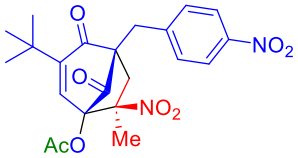
(±)-**10t** (80%)
20 min, *dr*: 2.6:1



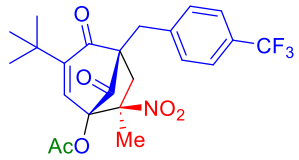
(±)-**10u** (87%)
20 min, *dr*: 2.9:1



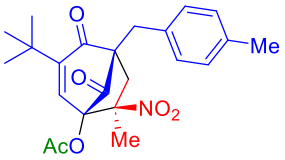
(±)-**10v** (82%)
20 min, *dr*: >20:1



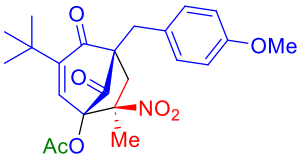
(±)-**10w** (82%)
20 min, *dr*: 11:1



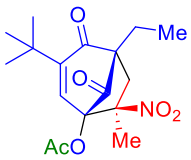
(±)-**10x** (94%)
20 min, *dr*: 4.0:1



(±)-**10y** (82%)
20 min, *dr*: 1.5:1

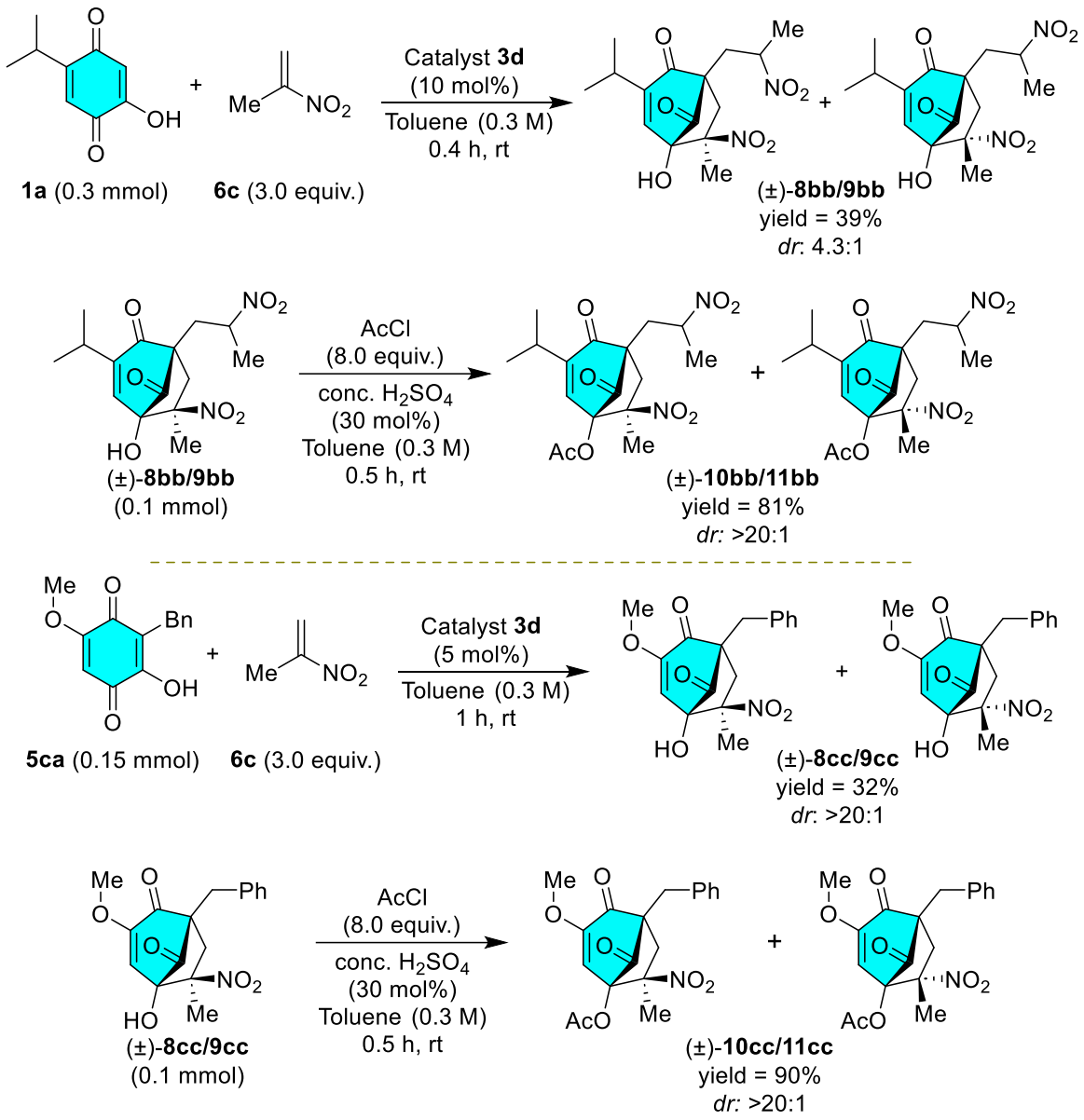


(±)-**10z** (60%)
20 min, *dr*: >20:1



(±)-**10aa** (80%)
20 min, *dr*: >20:1

[a] Reactions were carried out in toluene (0.05 mL) with 3.0 equiv. of **6c** (0.45 mL, 1.0 M in toluene) relative to **5** (0.15 mmol, 1.0 equiv.) in the presence of catalyst **3d** (5.38 mg, 10 mol%) at room temperature for 20-30 minutes followed by *in situ* protection of the *tert*-hydroxy group with 8.0 equiv. of acetyl chloride (85 µL) in the presence of 30 mol% of conc.H_2SO_4 (2.4 µL). [b] Yield refers to the column-purified combined products of **10** and **11**. [c] *dr* was determined by CSP-HPLC analysis of the column-purified combined products of **10** and **11**.



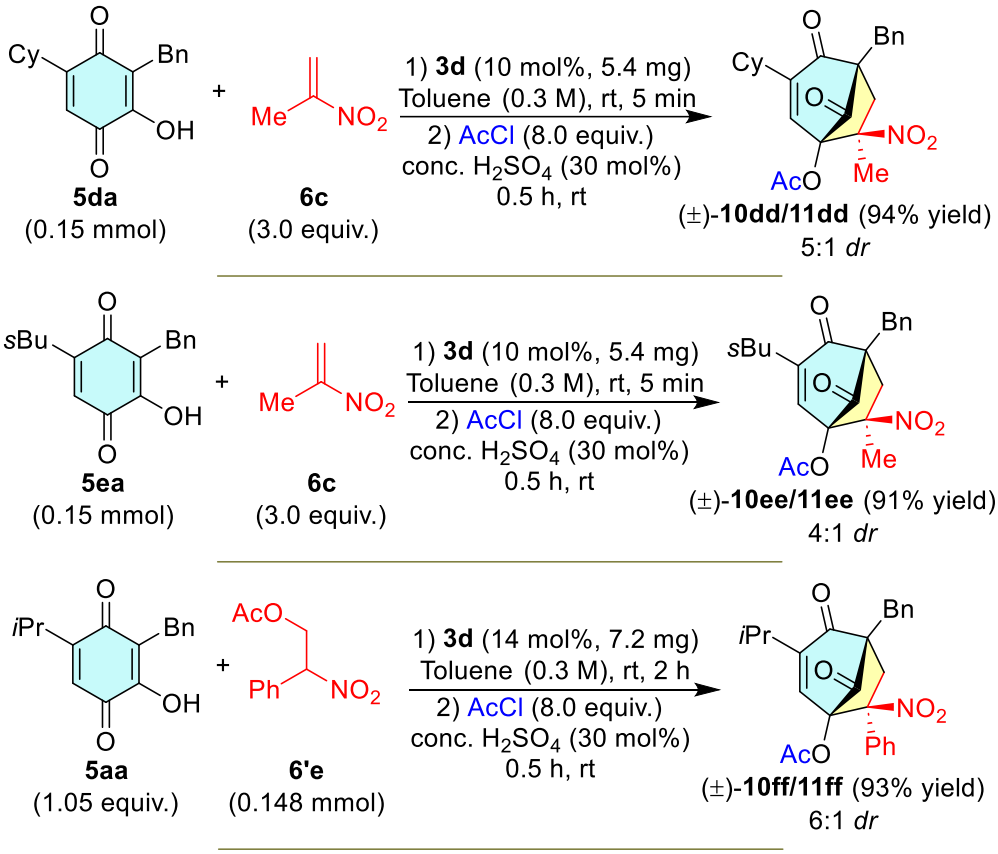
Scheme S1: Organocatalytic Racemic Synthesis of Bicyclo[3.2.1]octanes **10bb/11bb-10cc/11cc**.

Substrate Scope for the Racemic Synthesis of Bicyclo[3.2.1]octanes 10/11: Then, we went on to synthesize a library of racemic bicyclic compounds (±)-**10a** to (±)-**10o**, considering all the electronic and steric factors into account, and by using achiral amine-thiourea **3d** as the catalyst (Table S4). The [3+2]-annulation reaction of **5aa** with different α-substituted nitroethylenes **6a**, **6b**, **6c**, and **6d** under the catalysis of **3d** followed by *in situ* protection of the *tert*-hydroxy group with acetyl chloride in the presence of 30 mol% of conc.H_2SO_4 gave the

products (±)-**10a**, (±)-**10b**, (±)-**10c** and (±)-**10d** respectively, within 5 min, which is highlighting the high reactivity of nitroethylenes **6**. The [3+2]-annulation followed by *in situ* protection of the *tert*-hydroxy group reactions of **5aa** with **6a**, **6b** and **6c** gave excellent yields of cyclization products (±)-**10a** to (±)-**10c** in 93%, 91% and 83% with a *dr* of 2:1, 4.5:1 and 2.8:1, respectively (Table S4). The same reaction sequence with **6d** gave excellent diastereoselectivity of (±)-**10d** in 17.2 :1 *dr* with 88% yield, which can be attributed to the inherent nature of the benzyl group to participate in epimerization (Table S4). The reaction of **5ab** and **5ac** with **6c** followed by *in situ* protection of the *tert*-hydroxy group gave products (±)-**10e** and (±)-**10f** with 75% and 93% yield with a *dr* of 3.2:1 and 4:1 in 5 and 10 min, respectively (Table S4). The one-pot annulation products (±)-**10g**, (±)-**10h**, and (±)-**10i** were synthesized in very good yields with no remarkable change in yield, diastereoselectivity, and reaction time, stating its conditions to be independent of the steric factors (Table S4). The [3+2]-annulation followed by *in situ* protection of the *tert*-hydroxy reaction of **6c** with electron-withdrawing groups such as 4-CN, 4-NO_2, and 4-CF_3 contianing **5ag-5ai** reacted without any hassle in less than 20 min with excellent yields and *dr* of 2.5:1, 5.5:1, and 3.9:1 to give (±)-**10j**, (±)-**10k** and (±)-**10l** respectively (Table S4). Electron-donating groups such as 4-Me and 4-OMe contianing **5aj**-**5ak** gave (±)-**10m** and (±)-**10n** in 30 min with yields of 76% and 88% and a *dr* of 2.5:1 and 2.6:1 respectively (Table S4). The [3+2]-annulation followed by *in situ* protection of the *tert*-hydroxy group reaction of **6c** with **5al** gave (±)-**10o** in 83% yield with *dr* of 2.5:1 within 5 min ascertaining that the reaction conditions are independent of the reactant's substitution like aliphatic or aromatic nature.

After accomplishing the synthesis of a library of racemic bicyclic compounds with **5aa-5al** and **6c**, we further investigated the reaction scope of **5ba-5bl** with **6c** (Table S5). We performed the **3d**-catalyzed reaction of **6c** with **5ba**, **5bb** and **5bc** followed by *in situ* protection of the *tert*-hydroxy group to furnish (±)-**10p**, (±)-**10q**, and (±)-**10r** in excellent yields with *dr* of 4.5:1, 3:1 and 3.1:1, respectively within 30 min (Table S5). The **3d**-catalyzed reaction of **6c** with **5bd-5bf** furnished the racemic bicyclic products (±)-**10s**, (±)-**10t**, and (±)-**10u** in very good yields and *dr* within 20 min, without showing much of steric factors (Table S5). The annulation followed by *in situ* protection of the *tert*-hydroxy group reaction went smoothly with electron-withdrawing groups containing **5bg-5bi** with **6c** to furnish products (±)-**10v** and (±)-**10w** both in 82% yield and (±)-**10x** in 94% yield within 20 min (Table S5). The reaction of **6c** with electron-donating groups containing **5bj** and **5bk** gave (±)-**10y** and (±)-**10z** in 82% and 60% yield with *dr* of 1.5:1 and 20:1, respectively (Table S5). Obtaining the low yield of (±)-**10z**

from **5bk** can be attributed to the electronic factors related to the methoxy group (Table S5). Aliphatic group containing **5bl** with **6c** under the **3d**-catalysis furnished the annulation product (±)-**10aa** in 20 min with 80% yield and a *dr* of >20:1 (Table S5).



Scheme S2: Organocatalytic Racemic Synthesis of Bicyclo[3.2.1]octanes **10dd/11dd-10ff/11ff**.

In a similar manner, achiral bicyclo[3.2.1]octanes (±)-**10bb/11bb** to (±)-**10ff/11ff** containing different functional groups were constructed by using same achiral amine-thiourea **3d**-catalysed [3+2]-annulation of 3,5-dialkyl-2-hydroxy-*p*-quinones **5** with α-methyl nitroethylene **6c** or masked α-phenyl nitroethylene **6'e** in toluene at 25 °C for few minutes followed by *in situ* acid-catalysed *O*-acetylation with acetyl chloride at 25 °C for 0.5 h in toluene solvent furnished the racemic bicyclic products (±)-**10bb/11bb** to (±)-**10ff/11ff** in very good yield and selectivity as shown in Schemes S1 and S2.

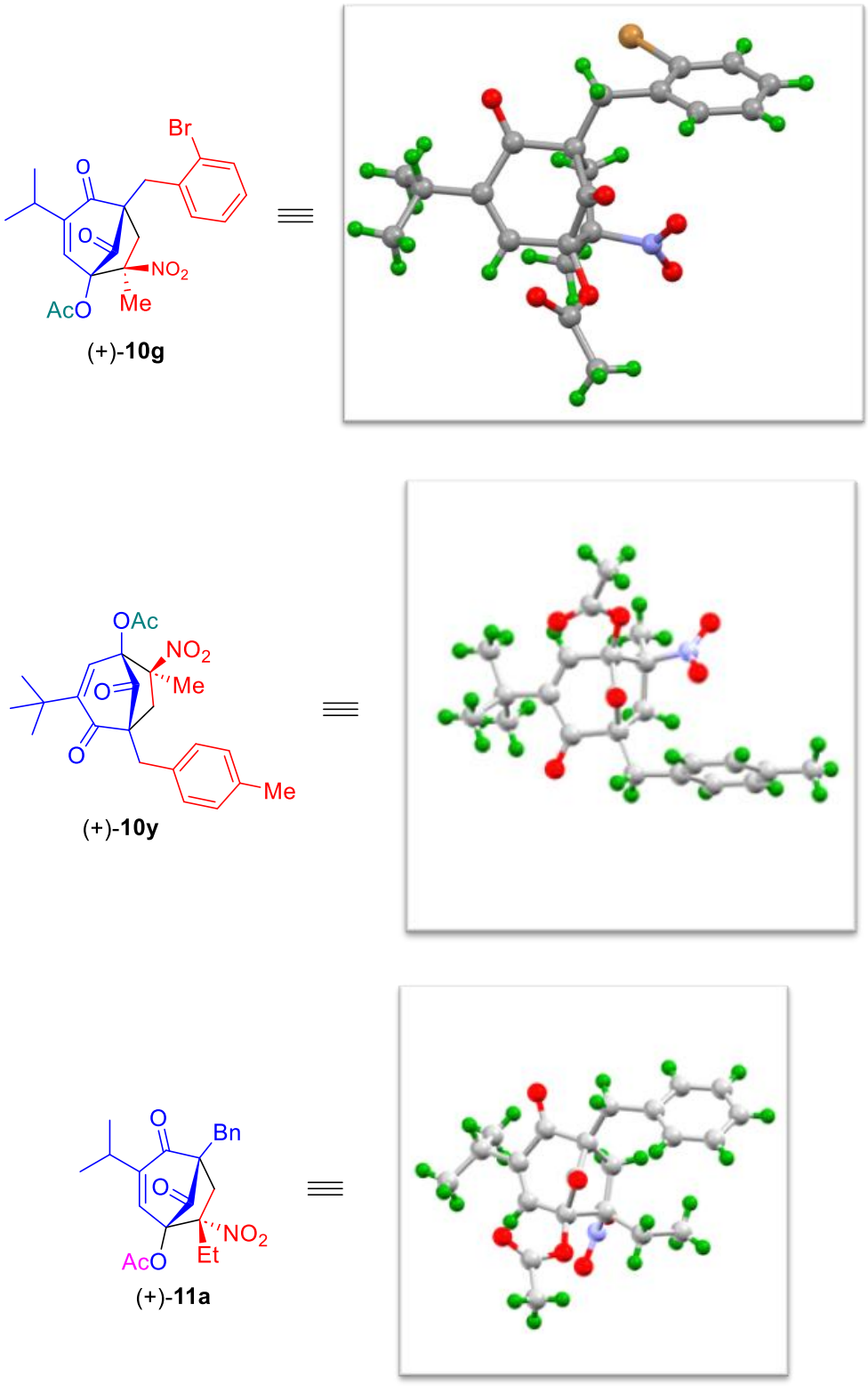
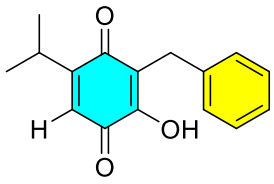


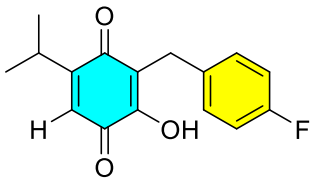
Figure S1. X-Ray crystal structure of compounds (+)-**10g**, (+)-**10y** and (+)-**11a**.

3-Benzyl-2-hydroxy-5-isopropylcyclohexa-2,5-diene-1,4-dione (5aa): The title compound was prepared following the procedure **A** and purified by column chromatography using EtOAc/hexanes (0.5:9.5 to 1:9) and isolated as a light brown solid; Yield: 70% (53.8 mg); Mp.: 80-82 ºC; IR (Neat): ν_{max} 3358, 2959, 2927, 2870, 1637, 1611, 1492, 1459, 1430, 1362, 1276, 1213, 1186, 1078, 972, 692, 630, 497 and 448 cm^{-1}; ^{1}H NMR ($CDCl_3$, 500 MHz): δ 7.32 (2H, d, *J* = 7.0 Hz), 7.27 (2H, t, *J* = 6.5 Hz), 7.18 (1H, t, *J* = 7.5 Hz), 6.97 (1H, br s, O*H*), 6.49 (1H, d, *J* = 1.0 Hz), 3.79 (2H, s), 3.11 (1H, dsept, *J* = 6.7, 1.0 Hz), 1.11 (6H, d, *J* = 7.0 Hz, 2 x CH_3); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135): δ 186.6 (C, *C*=O), 183.8 (C, *C*=O), 158.3 (C), 150.7 (C), 139.0 (C), 129.1 (2 x CH), 128.4 (2 x CH), 126.3 (CH), 125.6 (CH), 120.4 (C), 28.8 (CH_2), 27.3 (CH), 21.6 (2 x CH_3); HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{16}H_{16}O_3Na$ 279.0997; Found 279.0995.



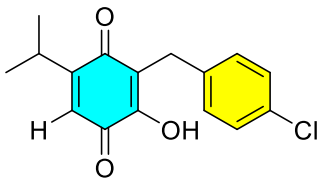
5aa

3-(4-Fluorobenzyl)-2-hydroxy-5-isopropylcyclohexa-2,5-diene-1,4-dione (5ab): The title compound was prepared following the procedure **A** and purified by column chromatography using EtOAc/hexanes (0.7:9.3 to 1.2:8.8) and isolated as a yellow solid; Yield: 72% (59 mg); Mp.: 110-112 ºC; IR (Neat): ν_{max} 3344, 2920, 2851, 1635, 1610, 1507, 1464, 1362, 1220, 1159, 935, 802, 745 and 687 cm^{-1}; ^{1}H NMR ($CDCl_3$, 500 MHz): δ 7.40 (2H, dd, *J* = 8.7, 5.5 Hz), 7.05 (2H, t, *J* = 8.5 Hz), 6.62 (1H, s), 3.87 (2H, s), 3.23 (1H, dseptet, *J* = 7.0, 1.0 Hz), 1.23 (6H, d, *J* = 7.0 Hz, 2 x CH_3); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135): δ 186.5 (C, *C*=*O*), 183.7 (C, *C*=*O*), 161.4 (C, d, *J* = 242.5 Hz, *C*-F), 158.2 (C), 150.6 (C), 134.6 (C, d, *J* = 3.7 Hz), 130.4 (2 x CH, d, *J* = 7.5 Hz), 125.6 (CH), 120.2 (C), 115.1 (2 x CH, d, *J* = 21.2 Hz), 28.0 (CH_2), 27.2 (CH), 21.6 (2 x CH_3); ^{19}F NMR ($CDCl_3$, 470 MHz): δ = –116.8; HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{16}H_{16}FO_3$ 275.1083; Found 275.1083.



5ab

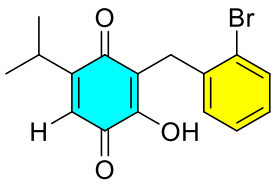
3-(4-Chlorobenzyl)-2-hydroxy-5-isopropylcyclohexa-2,5-diene-1,4-dione (5ac): The title compound was prepared following the procedure **A** and purified by column chromatography using EtOAc/hexanes (0.7:9.3 to 1.2:8.8) and isolated as a yellow solid; Yield: 65% (56.7 mg); Mp.: 105-107 ºC; IR (Neat): ν_{max} 3340, 2967, 1634, 1612, 1363, 1216, 1090, 1015, 936, 810, 685 and 501 cm^{-1}; ^{1}H NMR ($CDCl_3$, 500 MHz): δ 7.25 (2H, br d, *J* = 8.5 Hz), 7.21 (2H, br d, *J* = 8.5 Hz), 7.06 (1H, br s, O*H*), 6.49 (1H,



5ac

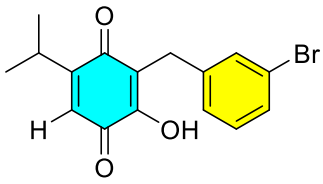
d, J = 1.0 Hz), 3.75 (2H, s), 3.10 (1H, dsept, J = 7.0 Hz, 1.0 Hz), 1.11 (6H, d, J = 7.0 Hz, 2 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135): δ 186.5 (*C*, *C*=*O*), 183.6 (*C*, *C*=*O*), 158.3 (C), 150.7 (C), 137.4 (C), 132.0 (C), 130.4 (2 x CH), 128.5 (2 x CH), 125.6 (CH), 119.9 (C), 28.2 (CH_2), 27.2 (CH), 21.6 (2 x CH_3); HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{16}H_{15}ClO_3Na$ 313.0607; Found 313.0603.

3-(2-Bromobenzyl)-2-hydroxy-5-isopropylcyclohexa-2,5-diene-1,4-dione (**5ad**): The title compound was prepared following the procedure **A** and purified by column chromatography using EtOAc/hexanes (0.7:9.3 to 1.2:8.8) and isolated as brown semisolid; Yield: 54% (54 mg); IR (Neat): ν_{max} 3355, 2964, 1639, 1610, 1465, 1363, 1323, 1216, 1024, 889 and 742 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz): δ 7.54 (1H, d, J = 8.0 Hz), 7.18 (1H, t, J = 7.5 Hz), 7.08 (1H, d, J = 7.5 Hz), 7.05 (1H, t, J = 7.5 Hz), 6.55 (1H, s), 3.93 (2H, s), 3.13 (1H, sept, J = 7.0 Hz), 1.13 (6H, d, J = 6.5 Hz, 2 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135): δ 186.3 (C, *C*=O), 183.5 (C, *C*=O), 158.7 (C), 151.6 (C), 137.8 (C), 132.7 (CH), 129.7 (CH), 127.8 (CH), 127.2 (CH), 125.6 (CH), 124.5 (C), 118.7 (C), 29.3 (CH_2), 27.3 (CH), 21.6 (2 x CH_3); HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{16}H_{16}BrO_3$ 335.0283; Found 335.0282.



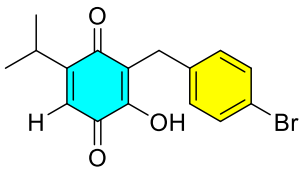
5ad

3-(3-Bromobenzyl)-2-hydroxy-5-isopropylcyclohexa-2,5-diene-1,4-dione (5ae): The title compound was prepared following the procedure **A** and purified by column chromatography using EtOAc/hexanes (0.7:9.3 to 1.2:8.8) and isolated as a yellow solid; Yield: 68% (68.3 mg); Mp.: 75-77 ºC; IR (Neat): ν_{max} 2970, 1718, 1441, 1368, 1280, 1220, 1099, 1042 and 771 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz): δ 7.46 (1H, br s), 7.31 (1H, br d, J = 8.0 Hz), 7.25 (1H, br d, J = 8.0 Hz), 7.12 (1H, t, J = 8.0 Hz), 7.01 (1H, br s, O*H*), 6.51 (1H, s), 3.75 (2H, s), 3.11 (1H, tsept, J = 7.0, 1.0 Hz), 1.12 (6H, d, J = 7.0 Hz, 2 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135): δ 186.4 (C, *C*=O), 183.6 (C, *C*=O), 158.4 (C), 150.8 (C), 141.2 (C), 132.0 (CH), 130.0 (CH), 129.4 (CH), 127.8 (CH), 125.7 (CH), 122.4 (C), 119.6 (C), 28.5 (CH_2), 27.3 (CH), 21.7 (2 x CH_3); HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{16}H_{16}BrO_3$ 335.0283; Found 335.0285.



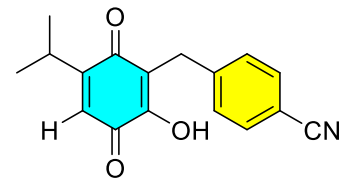
5ae

3-(4-Bromobenzyl)-2-hydroxy-5-isopropylcyclohexa-2,5-diene-1,4-dione (5af): The compound was prepared following the procedure **A** and purified by column chromatography using EtOAc/hexanes (0.7:9.3 to 1.2:8.8) and isolated as light brown solid; Yield: 67% (67.4 mg); Mp.: 92-94 ºC; IR (Neat): ν_{max} 3342, 2965, 1633, 1612, 1485, 1363, 1327, 1216, 1068, 1011, 979, 889, 808, 789, 715, 683, 642, 541, and 500 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz): δ 7.37 (2H, td, *J* = 8.5, 2.5 Hz), 7.19 (2H, td, *J* = 8.5, 2.5 Hz), 6.98 (1H, br s, O*H*), 6.50 (1H, d, *J* = 1.5 Hz), 3.73 (2H, s), 3.10 (1H, dsept, *J* = 7.0, 1.0 Hz), 1.11 (6H, d, *J* = 7.0 Hz, 2 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135): δ 186.5 (C, *C*=O), 183.7 (C, *C*=O), 158.4 (C), 150.7 (C), 138.0 (C), 131.5 (2 x CH), 130.9 (2 x CH), 125.7 (CH), 120.2 (C), 119.8 (C), 28.3 (CH_2), 27.3 (CH), 21.6 (2 x CH_3); HRMS (ESI-TOF) *m/z*: $[M + NH_4]^+$ Calcd for $C_{16}H_{19}BrO_3N$ 352.0548; Found 352.0546.



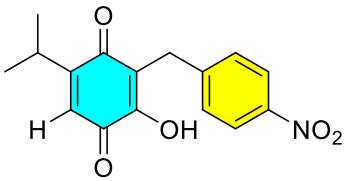
5af

4-((2-Hydroxy-5-isopropyl-3,6-dioxocyclohexa-1,4-dien-1-yl)methyl)benzonitrile (5ag): The title compound was prepared following the procedure **A**, purified by column chromatography using EtOAc/hexane (0.7:9.3 to 1.2:8.8), and was isolated as a yellow solid; Yield: 72% (60.7 mg); Mp.: 99-101 ºC; IR (Neat): ν_{max} 3259, 2228, 1636, 1605, 1380, 1357, 1268, 1210, 1186, 1020, 899, 817, 744, 689, 616 and 546 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz): δ 7.55 (2H, d, *J* = 8.0 Hz), 7.43 (2H, d, *J* = 8.0 Hz), 6.53 (1H, s), 3.84 (2H, s), 3.10 (1H, sept, *J* = 7.0 Hz), 1.12 (6H, d, *J* = 7.0 Hz, 2 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135): δ 186.3 (C, *C*=*O*), 183.4 (C, *C*=*O*), 158.3 (C), 151.0 (C), 144.5 (C), 132.2 (2 x CH), 129.8 (2 x CH), 125.8 (CH), 118.9 (C), 118.8 (C), 110.1 (C), 29.0 (CH_2), 27.3 (CH), 21.6 (2 x CH_3); HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{17}H_{15}NO_3Na$ 304.0950; Found 304.0955.



5ag

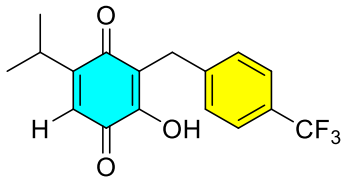
2-Hydroxy-5-isopropyl-3-(4-nitrobenzyl)cyclohexa-2,5-diene-1,4-dione (5ah): The title compound was prepared following the procedure **A**, purified by column chromatography using EtOAc/hexane (1.5:8.5 to 2.0:8.0) and was isolated as a yellow solid; Yield: 70% (63 mg); Mp.: 120-122 ºC; IR (Neat): ν_{max} 3345, 2964, 1634, 1598, 1514, 1336, 1218, 1105, 890, 853, 743, 684 and 499 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz): δ 8.11 (2H, td, *J* = 9.5, 4.5 Hz), 7.47 (2H, td, *J* = 10.0, 4.5 Hz), 7.18 (1H, br s, O*H*), 6.52 (1H, d, *J* = 1.5 Hz), 3.87 (2H s), 3.09 (1H, dsept, *J* = 7.0, 1.0 Hz), 1.11 (6H, d, *J* = 7.0 Hz,



5ah

2 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135): δ 186.3 (C, *C*=*O*), 183.3 (C, *C*=*O*), 158.4 (C), 151.1 (C), 146.6 (C), 146.6 (C), 129.8 (2 x CH), 125.8 (CH), 123.6 (2 x CH), 118.7 (C), 28.8 (CH_2), 27.3 (CH), 21.6 (2 x CH_3); HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{16}H_{15}NO_5Na$ 324.0848; Found 324.0851.

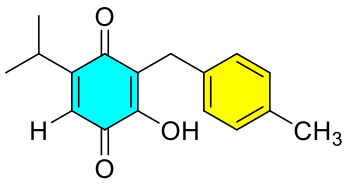
2-Hydroxy-5-isopropyl-3-(4-(trifluoromethyl)benzyl)cyclohexa-2,5-diene-1,4-dione (**5ai**):



5ai

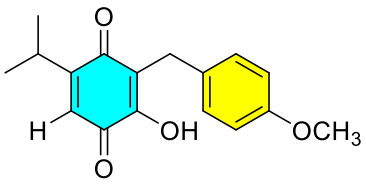
The title compound was prepared following the procedure **A** and purified by column chromatography using EtOAc/hexanes (0.8:9.2 to 1.3:8.7), and isolated as a yellow solid; Yield: 74% (72 mg); Mp.: 138-140 ºC; IR (Neat): ν_{max} 3351, 2969, 1636, 1613, 1363, 1323, 1155, 1122, 1066, 821 and 744 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz): δ 7.50 (2H, d, *J* = 8.0 Hz), 7.43 (2H, d, *J* = 8.0 Hz), 7.09 (1H, br s, O*H*), 6.51 (1H, d, *J* = 1.0 Hz), 3.84 (2H, s), 3.10 (1H, dsept, *J* = 7.0, 1.5 Hz), 1.11 (6H, d, *J* = 6.5 Hz, 2 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135) δ 186.4 (C, *C*=O), 183.5 (C, *C*=O), 158.4 (C), 150.9 (C), 143.0 (C), 129.3 (2 x CH), 128.9 (C, q, *J* = 32.5 Hz), 125.7 (CH), 125.3 (2 x CH, q, *J* = 3.7 Hz), 123.1 (C, q, *J* = 270.0 Hz, *C*F_3), 119.4 (C), 28.7 (CH_2), 27.3 (CH), 21.6 (2 x CH_3); ^{19}F NMR ($CDCl_3$, 470 MHz): δ = –62.4; HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{17}H_{16}F_3O_3$ 325.1051; Found 325.1054.

2-Hydroxy-5-isopropyl-3-(4-methylbenzyl)cyclohexa-2,5-diene-1,4-dione (5aj): The title compound was prepared following the procedure **A** and purified by column chromatography using EtOAc/hexane (0.8:9.2 to 1.3:8.7) and isolated as a yellow solid; Yield: 52% (42 mg); Mp.: 80-82 ºC; IR (Neat): ν_{max} 3350, 2968, 2918, 1634, 1612, 1387, 1362, 1315, 1216, 886, 806, 676 and 625 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz): δ 7.23 (2H, d, *J* = 8.0 Hz), 7.08 (2H, d, *J* = 7.5 Hz), 7.04 (1H, br s, O*H*), 6.49 (1H, d, *J* = 1.0 Hz), 3.77 (2H, s), 3.12 (1H, dsept, *J* = 7.0, 1.0 Hz), 2.30 (3H, s, Ar-CH_3), 1.12 (6H, d, *J* = 7.0 Hz, 2 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135) δ 186.6 (C, *C*=O), 183.8 (C, *C*=O), 158.2 (C), 150.5 (C), 135.9 (C), 135.7 (C), 129.1 (2 x CH), 128.9 (2 x CH), 125.5 (CH), 120.6 (C), 28.3 (CH_2), 27.2 (CH), 21.6 (2 x CH_3), 21.0 (CH_3); HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{17}H_{19}O_3$ 271.1334; Found 271.1333.



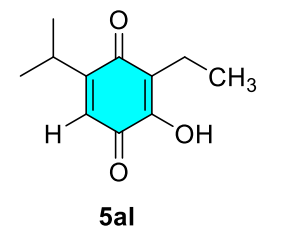
5aj

2-Hydroxy-5-isopropyl-3-(4-methoxybenzyl)cyclohexa-2,5-diene-1,4-dione (5ak): The compound was prepared following the procedure **A** and purified by column chromatography using EtOAc/hexanes (0.8:9.2 to 1.3:8.7) and isolated as a yellow solid; Yield: 60% (51.5 mg); Mp.: 87-89 ºC; IR (Neat): ν_{max} 3368, 2968, 1738, 1639, 1610, 1363, 1215 and 805 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz): δ 7.25-7.23 (2H, m), 6.94 (1H, br s, O*H*), 6.80 (2H, td, *J* = 8.5, 3.0 Hz), 6.47 (1H, d, *J* = 1.0 Hz), 3.76 (3H, s, OC*H*$_3$), 3.73 (2H, s), 3.10 (1H, dsept, *J* = 7.0, 1.0 Hz), 1.11 (6H, d, *J* = 7.0 Hz, 2 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135): δ 186.6 (*C*, *C*=O), 183.9 (*C*, *C*=O), 158.2 (C), 158.1 (C), 150.4 (C), 131.1 (C), 130.0 (2 x CH), 125.5 (CH), 120.7 (C), 113.8 (2 x CH), 55.2 (O*C*H$_3$), 27.9 (CH_2), 27.2 (CH), 21.6 (2 x CH_3); HRMS (ESI-TOF) *m*/*z*: $[M + H]^+$ Calcd for $C_{17}H_{19}O_4$ 287.1283; Found 287.1280.



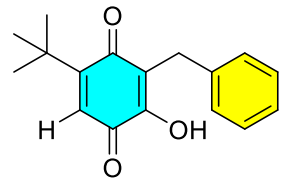
5ak

3-Ethyl-2-hydroxy-5-isopropylcyclohexa-2,5-diene-1,4-dione (5al): The title compound was prepared following the procedure **A**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 2.0:8.0) and was isolated yellow solid; Yield: 60% (35 mg); Mp.: 103-105 ºC; IR (Neat): ν_{max} 2965, 1785, 1756, 1679, 1550, 1459, 1369, 1205, 1108 and 847 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz): δ 6.93 (1H, br s, O*H*), 6.47 (1H, d, *J* = 1.0 Hz), 3.11 (1H, dsept, *J* = 7.0, 1.0 Hz), 2.46 (2H, q, *J* = 7.5 Hz), 1.11 (6H, d, *J* = 6.5 Hz, 2 x CH_3), 1.05 (3H, t, *J* = 7.5 Hz); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135): δ 186.8 (C, *C*=O), 183.8 (C, *C*=O), 158.3 (C), 150.3 (C), 125.4 (CH), 123.0 (C), 27.1 (CH), 21.6 (2 x CH_3), 16.4 (CH_2), 12.6 (CH_3); HRMS (ESI-TOF) *m*/*z*: $[M + Na]^+$ Calcd for $C_{11}H_{14}O_3Na$ 217.0841; Found 217.0838.



5al

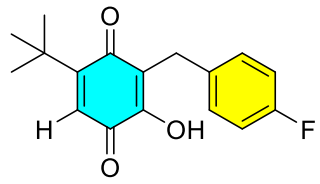
3-Benzyl-5-(*tert*-butyl)-2-hydroxycyclohexa-2,5-diene-1,4-dione (5ba): The title compound was prepared following the procedure **A** and purified by column chromatography using EtOAc/hexane (1.0:9.0 to 2.0:8.0) and isolated as a pale yellow solid; Yield: 70% (56.7 mg); Mp.: 78-80 ºC; IR (Neat): ν_{max} 3371, 2927, 1635, 1598, 1072, 1026, 923, 743, 628, 662 and 500 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz): δ 7.31 (2H, d, *J* = 7.5 Hz), 7.26 (2H, d, *J* = 7.5 Hz), 7.18 (1H, t, *J* = 7.5 Hz), 6.88 (1H, br s, O*H*), 6.56 (1H, s), 3.78 (2H, s), 1.28 (9H, s, 3 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135): δ 186.8 (C, *C*=O), 184.0 (C, *C*=O), 159.2 (C), 150.1 (C), 139.0 (C), 129.0 (2 x CH), 128.4 (2 x CH), 126.9 (CH),



5ba

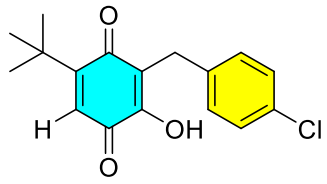
126.2 (CH), 121.5 (C), 35.9 (C), 29.6 (3 x CH_3), 28.8 (CH_2); HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{17}H_{19}O_3$ 271.1334; Found 271.1334.

5-(*tert*-Butyl)-3-(4-fluorobenzyl)-2-hydroxycyclohexa-2,5-diene-1,4-dione (5bb): The title compound was prepared following the procedure **A** and purified by column chromatography using EtOAc/hexanes (0.7:9.3 to 1.2:8.8) and isolated as a light yellow solid; Mp.: 70-72 ºC; Yield: 70% (60.5 mg); IR (Neat): ν_{max} 2957, 2922, 2851, 1644, 1508, 1462, 1380, 1260, 1221, 1096, 1023, 806, 595 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz): δ 7.29-7.27 (2H, m), 6.93 (2H, tt, *J* = 8.5, 2.0 Hz), 6.90 (1H, br s, O*H*), 6.56 (1H, s), 3.74 (2H, s), 1.27 (9H, s, 3 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135): δ 186.8 (C, *C*=O), 184.0 (C, *C*=O), 161.5 (C, d, *J* = 242.5 Hz, *C*-F), 159.3 (C), 150.0 (C), 134.7 (C, d, *J* = 2.5 Hz), 130.5 (2 x CH, d, *J* = 7.5 Hz), 126.9 (CH), 121.4 (C), 115.1 (2 x CH, d, *J* = 21.2 Hz), 36.0 (C), 29.6 (3 x CH_3), 28.0 (CH_2); ^{19}F NMR ($CDCl_3$, 375 MHz): δ = –117.0; HRMS (ESI-TOF) *m/z*: $[M + NH_4]^+$ Calcd for $C_{17}H_{21}FO_3N$ 306.1505; Found 306.1500.



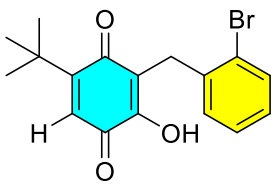
5bb

5-(*tert*-Butyl)-3-(4-chlorobenzyl)-2-hydroxycyclohexa-2,5-diene-1,4-dione (5bc): The title compound was prepared following the procedure **A**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 2.0:8.0), and was isolated yellow solid; Yield: 76% (69.5 mg); Mp.: 102-104 ºC; IR (Neat): ν_{max} 3354, 2958, 1638, 1599, 1485, 1378, 1364, 1220, 1195, 1070, 1011, 981, 913, 808, 744, 675 and 500 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz): δ 7.25 (2H, td, *J* = 9.0, 2.0 Hz), 7.21 (2H, td, *J* = 9.0, 2.5 Hz), 6.94 (1H, br s, O*H*), 6.57 (1H, s), 3.73 (2H, s), 1.27 (9H, s, 3 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135): δ 186.7 (C, *C*=*O*), 183.9 (C, *C*=*O*), 159.3 (C), 150.1 (C), 137.5 (C), 132.0 (C), 130.4 (2 x CH), 128.5 (2 x CH), 126.9 (CH), 121.0 (C), 36.0 (C), 29.6 (3 x CH_3), 28.2 (CH_2); HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{17}H_{18}ClO_3$ 305.0944; Found 305.0938.



5bc

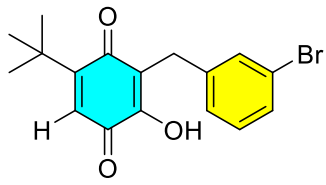
3-(2-Bromobenzyl)-5-(*tert*-butyl)-2-hydroxycyclohexa-2,5-diene-1,4-dione (5bd): The title compound was prepared following the procedure **A** and purified by column chromatography using EtOAc/hexane (1.0:9.0 to 2.0:8.0) and isolated as a brown semi solid; Yield: 54% (56.6 mg); IR (Neat): ν_{max} 3369, 2960, 1640, 1597, 1418, 1377, 1363, 1335, 1223, 1193, 1025 and 741 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz): δ 7.53 (1H, dd, *J* = 8.2, 1.5 Hz), 7.17 (1H, dt, *J* =7.5, 1.5 Hz), 7.06-7.02 (2H, m), 6.63 (1H, s), 3.91 (2H, s), 1.29 (9H,



5bd

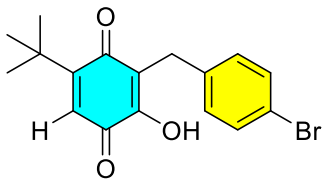
s, 3 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135): δ 186.7 (C, *C*=*O*), 183.8 (C, *C*=*O*), 159.7 (C), 151.1 (C), 137.9 (C), 132.8 (CH), 129.5 (CH), 127.8 (CH), 127.2 (CH), 127.0 (CH), 124.5 (C), 119.9 (C), 36.0 (C), 29.6 (3 x CH_3), 29.4 (CH_2); HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{17}H_{17}BrO_3Na$ 349.0439; Found 349.0440.

3-(3-Bromobenzyl)-5-(*tert*-butyl)-2-hydroxycyclohexa-2,5-diene-1,4-dione (5be): The compound was prepared following the procedure **A** and purified by column chromatography using EtOAc/hexanes (1.0:9.0 to 2.0:8.0) and isolated as a yellow semi solid; Yield: 66% (69 mg); IR (Neat): ν_{max} 2043, 1708, 1630, 1358, 1274, 1190, 1070, 980, 764, 699, 565 and 459 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz): δ 7.45 (1H, s), 7.31 (1H, d, *J* = 8.0 Hz), 7.24 (1H, d, *J* = 7.6 Hz), 7.12 (1H, t, *J* = 8.0 Hz), 6.90 (1H, br s, O*H*), 6.58 (1H, s), 3.74 (2H, s), 1.28 (9H, s, 3 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135): δ 186.7 (C, *C*=*O*), 183.9 (C, *C*=*O*), 159.4 (C), 150.2 (C), 141.3 (C), 132.0 (CH), 129.9 (CH), 129.4 (CH), 127.7 (CH), 127.0 (CH), 122.4 (C), 120.7 (C), 36.0 (C), 29.6 (3 x CH_3), 28.5 (CH_2); HRMS (ESI-TOF) *m/z*: $[M + NH_4]^+$ Calcd for $C_{17}H_{21}BrO_3N$ 366.0705; Found 366.0700.



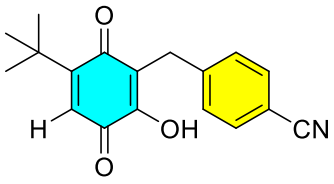
5be

3-(4-Bromobenzyl)-5-(*tert*-butyl)-2-hydroxycyclohexa-2,5-diene-1,4-dione (5bf): The title compound was prepared following the procedure **A**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 2.0:8.0), and was isolated yellow solid; Yield: 74% (77.5 mg); Mp.: 106-108 ºC; IR (Neat): ν_{max} 3352, 2963, 1637, 1600, 1485, 1379, 1364, 1222, 1196, 1070, 1011, 982, 914, 898, 807, 745, 675 and 528 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz): δ 7.37 (2H, td, *J* = 8.5 Hz, 2.5 Hz), 7.19 (2H, td, *J* = 8.5, 2.5 Hz), 6.89 (1H, br s, O*H*), 6.57 (1H, s), 3.72 (2H, s), 1.27 (9H, s, 3 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135): δ 186.7 (C, *C*=*O*), 183.9 (C, *C*=*O*), 159.3 (C), 150.1 (C), 138.0 (C), 131.4 (2 x CH), 130.8 (2 x CH), 126.9 (CH), 120.9 (C), 120.0 (C), 35.0 (C), 29.6 (3 x CH_3), 28.3 (CH_2); HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{17}H_{18}BrO_3$ 349.0439; Found 349.0435.



5bf

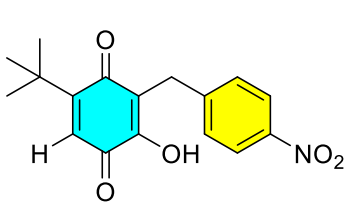
4-((5-(*tert*-Butyl)-2-hydroxy-3,6-dioxocyclohexa-1,4-dien-1-yl)methyl)benzonitrile (**5bg**):



5bg

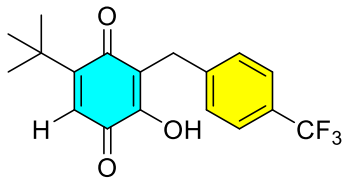
The title compound was prepared following the procedure **A** and purified by column chromatography using EtOAc/hexanes (0.7:9.3 to 1.2:8.8), and isolated as a yellow solid; Mp.: 100-102 ºC; Yield: 72% (63.8 mg); IR (Neat): ν_{max} 3367, 2960, 2228, 1641, 1600, 1377, 1364, 1220, 1195, 983, 916, 547 and 421 cm^{-1}; ^{1}H NMR ($CDCl_3$, 500 MHz): δ 7.54 (2H, d, *J* = 8.5 Hz), 7.41 (2H, d, *J* = 8.5 Hz), 6.95 (1H, br s, O*H*), 6.59 (1H, s), 3.81 (2H, s), 1.27 (9H, s, 3 x CH_3); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135) δ 186.6 (C, *C*=O), 183.7 (C, *C*=O), 159.4 (C), 150.4 (C), 144.6 (C), 132.3 (2 x CH), 129.8 (2 x CH), 127.1 (CH), 120.0 (C), 119.0 (C), 110.2 (C), 36.0 (C), 29.6 (3 x CH_3), 29.1(CH_2); HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{18}H_{18}NO_3$ 296.1287; Found 296.1285.

5-(*tert*-Butyl)-2-hydroxy-3-(4-nitrobenzyl)cyclohexa-2,5-diene-1,4-dione (5bh): The title compound was prepared following the procedure **A**, purified by column chromatography using EtOAc/hexane (1.5:8.5 to 2.5:7.5), and was isolated yellow solid; Yield: 76% (72 mg). Mp.: 142-144 ºC; IR (Neat): ν_{max} 3409, 2920, 1638, 1596, 1513, 1379, 1338, 1287, 1215, 1105, 979, 820, 700 and 495 cm^{-1}; ^{1}H NMR ($CDCl_3$, 500 MHz): δ 8.12 (2H, td, *J* = 8.5, 2.5 Hz), 7.47 (2H, td, *J* = 9.0, 2.5 Hz), 6.99 (1H, br s, O*H*), 6.60 (1H, s), 3.86 (2H, s), 1.28 (9H, s, 3 x CH_3); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135): δ 186.5 (C, *C*=O), 183.6 (C, *C*=O), 159.4 (C), 150.5 (C), 146.7 (C), 146.5 (C), 129.8 (2 x CH), 127.1 (CH), 123.6 (2 x CH), 119.8 (C), 36.0 (C), 29.5 (3 x CH_3), 28.8 (CH_2); HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{17}H_{17}NO_5Na$ 338.1004; Found 338.1009.



5bh

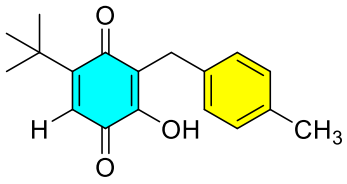
5-(*tert*-Butyl)-2-hydroxy-3-(4-(trifluoromethyl)benzyl)cyclohexa-2,5-diene-1,4-dione (**5bi**): The title compound was prepared following the procedure **A** and purified by column chromatography using EtOAc/hexanes (0.8:9.2 to 1.3:8.7), and isolated as a yellow solid; Yield: 74% (75 mg); Mp.: 117-119 ºC; IR (Neat): ν_{max} 3343, 2970, 1656, 1640, 1615, 1600, 1365, 1226, 1198, 1122, 1105, 1064, 1033, 681 and 650 cm^{-1}; ^{1}H NMR ($CDCl_3$, 500 MHz): δ 7.51 (2H, d, *J* = 8.0 Hz), 7.42 (2H, d, *J* = 8.0 Hz), 6.93 (1H, br s, O*H*), 6.58 (1H, s), 3.82 (2H, s), 1.28 (9H, s, 3 x CH_3); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135): δ 186.7 (C, *C*=O), 183.8 (C, *C*=O), 159.4 (C), 150.3 (C), 143.1 (C), 129.3 (2 x CH), 128.6 (C, q, *J* = 32.5 Hz), 127.0 (CH), 125.3 (2 x CH, q, *J* = 3.75 Hz),



5bi

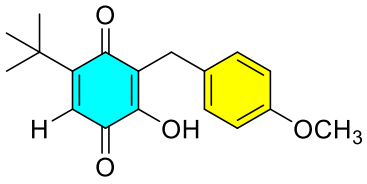
123.2 (C, q, J = 270.0 Hz, CF_3), 120.5 (C), 36.0 (C), 29.6 (3 x CH_3), 28.7 (CH_2); ^{19}F NMR ($CDCl_3$, 470 MHz): δ = –62.4; HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{18}H_{18}F_3O_3$ 339.1208; Found 339.1205.

5-(*tert*-Butyl)-2-hydroxy-3-(4-methylbenzyl)cyclohexa-2,5-diene-1,4-dione (5bj): The compound was prepared following the procedure **A** and purified by column chromatography using EtOAc/hexane (0.5:9.5 to 1.0:9.0) and isolated as a yellow solid; Yield: 52% (44.3 mg); Mp.: 75-77 ºC; IR (Neat): ν_{max} 3383, 2959, 1639, 1598, 1376, 1362, 1336, 1217, 1193, 913 and 891 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz): δ 7.22 (2H, d, J = 8.0 Hz), 7.07 (2H, d, J = 8.0 Hz), 6.89 (1H, d, J = 2.5 Hz), 6.55 (1H, s), 3.75 (2H, s), 2.30 (3H, s, Ar-CH_3), 1.28 (9H, s, 3 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135) δ 187.0 (C, *C*=O), 184.1 (C, *C*=O), 159.2 (C), 150.0 (C), 136.0 (C), 135.8 (C), 129.1 (2 x CH), 128.9 (2 x CH), 126.9 (CH), 121.7 (C), 36.0 (C), 29.6 (3 x CH_3), 28.4 (CH_2), 21.0 (CH_3); HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{18}H_{21}O_3$ 285.1491; Found 285.1494.



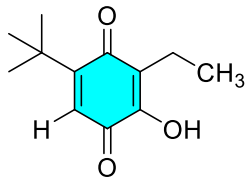
5bj

5-(*tert*-Butyl)-2-hydroxy-3-(4-methoxybenzyl)cyclohexa-2,5-diene-1,4-dione (5bk): The compound was prepared following the procedure **A** and purified by column chromatography using EtOAc/hexanes (1.0:9.0 to 2.0:8.0) and isolated as a semi solid; Yield: 60% (54 mg); IR (Neat): $\nu_{max,}$ 3339, 2957, 1642, 1599, 1510, 1458, 1378, 1299, 1246, 1220, 1195, 1033, 913, 821 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz): δ 7.24 (2H, d, J = 8.4 Hz), 6.83 (1H, br s, O*H*), 6.80 (2H, d, J = 8.4 Hz), 6.55 (1H, s), 3.76 (3H, s, OCH_3), 3.71 (2H, s), 1.27 (9H, s, 3 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135): δ 186.9 (C, *C*=O), 184.1 (C, *C*=O), 159.2 (C), 158.0 (C), 149.9 (C), 131.1 (C), 130.0 (2 x CH), 126.8 (CH), 121.9 (C), 113.8 (2 x CH), 55.2 (O*C*H_3), 35.9 (C), 29.6 (3 x CH_3), 27.9 (CH_2); HRMS (ESI-TOF) *m/z*: [M-H] Calcd for $C_{18}H_{19}O_4$ 299.1284; Found 299.1284.



5bk

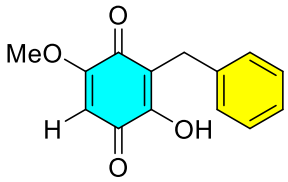
5-(*tert*-Butyl)-3-ethyl-2-hydroxycyclohexa-2,5-diene-1,4-dione (5bl): The title compound



5bl

was prepared following the procedure **A**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 2.0:8.0) and was isolated yellow solid; Yield: 60% (37.5 mg); Mp.: 108-110 ºC; IR (Neat): ν_{max} 3386, 2964, 1639, 1598, 1382, 1361, 1246, 1192, 1115, 891, 742 and 577 cm^{-1}; ^{1}H NMR ($CDCl_3$, 500 MHz): δ 6.54 (1H, s), 2.44 (2H, q, *J* = 7.5 Hz), 1.28 (9H, s, 3 x CH_3), 1.05 (3H, t, *J* = 7.5 Hz); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135): δ 187.1 (C, *C*=O), 184.1 (C, *C*=O), 159.2 (C), 149.7 (C), 126.8 (CH), 124.3 (C), 35.9 (C), 29.6 (3 x CH_3), 16.5 (CH_2), 12.7 (CH_3); HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{12}H_{17}O_3$ 209.1178; Found 209.1179.

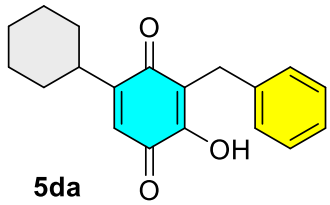
3-Benzyl-2-hydroxy-5-methoxycyclohexa-2,5-diene-1,4-dione (5ca): The title compound



5ca

was prepared following the procedure **A**, purified by column chromatography using EtOAc/hexane (1.2:8.8 to 2.0:8.0), and was isolated yellow solid. Mp.: 155-157 ºC. Yield: 70% (51.3 mg). IR (Neat): ν_{max} 3341, 2922, 1640, 1596, 1356, 1221, 1034, 978, 865, 742, 695 and 626 cm^{-1}. ^{1}H NMR ($CDCl_3$, 500 MHz): δ 7.32 (2H, d, *J* = 7.5 Hz), 7.24, (2H, t, *J* = 7.5 Hz), 7.16 (1H, t, *J* = 7.5 Hz), 5.83 (1H, s), 3.83 (3H, s, O*C*H_3), 3.78 (2H, s); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135): δ 182.7 (C, *C*=O), 181.3 (C, *C*=O), 161.1 (C), 151.6 (C), 138.7 (C), 129.0 (2 x CH), 128.4 (2 x CH), 126.3 (CH), 117.9 (C), 102.3 (CH), 56.7 (O*C*H_3), 28.4 (CH_2); HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{14}H_{13}O_4$ 245.0814; Found 245.0814.

3-Benzyl-4-hydroxy-[1,1'-bi(cyclohexane)]-3,6-diene-2,5-dione (5da): The title compound

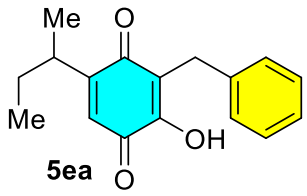


5da

was prepared following the procedure **A** and purified by column chromatography using EtOAc/hexanes (0.5:9.5 to 1:9) and isolated as a light orange solid; Yield: 56% (50 mg); Mp.: 62-64 ºC; IR (Neat): ν_{max} 3460, 3016, 2969, 1738, 1642, 1437, 1367, 1215, 1091, 901, and 528 cm^{-1}; ^{1}H NMR ($CDCl_3$, 500 MHz): δ 7.25 (2H, d, *J* = 7.0 Hz), 7.18 (2H, t, *J* = 8.0 Hz), 7.10 (1H, t, *J* = 7.5 Hz), 6.93 (1H, br s, O*H*), 6.37 (1H, s, olefinic-*H*), 3.71 (2H, s), 2.69 (1H, t, *J* = 7.0 Hz), 1.74 (2H, d, *J* = 13.0 Hz), 1.67 (3H, d, *J* = 12.0 Hz), 1.31 (2H, tq, *J* = 13.0, 3.5 Hz), 1.13 (1H, tt, *J* = 13.0, 3.5 Hz), 1.05 (2H, dq, *J* = 12.5, 2.8 Hz); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135): δ 186.6 (C, *C*=O), 183.8 (C, *C*=O), 157.3 (C), 150.6 (C), 139.1 (C), 129.1 (2 x CH), 128.4 (2 x CH), 126.3 (CH), 126.0 (CH), 120.3 (C), 37.0 (CH), 32.4

(2 x CH_2), 28.9 (CH_2), 26.3 (2 x CH_2), 26.0 (CH_2); HRMS (ESI-TOF) *m/z*: $[M + H]^+$ Calcd for $C_{19}H_{21}O_3$ 297.1491; Found 297.1492.

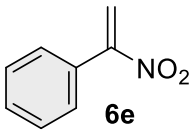
3-Benzyl-5-(*sec*-butyl)-2-hydroxycyclohexa-2,5-diene-1,4-dione (5ea): The title compound



5ea

was prepared following the procedure **A** and purified by column chromatography using EtOAc/hexanes (0.5:9.5 to 1:9) and isolated as a light orange solid; Yield: 66% (54 mg); Mp.: 82-84 ºC; IR (Neat): ν_{max} 3379, 2966, 2930, 2876, 1641, 1609, 1363, 1214, 733, and 698 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz): δ 7.32 (2H, br d, *J* = 7.5 Hz), 7.26 (2H, br t, *J* = 7.5 Hz), 7.18 (1H, br t, *J* = 7.5 Hz), 7.01 (1H, br s, O*H*), 6.47 (1H, d, *J* = 1.0 Hz, olefinic-*H*), 3.80 (2H, s), 2.94 (1H, sextet, *J* = 7.0 Hz), 1.59-1.49 (1H, m), 1.45-1.34 (1H, m), 1.10 (3H, d, *J* = 6.5 Hz), 0.88 (3H, t, *J* = 7.5 Hz); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135): δ 186.7 (C, *C*=O), 183.7 (C, *C*=O), 157.5 (C), 150.6 (C), 139.0 (C), 129.1 (2 x CH), 128.4 (2 x CH), 126.3 (2 x CH), 120.3 (C), 33.6 (CH), 28.94 (CH_2), 28.90 (CH_2), 19.0 (CH_3), 11.7 (CH_3); HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{17}H_{18}O_3Na$ 293.1154; Found 293.1156.

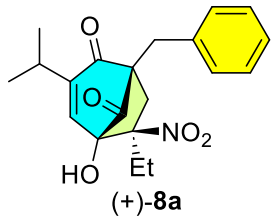
(1-Nitrovinyl)benzene (6e):[2c-2e] The title compound was prepared following literature and



6e

purified by column chromatography using hexanes and isolated as a yellow liquid; Yield: 50% (15 mg); IR (Neat): ν_{max} 2926, 1528, 1494, 1446, 1345, 1236, 1075, 1027, 906, 769 and 696 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz): δ 7.50-7.40 (5H, m), 6.52 (1H, d, *J* = 2.0 Hz), 5.87 (1H, d, *J* = 1.0 Hz); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135): 158.2 (C), 130.6 (C), 130.1 (CH), 128.8 (2 x CH), 128.5 (2 x CH), 118.1 (CH_2); HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_8H_7NO_2Na$ 172.0375; Found 172.0378.

(1*S*,5*R*,6*R*)-1-Benzyl-6-ethyl-5-hydroxy-3-isopropyl-6-nitrobicyclo[3.2.1]oct-3-ene-2,8-dione (8a): The compound was prepared following the procedure **C** and purified by column

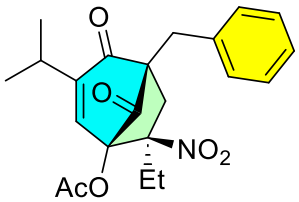


(+)-**8a**

chromatography using EtOAc/hexanes (1.0:9.0 to 2.0:8.0) and isolated as a semi solid; Yield: 80 (42.9 mg); The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 97:3, flow rate 0.7 mL/min, λ = 254 nm), t_R = 28.619 min (minor), t_R = 34.001 min (major) [For major isomer]; t_R = 44.049 min (minor), t_R = 47.611 min (major) [For minor isomer]; $[\alpha]_D^{25}$ = +174.0° (*c* = 0.100, $CHCl_3$, 88% major *ee*, 12% minor *ee*, and 22:1 *dr*); IR (Neat): ν_{max} 3437 (O-H), 2965, 1774, 1686, 1542, 1553, 1494, 1455, 1353, 1297, 1129, 1014, 837 and 704 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, 2:1 *dr*, for major isomer): δ 7.32-7.27 (5H, m), 6.68 (1H, d, *J* = 1.0 Hz,

olefinic-*H*), 3.63 (1H, br s, O*H*), 3.46 (1H, d, *J* = 14.5 Hz), 3.19 (1H, d, *J* = 14.5 Hz), 2.85 (1H, dsept, *J* = 7.0, 1.0 Hz), 2.58 (1H, dd, *J* = 15.5, 1.5 Hz), 2.33 (1H, d, *J* = 15.5 Hz), 2.27-2.19 (2H, m), 1.05 (3H, d, *J* = 7.0 Hz), 1.00 (3H, d, *J* = 7.0 Hz), 0.38 (3H, *t*, *J* = 7.0 Hz); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, 2:1 *dr*, for major isomer): δ 200.0 (C, *C*=O), 195.0 (C, *C*=O), 147.2 (C), 142.9 (CH), 135.8 (C), 130.9 (2 x CH), 128.6 (2 x CH), 127.2 (CH), 94.7 (C), 84.6 (C), 66.9 (C), 32.0 (CH_2), 31.1 (CH_2), 27.2 (CH_2), 26.9 (CH), 21.7 (CH_3), 20.5 (CH_3), 7.1 (CH_3); ^{1}H NMR ($CDCl_3$, 500 MHz, 2:1 *dr*, for minor isomer): δ 7.25-7.21 (5H, m), 6.80 (1H, d, *J* = 1.0 Hz, olefinic-*H*), 3.77 (1H, br s, O*H*), 3.46 (1H d, *J* = 14.5 Hz), 3.36 (1H, d, *J* = 14.5 Hz), 2.92 (1H, dsept, *J* = 7.0, 1.0 Hz), 2.63 (1H, d, *J* = 15.5 Hz), 1.87-1.78 (1H, m), 1.65 (1H, d, *J* = 15.5 Hz), 1.11 (3H, d, *J* = 7.0 Hz), 1.08 (3H, d, *J* = 6.5 Hz), 1.00 (3H, *t*, *J* = 7.0 Hz), 0.82-0.75 (1H, m); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, 2:1 *dr*, for minor isomer): δ 200.7 (C, *C*=O), 195.6 (C, *C*=O), 147.7 (C), 142.2 (CH), 135.8 (C), 131.0 (2 x CH), 128.3 (2 x CH), 126.9 (CH), 95.1 (C), 86.4 (C), 65.7 (C), 37.6 (CH_2), 31.7 (CH_2), 27.0 (CH), 26.0 (CH_2), 21.4 (CH_3), 20.8 (CH_3), 7.8 (CH_3); HRMS (ESI-TOF) *m/z*: $[M+Na]^+$ Calcd for $C_{20}H_{23}NO_5Na$ 380.1474; Found 380.1476.

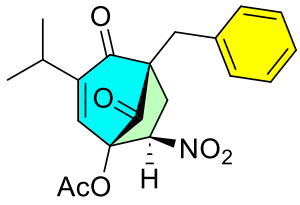
(1*R*,5*S*,7*R*)-5-Benzyl-7-ethyl-3-isopropyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10a): The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 2.0:8.0) and was isolated as a white solid; Yield: 93% (56 mg); Mp.: 128-130 °C; The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 1.0 mL/min, λ = 254 nm), t_R = 4.674 min (major), t_R = 6.253 min (minor) [For major isomer]; t_R = 7.554 min (major), t_R = 13.145 min (minor) [For minor isomer]; $[\alpha]_D^{25}$ = +175.0° [*c* = 0.100, $CHCl_3$, 99% major *ee*, 86% minor *ee*, and 1.5:1 *dr*]; IR (Neat): ν_{max} 2964, 1784, 1761, 1688, 1546, 1368, 1211, 1017, 962, 846, 737 and 704 cm^{-1}; ^{1}H NMR ($CDCl_3$, 500 MHz, 1.5:1 *dr*, major isomer): δ 7.37-7.35 (1H, m), 7.32-7.24 (3H, m), 7.24-7.21 (1H, m), 6.78 (1H, d, *J* = 1.0 Hz), 3.43 (1H, d, *J* = 14.5 Hz), 3.23 (1H, d, *J* = 15.0 Hz). 2.89 (1H, dsept, *J* = 7.0, 1.0 Hz), 2.57 (1H, dd, *J* = 15.0, 1.5 Hz), 2.31 (1H, br d, *J* = 15.0 Hz), 2.32-2.25 (1H, m), 2.27 (3H, s), 1.08 (3H, d, *J* = 7.0 Hz), 1.02 (1H, m), 0.99 (3H, d, *J* = 7.0 Hz), 0.40 (3H, t, *J* = 7.5 Hz); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135, 1.5:1 *dr*, major isomer): δ 194.5 (C, *C*=O), 194.1 (C, *C*=O), 168.3 (C, O-*C*=O), 144.5 (C), 141.1 (CH), 135.9 (C), 131.1 (2 x CH), 128.5 (2 x CH), 127.1 (CH), 93.5 (C), 87.5 (C), 67.1 (C), 31.8



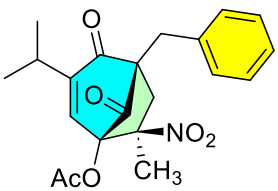
(+)-**10a**

(CH_2), 31.1 (CH_2), 27.7 (CH_2), 27.0 (CH), 21.6 (CH_3), 20.9 (CH_3), 20.4 (CH_3), 7.1 (CH_3); ^{1}H NMR ($CDCl_3$, 500 MHz, 1.5:1 *dr*, minor isomer): δ 7.37-7.35 (1H, m), 7.32-7.24 (3H, m), 7.23-7.21 (1H, m), 6.90 (1H, d, *J* = 1.0 Hz), 3.55 (1H, d, *J* = 15.0 Hz), 3.32 (1H, d, *J* = 14.5 Hz), 2.97 (1H, dsept, *J* = 7.0, 1.0 Hz), 2.68 (1H, d, *J* = 15.5 Hz), 2.46-2.39 (1H, m), 2.16 (3H, s), 1.71-1.65 (1H, m), 1.61 (1H, d, *J* = 15.5 Hz), 1.14 (3H, d, *J* = 6.5 Hz), 1.07 (3H, d, *J* = 7.0 Hz), 0.94 (3H, t, *J* = 7.5 Hz); ^{13}C{^{1}H} NMR ($CDCl_3$, 125 MHz, DEPT-135, 1.5:1 *dr*, minor isomer): δ 195.2 (C, *C*=O), 193.6 (C, *C*=O), 168.1 (C, O-*C*=O), 145.7 (C), 140.0 (CH), 136.1 (C), 131.2 (2 x CH), 128.3 (2 x CH), 126.8 (CH), 94.0 (C), 89.2 (C), 66.1 (C), 36.1 (CH_2), 31.7 (CH_2), 27.1 (CH), 25.5 (CH_2), 21.4 (CH_3), 20.8 (CH_3), 20.7 (CH_3), 7.3 (CH_3); HRMS (ESI-TOF) *m*/*z*: [M + NH_4]$^+$ Calcd for $C_{22}H_{29}N_2O_6$ 417.2026; Found 417.2030.

(1*R*,5*S*,7*R*)-5-Benzyl-3-isopropyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10b): The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 2.0:8.0) and was isolated as a white solid; Yield: 81% (45 mg); Mp.: 124-126 °C; The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 1.0 mL/min, λ = 254 nm), t_R = 7.804 min (major), t_R = 9.185 min (minor); $[\alpha]_D^{25}$ = +157.0° [*c* = 0.100, $CHCl_3$, 79% major *ee,* >50:1 *dr*]; IR (Neat): ν_{max} 2967, 1784, 1755, 1681, 1560, 1369, 1213, 1164, 1041, 954, 854, 704, 595, and 508 cm^{-1}; ^{1}H NMR ($CDCl_3$, 500 MHz, >50:1 *dr*, major isomer): δ 7.33-7.27 (4H, m), 7.23 (1H, tt, *J* = 7.0, 2.5 Hz), 7.01 (1H, d, *J* = 1.0 Hz), 5.17 (1H, dd, *J* = 8.5, 1.0 Hz), 3.46 (1H, d, *J* = 14.5 Hz), 3.39 (1H, d, *J* = 14.5 Hz), 2.91 (1H, dsept, *J* = 7.0, 1.0 Hz), 2.56 (1H, dd, *J* = 16.0, 1.0 Hz), 2.20 (3H, s), 2.01 (1H, dd, *J* = 16.0, 8.5 Hz), 1.11 (3H, d, *J* = 7.0 Hz), 1.06 (3H, d, *J* = 6.5 Hz); ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz, DEPT-135, >50:1 *dr*, major isomer): δ 194.8 (C, *C*=O), 193.9 (C, *C*=O), 169.0 (C, O-*C*=O), 147.3 (C), 137.7 (CH), 135.6 (C), 131.1 (2 x CH), 128.4 (2 x CH), 127.0 (CH), 86.0 (C), 82.3 (CH), 65.1 (C), 31.5 (CH_2), 31.0 (CH_2), 27.3 (CH_3), 21.4 (CH_3), 20.8 (CH), 20.5 (CH_3); HRMS (ESI-TOF) *m*/*z*: [M + NH_4]$^+$ Calcd for $C_{20}H_{25}N_2O_6$ 389.1713; Found 389.1714.



(+)-**10b**

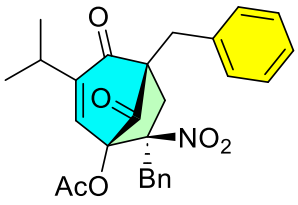


(+)-**10c**

(1*R*,5*S*,7*R*)-5-Benzyl-3-isopropyl-7-methyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10c): The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 2.0:8.0) and was

isolated as a white solid; Yield: 91% (52.6 mg); Mp.: 138-140 °C; The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 1.0 mL/min, λ = 254 nm), t_R = 4.789 min (major), t_R = 6.459 min (minor) [For minor isomer]; t_R = 7.958 min (major), t_R = 12.686 min (minor) [For major isomer]; $[\alpha]_D^{25}$ = +347.0° [*c* = 0.100, $CHCl_3$, 93% major *ee*, 99% minor *ee* and 14.3:1 *dr*]; IR (Neat): ν_{max} 2960, 1775, 1758, 1687, 1547, 1442, 1370, 1203, 1122, 1031, 927, 847, 761, 705 and 598 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, 11:1 *dr*, major isomer): δ 7.32 (2H, br d, *J* = 7.0 Hz), 7.27 (2H, tt, *J* = 7.0, 2.0 Hz), 7.22 (1H, tt, *J* = 7.0, 2.5 Hz), 6.89 (1H, d, *J* = 1.0 Hz), 3.52 (1H, d, *J* = 14.5 Hz), 3.35 (1H, d, *J* = 14.5 Hz), 2.98 (1H, dsept, *J* = 7.0, 1.0 Hz), 2.66 (1H, d, *J* = 15.5 Hz), 2.17 (3H, s), 1.61 (3H, s), 1.59 (1H, d, *J* = 16.0 Hz), 1.14 (3H, d, *J* = 6.5 Hz), 1.07 (3H, d, *J* = 7.0 Hz); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, 11:1 *dr*, major isomer): δ 195.1 (C, *C*=O), 193.5 (C, *C*=O), 168.1 (C, O-*C*=O), 145.8 (C), 140.1 (CH), 136.0 (C), 131.2 (2 x CH), 128.3 (2 x CH), 126.8 (CH), 89.7 (C), 88.9 (C), 66.4 (C), 38.3 (CH_2), 31.7 (CH_2), 27.1 (CH), 21.5 (CH_3), 20.7 (CH_3), 20.6 (CH_3), 18.5 (CH_3); HRMS (ESI-TOF) *m*/*z*: $[M + Na]^+$ Calcd for $C_{21}H_{23}NO_6Na$ 408.1423; Found 408.1421.

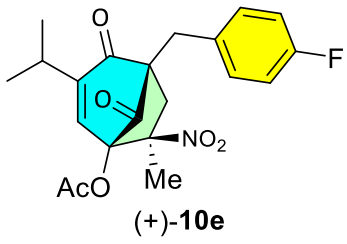
(1*R*,5*S*,7*R*)-5,7-dibenzyl-3-isopropyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10d): The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 2.0:8.0) and was isolated as a white solid; Yield: 94% (65 mg); Mp.: 126-128 °C; The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 1.0 mL/min, λ = 254 nm), t_R = 4.747 min (major), t_R = 5.791 min (minor) [For major isomer]; $[\alpha]_D^{25}$ = +108.0° [*c* = 0.100, $CHCl_3$, 98.7% major *ee*, and >30:1 *dr*]; IR (Neat): ν_{max} 2962, 1776, 1762, 1690, 1544, 1494, 1452, 1370, 1242, 1206, 1164, 1032, 978, 920, 789, 732, 702, 594, and 491 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, >30:1 *dr*, major isomer): δ 7.44-7.38 (3H, m), 7.32 (2H, br d, *J* = 6.5 Hz), 7.17 (1H, br t, *J* = 7.5 Hz), 7.06 (2H, t, *J* = 7.5 Hz), 6.78 (1H, s, olefinic-*H*), 6.02 (2H, d, *J* = 7.5 Hz), 3.75 (1H, d, *J* = 14.5 Hz), 3.49 (1H, d, *J* = 15.0 Hz), 3.27 (1H, d, *J* = 14.5 Hz), 2.88 (1H, sept, *J* = 6.7 Hz), 2.55-2.20 (2H, m), 2.36 (3H, s), 2.11 (1H, d, *J* = 14.5 Hz), 1.07 (3H, d, *J* = 7.0 Hz), 0.95 (3H, d, *J* = 7.0 Hz); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, >30:1 *dr*, major isomer): δ 194.5 (C, *C*=O), 194.3 (C, *C*=O), 168.4 (C, O-*C*=O), 144.7 (C), 140.6 (CH), 136.5 (C), 131.5 (2 x CH), 131.56 (C), 129.6 (2 x CH), 129.1 (2 x CH), 128.6 (2 x CH), 127.9 (CH), 127.2 (CH), 93.6 (C), 87.4



(+)-**10d**

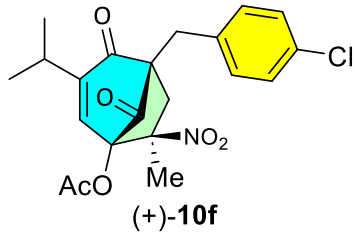
(C), 67.2 (C), 39.6 (CH_2), 30.9 (CH_2), 30.2 (CH_2), 27.0 (CH), 21.6 (CH_3), 20.99 (CH_3), 20.3 (CH_3); HRMS (ESI-TOF) *m/z*: $[M + NH_4]^+$ Calcd for $C_{27}H_{31}N_2O_6$ 479.2182; Found 479.2183.

(1*R*,5*S*,7*R*)-5-(4-Fluorobenzyl)-3-isopropyl-7-methyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10e): The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 1.5:8.5) and was isolated as a semi solid; Yield: 80% (48.4 mg); The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 0.8 mL/min, λ = 254 nm), t_R = 4.951 min (major), t_R = 7.643 min (minor) [For minor isomer]; t_R = 8.138 min (major), t_R = 14.347 min (minor) [For major isomer]; $[\alpha]_D^{25}$ = +181.0° [*c* = 0.100, $CHCl_3$, 94% major *ee*, 96% minor *ee* and 14:1 *dr*]; IR (Neat): ν_{max} 2923, 1785, 1686, 1552, 1508, 1369, 1205, 1007, 844, 761 and 484 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, 10:1 *dr*, major isomer): δ 7.31-7.29 (2H, m), 6.96 (2H, tt, *J* = 9.0, 2.5 Hz), 6.90 (1H, d, *J* = 1.0 Hz), 3.45 (1H, d, *J* = 15.0 Hz), 3.34 (1H, d, *J* = 15.0 Hz), 2.97 (1H, dseptet, *J* = 6.7, 1.0 Hz), 2.63 (1H, d, *J* = 15.5 Hz), 2.17 (3H, s), 1.62 (3H, s), 1.60 (1H, d, *J* = 15.5 Hz), 1.14 (3H, d, *J* = 6.5 Hz), 1.07 (3H, d, *J* = 7.0 Hz); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, 10:1 *dr*, major isomer): δ 195.0 (C, *C*=O), 193.5 (C, *C*=O), 168.1 (C, O-*C*=O), 161.8 (C, d, *J* = 243.7 Hz, *C*-F), 145.8 (C), 140.2 (CH), 132.7 (2 x CH, d, *J* = 8.75 Hz), 131.5 (C, d, *J* = 2.5 Hz), 115.1 (2 x CH, d, *J* = 20.0 Hz), 89.6 (C), 88.9 (C), 66.3 (C), 38.2 (CH_2), 31.0 (CH_2), 27.1 (CH), 21.5 (CH_3), 20.7 (CH_3), 20.6 (CH_3), 18.5 (CH_3); ^{19}F NMR ($CDCl_3$, 470 MHz): δ = –115.9; HRMS (ESI-TOF) *m/z*: $[M + NH_4]^+$ Calcd for $C_{21}H_{26}FN_2O_6$ 421.1775; Found 421.1778.



(+)-**10e**

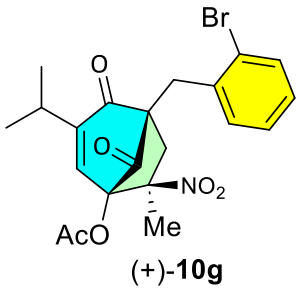
(1*R*,5*S*,7*R*)-5-(4-Chlorobenzyl)-3-isopropyl-7-methyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10f): The compound was prepared following the procedure **C** and purified by column chromatography using EtOAc/hexane (1.0:9.0 to 1.5:8.5) and isolated as a pale yellow semisolid; Yield: 93% (58.5 mg); The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 0.7 mL/min, λ = 254 nm); t_R = 7.834 min (major), t_R = 16.045 min (minor) [For major isomer]; $[\alpha]_D^{25}$ = +163.2° [*c* = 0.250, $CHCl_3$, 95% major *ee*, >99% minor *ee*, and >20:1 *dr*]; IR (Neat): ν_{max} 2963, 2927, 1787, 1767, 1686, 1554, 1369, 1205, 1012 and 847 cm^{-1}; ^1H NMR ($CDCl_3$,



(+)-**10f**

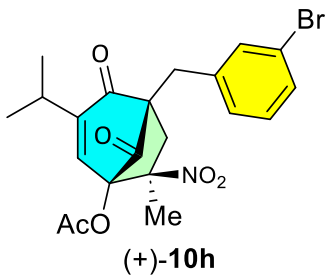
500 MHz, >20:1 *dr*, major isomer): δ 7.28 (2H, br d, *J* = 8.5 Hz), 7.24 (2H, br d, *J* = 8.5 Hz), 6.90 (1H, br s), 3.46 (1H, d, *J* = 15.0 Hz), 3.32 (1H, d, *J* = 14.5 Hz), 2.96 (1H, sept, *J* = 7.0 Hz), 2.61 (1H, d, *J* = 15.5 Hz), 2.17 (3H, s), 1.62 (3H, s), 1.60 (1H, d, *J* = 15.5 Hz), 1.14 (3H, d, *J* = 7.0 Hz), 1.07 (3H, d, *J* = 7.0 Hz); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, >20:1 *dr*, major isomer): δ 194.9 (C, *C*=O), 193.4 (C, *C*=O), 168.1 (C, O-*C*=O), 145.8 (C), 140.2 (CH), 134.4 (C), 132.8 (C), 132.5 (2 x CH), 128.4 (2 x CH), 89.7 (C), 88.8 (C), 66.2 (C), 38.3 (CH_2), 31.2 (CH_2), 27.1 (CH), 21.4 (CH_3), 20.7 (CH_3), 20.6 (CH_3), 18.5 (CH_3); HRMS (ESI-TOF) *m/z*: $[M + NH_4]^+$ Calcd for $C_{21}H_{26}ClN_2O_6$ 437.1479; Found 437.1479.

(1*R*,5*S*,7*R*)-5-(2-Bromobenzyl)-3-isopropyl-7-methyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10g): The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 2.0:8.0) and was isolated as a white solid; Yield: 90% (62.7 mg); Mp.: 136-138 °C; The enanantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 0.8 mL/min, λ = 254 nm), t_R = 4.639 min (major), t_R = 5.589 min (minor) [For minor isomer]; t_R = 7.006 min (major), t_R = 11.348 min (minor) [For major isomer]; $[\alpha]_D^{25}$ = +65.0° [*c* = 0.100, $CHCl_3$, 93% major *ee*, >99% minor *ee* and >20:1 *dr*]; IR (Neat): ν_{max} 2961, 1785, 1689, 1551, 1440, 1370, 1204, 1120, 1007, 914, 846, 735, 629 and 446 cm^{-1}; ^{1}H NMR ($CDCl_3$, 500 MHz, >20:1 *dr*, major isomer): δ 7.62 (1H, dd, *J* = 8.0, 1.5 Hz), 7.49 (1H, dd, *J* = 8.0, 1.0 Hz), 7.27 (1H, dt, *J* = 7.5, 1.5 Hz), 7.09 (1H, dt, *J* = 7.5, 2.0 Hz), 6.91 (1H, d, *J* = 1.0 Hz), 3.85 (1H, d, *J* = 15.0 Hz). 3.54 (1H, d, *J* = 15.0 Hz), 2.99 (1H, sept, *J* = 7.0 Hz), 2.55 (1H, d, *J* = 15.5 Hz), 2.16 (3H, s), 1.82 (1H, d, *J* = 15.5 Hz), 1.62 (3H, s), 1.15 (3H, d, *J* = 7.0 Hz), 1.10 (3H, d, *J* = 6.5 Hz); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, >20:1 *dr*, major isomer): δ 194.0 (C, *C*=O), 193.5 (C, *C*=O), 168.1 (C, O-*C*=O), 145.5 (C), 140.4 (CH), 135.6 (C), 134.0 (CH), 132.4 (CH), 128.8 (CH), 127.6 (CH), 126.0 (C), 89.6 (C), 88.7 (C), 66.6 (C), 38.0 (CH_2), 30.5 (CH_2), 27.1 (CH), 21.4 (CH_3), 20.7 (CH_3), 20.7 (CH_3), 18.5 (CH_3); HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{21}H_{22}BrNO_6Na$ 486.0528; Found 486.0525.



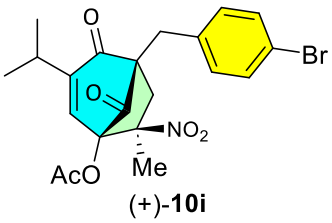
(+)-**10g**

(1*R*,5*S*,7*R*)-5-(3-Bromobenzyl)-3-isopropyl-7-methyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10h): The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 2.0:8.0), and was isolated as white solid; Yield: 93% (65 mg); Mp.: 97-99 °C; The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 0.7 mL/min, λ = 254 nm), t_R = 5.018 min (major), t_R = 6.995 min (minor) [For minor isomer]; t_R = 9.077 min (major), t_R = 18.681 min (minor) [For major isomer]; $[\alpha]_D^{25}$ = +241.0° [*c* = 0.100, $CHCl_3$, 93% major *ee*, 99% minor *ee* and 19.2:1 *dr*]; IR (Neat): ν_{max} 2964, 1787, 1762, 1687, 1554, 1369, 1204, 1097, 1006, 848, 734 and 704 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, 13.4:1 *dr*, major isomer): δ 7.49 (1H, br s), 7.36 (1H, br d, *J* = 8.0 Hz), 7.29 (1H, br d, *J* = 7.5 Hz), 7.15 (1H, br t, *J* = 8.0 Hz), 6.90 (1H, br s), 3.47 (1H, d, *J* = 14.5 Hz). 3.31 (1H, d, *J* = 14.5 Hz), 2.97 (1H, sept, *J* = 7.0 Hz), 2.61 (1H, d, *J* = 15.5 Hz), 2.18 (3H, s), 1.63 (3H, s), 1.62 (1H, d, *J* = 15.0 Hz), 1.14 (3H, d, *J* = 7.0 Hz), 1.08 (3H, d, *J* = 7.0 Hz); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, 13.4:1 *dr*, major isomer): δ 194.8 (C, *C*=O), 193.2 (C, *C*=O), 168.1 (C, O-*C*=O), 145.8 (C), 140.2 (CH), 138.4 (C), 134.0 (CH), 130.1 (CH), 130.0 (CH), 129.8 (CH), 122.3 (C), 89.7 (C), 88.8 (C), 66.2 (C), 38.3 (CH_2), 31.5 (CH_2), 27.1 (CH), 21.5 (CH_3), 20.7 (CH_3), 20.6 (CH_3), 18.5 (CH_3); HRMS (ESI-TOF) *m*/*z*: $[M + Na]^+$ Calcd for $C_{21}H_{22}BrNO_6Na$ 486.0528; Found 486.0527.



(+)-**10h**

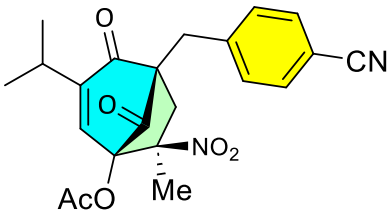
(1*R*,5*S*,7*R*)-5-(4-Bromobenzyl)-3-isopropyl-7-methyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10i): The compound was prepared following the procedure **C** and purified by column chromatography using EtOAc/hexanes (1.0:9.0 to 2.0:8.0) and isolated as brown semi solid; Yield: 86% (60 mg); The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 1.0 mL/min, λ = 254 nm), t_R = 4.949 min (major), t_R = 9.906 min (minor). [for minor isomer], t_R = 8.070 min (major), t_R = 17.153 min (minor) [for major isomer]; $[\alpha]_D^{25}$ = +365.0° (*c* = 0.100, $CHCl_3$, 94% major *ee,* 99% minor *ee* and 12:1 *dr*); IR (Neat): ν_{max} 2963, 1786, 1687, 1553, 1487, 1369, 1205, 1010, 847 and 733 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, 12:1 *dr*, major isomer): δ 7.40 (2H, d, *J* = 8.0 Hz), 7.22 (2H, d, *J* = 8.0 Hz), 6.90 (1H, s), 3.45 (1H, d, *J* = 14.5 Hz), 3.30 (1H, d, *J* = 14.5 Hz), 2.97 (1H, sept, *J* = 7.0 Hz), 2.61 (1H, d, *J* = 15.5 Hz), 2.17 (3H, s), 1.62 (3H, s), 1.60 (1H, d, *J*



(+)-**10i**

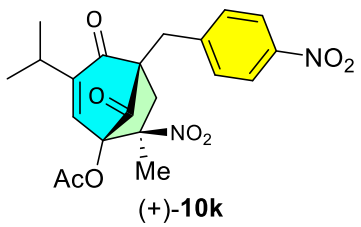
= 15.5 Hz), 1.14 (3H, d, *J* = 7.0 Hz), 1.07 (3H, d, *J* = 7.0 Hz); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, 12:1 *dr*, major isomer): δ 194.9 (C, *C*=O), 193.4 (C, *C*=O), 168.1 (C, O-*C*=O), 145.8 (C), 140.3 (CH), 135.0 (C), 133.0 (2 x CH), 131.4 (2 x CH), 121.0 (C), 89.7 (C), 88.9 (C), 66.2 (C), 38.4 (CH_2), 31.3 (CH_2), 27.1 (CH), 21.5 (CH_3), 20.7 (CH_3), 20.6 (CH_3), 18.5 (CH_3); HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{21}H_{22}BrNO_6Na$ 486.0528; Found 486.0529.

(1*R*,5*S*,7*R*)-5-(4-Cyanobenzyl)-3-isopropyl-7-methyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10j): The title compound was prepared following the procedure **C** and purified by column chromatography using EtOAc/hexanes (1.0:9.0 to 1.5:8.5) and isolated as a light brown semi solid; Yield: 90% (55 mg); The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 1.0 mL/min, λ = 254 nm), t_R = 24.652 min (major), t_R = 49.991 min (minor) [for major isomer]; $[\alpha]_D^{25}$ = +191.0° (*c* = 0.290, $CHCl_3$, 94% major *ee* and >20:1 *dr*); IR (Neat): ν_{max} 2958, 2872, 2359, 2227, 1787, 1759, 1687, 1554, 1439, 1367, 1205, 1007, 846 and 736 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, 12.5:1 *dr*, major isomer): δ 7.58 (2H, d, *J* = 8.0 Hz), 7.47 (2H, d, *J* = 8.0 Hz), 6.92 (1H, s), 3.50 (1H, d, *J* = 14.5 Hz), 3.43 (1H, d, *J* = 14.5 Hz), 2.97 (1H, sept, *J* = 7.0 Hz), 2.56 (1H, d, *J* = 15.5 Hz), 2.17 (3H, s), 1.65 (1H, d, *J* = 15.5 Hz), 1.63 (3H, s) 1.15 (3H, d, *J* = 6.5 Hz), 1.08 (3H, d, *J* = 6.5 Hz); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, 12.5:1 *dr*, major isomer): δ 194.5 (C, *C*=O), 193.1 (C, *C*=O), 168.1 (C, O-*C*=O), 145.8 (C), 141.6 (C), 140. 4 (CH), 132.0 (4 x CH), 118.8 (C), 110.9 (C), 89.7 (C), 88.7 (C), 65.9 (C), 38.4 (CH_2), 32.2 (CH_2), 27.1 (CH), 21.5 (CH_3), 20.7 (CH_3), 20.6 (CH_3), 18.5 (CH_3); HRMS (ESI-TOF) *m/z*: $[M + NH_4]^+$ Calcd for $C_{22}H_{26}N_3O_6$ 428.1822; Found 428.1822.



(+)-**10j**

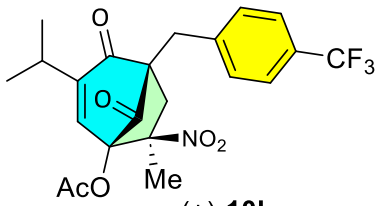
(1*R*,5*S*,7*R*)-3-Isopropyl-7-methyl-7-nitro-5-(4-nitrobenzyl)-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10k): The compound was prepared following the procedure **C** and purified by column chromatography using EtOAc/hexanes (1.0:9.0 to 1.5:8.5) and isolated as a yellow solid; Yield: 96% (62 mg); Mp.: 151-153 °C; The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 1.0 mL/min, λ = 254 nm), t_R = 21.701 min (major), t_R = 48.251 min (minor) [for major isomer], t_R = 8.817



(+)-**10k**

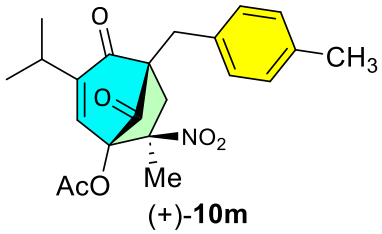
min (major), t_R = 18.460 min (minor) [for minor isomer]; $[\alpha]_D^{25}$ = +268.0° (*c* = 0.100, $CHCl_3$, 95% major *ee*, >99% minor *ee* and 11.5:1 *dr*); IR (Neat): ν_{max} 2962, 2922, 2850, 1787, 1766, 1687, 1554, 1519, 1440, 1346, 1206, 1109, 1044, 1009, 850 and 736 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, 10:1 *dr*, major isomer): δ 8.14 (2H, br d, *J* = 8.5 Hz), 7.53 (2H, br d, *J* = 8.5 Hz), 6.92 (1H, br s), 3.54 (1H, d, *J* = 14.5 Hz), 3.48 (1H, d, *J* = 14.5 Hz), 2.97 (1H, dsept, *J* = 6.7, 1.0 Hz), 2.58 (1H, d, *J* = 15.5 Hz), 2.18 (3H, s), 1.68 (1H, d, *J* = 15.0 Hz), 1.63 (3H, s), 1.15 (3H, d, *J* = 7.0 Hz), 1.08 (3H, d, *J* = 7.0 Hz); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135, 10:1 *dr*, major isomer): δ 194.5 (C, *C*=O), 193.1 (C, *C*=O), 168.1 (C, O-*C*=O), 147.0 (C), 145.8 (C), 143.7 (C), 140.5 (CH), 132.1 (2 x CH), 123.4 (2 x CH), 89.6 (C), 88.7 (C), 65.9 (C), 38.4 (CH_2), 32.0 (CH_2), 27.1 (CH), 21.4 (CH_3), 20.7 (CH_3), 20.6 (CH_3), 18.5 (CH_3); HRMS (ESI-TOF) *m*/*z*: $[M + Na]^+$ Calcd for $C_{21}H_{22}N_2O_8Na$ 453.1274; Found 453.1273.

(1*R*,5*S*,7*R*)-3-Isopropyl-7-methyl-7-nitro-4,8-dioxo-5-(4-(trifluoromethyl)benzyl)bicyclo[3.2.1]oct-2-en-1-yl acetate (10l): The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 1.5:8.5) and was isolated as white solid; Mp.: 138-140 °C; Yield: 85% (57.8 mg) The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 1.0 mL/min, λ = 254 nm), t_R = 4.582 min (major), t_R = 7.947 min (minor) [For minor isomer]; t_R = 6.368 min (major), t_R = 12.402 min (minor) [For major isomer]; $[\alpha]_D^{25}$ = +295.0° [*c* = 0.100, $CHCl_3$, 95% major *ee*, >99% minor *ee* and >20:1 *dr*]; IR (Neat): ν_{max} 2965, 1788, 1687, 1554, 1322, 1205, 1163, 1113, 1065, 1007, 846, 736, 594 and 410 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, >20:1 *dr*, major isomer): δ 7.54 (2H, d, *J* = 8.0 Hz), 7.47 (2H, d, *J* = 8.5 Hz), 6.91 (1H, d, *J* = 1.0 Hz), 3.56 (1H, d, *J* = 14.5 Hz), 3.40 (1H, d, *J* = 14.5 Hz), 2.97 (1H, dsept, *J* = 6.7, 1.0 Hz), 2.60 (1H, d, *J* = 15.5 Hz), 2.17 (3H, s), 1.63 (1H, d, *J* = 15.5 Hz), 1.63 (3H, s), 1.15 (3H, d, *J* = 7.0 Hz), 1.08 (3H, d, *J* = 7.0 Hz); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, >20:1 *dr*, major isomer): δ 194.8 (*C*, *C*=O), 193.3 (*C*, *C*=O), 168.1 (*C*, O-*C*=O), 145.8 (C), 140.3 (CH), 140.2 (C), 131.5 (2 x CH), 129.1 (*C*, q, *J* = 32.5 Hz), 125.2 (2 x CH, q, *J* = 3.7 Hz), 124.2 (C, q, *J* = 271.2 Hz, *C*F_3), 89.6 (C), 88.8 (C), 66.0 (C), 38.4 (CH_2), 31.8 (CH_2), 27.1 (CH), 21.4 (CH_3), 20.7 (CH_3), 20.6 (CH_3), 18.5 (CH_3); ^{19}F NMR ($CDCl_3$, 470 MHz): δ = –62.5; HRMS (ESI-TOF) *m*/*z*: $[M + Na]^+$ Calcd for $C_{22}H_{22}F_3NO_6Na$ 476.1297; Found 476.1297.



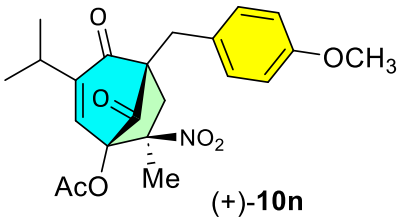
(+)-**10l**

(1*R*,5*S*,7*R*)-3-Isopropyl-7-methyl-5-(4-methylbenzyl)-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10m): The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 2.0:8.0) and was isolated as a white solid; Yield: 78% (46.7 mg); Mp.: 105-107 °C; The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak ID column (hexane/2-propanol = 95:5, flow rate 0.8 mL/min, λ = 254 nm), t_R = 7.094 min (major), t_R = 12.377 min (minor) [For minor isomer]; t_R = 13.553 min (major), t_R = 26.552 min (minor) [For major isomer]; $[\alpha]_D^{25}$ = +297.0° [*c* = 0.100, $CHCl_3$, 94% major *ee*, >99% minor *ee* and >20:1 *dr*]; IR (Neat): ν_{max} 2963, 1786, 1686, 1552, 1439, 1368, 1203, 1006, 847, 734, 592 and 471 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, >20:1 *dr*, major isomer): δ 7.21 (2H, d, *J* = 8.0 Hz), 7.08 (2H, d, *J* = 8.0 Hz), 6.89 (1H, d, *J* = 1.0 Hz), 3.48 (1H, d, *J* = 14.5 Hz), 3.29 (1H, d, *J* = 14.5 Hz), 2.97 (1H, dsept, *J* = 7.0, 1.0 Hz). 2.67 (1H, d, *J* = 15.5 Hz), 2.30 (3H, s), 2.20 (3H, s), 1.61 (3H, s), 1.57 (1H, d, *J* = 15.5 Hz), 1.14 (3H, d, *J* = 6.5 Hz). 1.07 (3H, d, *J* = 7.0 Hz); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135, >20:1 *dr*, major isomer): δ 195.2 (*C*, *C*=O), 193.6 (*C*, *C*=O), 168.1 (*C,* O-*C*=O), 145.8 (C), 140.0 (CH), 136.3 (C), 132.8 (C), 131.0 (2 x CH), 129.0 (2 x CH), 89.7 (C), 89.0 (C), 66.5 (C), 38.3 (CH_2), 31.3 (CH_2), 27.1 (CH), 21.5 (CH_3), 21.0 (CH_3), 20.7 (CH_3), 20.6 (CH_3), 18.5 (CH_3); HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{22}H_{25}NO_6Na$ 422.1580; Found 422.1580.



(+)-**10m**

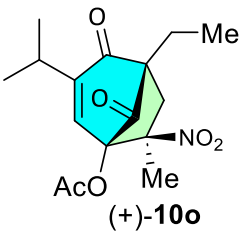
(1*R*,5*S*,7*R*)-3-Isopropyl-5-(4-methoxybenzyl)-7-methyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10n): The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 2.0:8.0) and was isolated as a white solid; Yield: 85% (53 mg). Mp.: 114-116 °C. The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak ID column (hexane/2-propanol = 95:5, flow rate 0.7 mL/min, λ = 254 nm), t_R = 9.230 min (major), t_R = 15.800 min (minor) [For minor isomer]; t_R = 25.182 min (major), t_R = 41.793 min (minor) [For major isomer]; $[\alpha]_D^{25}$ = +112.1° [*c* = 0.238, MeOH, 91% major *ee*, 98% minor *ee*, and 3.1:1 *dr*]; IR (Neat): ν_{max} 2964, 1786, 1685, 1553, 1514, 1369, 1203, 1006, 911, 847, 730 and 486 cm^{-1}. ^1H NMR ($CDCl_3$, 500 MHz, 3.1:1 *dr*, major isomer): δ 7.24 (2H, td, *J* = 8.5, 2.0 Hz), 6.89 (1H, d, 1.0 Hz), 6.80 (2H, td, *J* = 8.5, 2.0 Hz), 3.77 (3H, s), 3.45 (1H, d, *J* = 14.5 Hz), 3.28 (1H, d, *J* =



(+)-**10n**

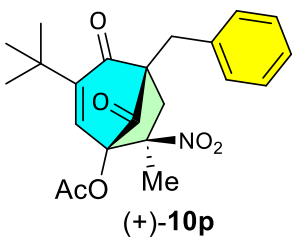
15.0 Hz). 2.97 (1H, dsept, J = 7.0, 1.0 Hz), 2.66 (1H, d, J = 15.5 Hz), 2.16 (3H, s), 1.61 (3H, s), 1.56 (1H, d, J = 15.5 Hz), 1.14 (3H, d, J = 7.0 Hz), 1.07 (3H, d, J = 7.0 Hz); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, 3.1:1 *dr*, major isomer): δ 195.3 (C, *C*=O), 193.6 (C, *C*=O), 168.1 (C, O-*C*=O), 158.5 (C), 145.9 (C), 140.1 (CH), 132.2 (2 x CH), 127.9 (C), 113.7 (2 x CH), 89.7 (C), 89.0 (C), 66.6 (C), 55.2 (OCH_3), 38.4 (CH_2), 30.9 (CH_2), 27.1 (CH), 21.5 (CH_3), 20.7 (CH_3), 20.6 (CH_3), 18.6 (CH_3); HRMS (ESI-TOF) *m*/*z*: $[M + Na]^+$ Calcd for $C_{22}H_{25}NO_7Na$ 438.1529; Found 438.1525.

(1*R*,5*S*,7*R*)-5-Ethyl-3-isopropyl-7-methyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10o): The title compound was prepared following the procedure **C** purified by column chromatography using EtOAc/hexane (0.7:9.3 to 1.2:8.8) and was isolated as a white solid; Yield: 82% (40 mg); Mp.: 145-147 °C; The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 1.0 mL/min, λ = 254 nm), t_R = 7.837 min (major), t_R = 9.353 min (minor) [For major isomer]; $[\alpha]_D^{25}$ = +261.0° [*c* = 0.100, $CHCl_3$, 92% major *ee* and >20:1 *dr*]; IR (Neat): ν_{max} 2961, 1786, 1755, 1673, 1554, 1448, 1370, 1207, 1055, 848, 594 and 404 cm^{-1}; ^{1}H NMR ($CDCl_3$, 500 MHz, >20:1 *dr*, major isomer): δ 6.88 (1H, d, J = 1.0 Hz), 2.92 (1H, dsept, J = 7.0, 1.0 Hz), 2.74 (1H, d, J = 15.5 Hz), 2.17 (3H, s), 2.03 (2H, q, J = 7.5 Hz), 1.76 (1H, d, J = 15.5 Hz). 1.69 (3H, s), 1.11 (3H, d, J = 7.0 Hz), 1.08 (3H, t, J = 7.5 Hz), 1.06 (3H, d, J = 7.0 Hz); $^{13}C\{^{1}H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135, >20:1 *dr*, major isomer): δ 195.5 (C, *C*=O), 194.0 (C, *C*=O), 168.2 (C, O-*C*=O), 146.0 (C), 140.0 (CH), 89.8 (C), 88.9 (C), 65.5 (C), 39.3 (CH_2), 26.9 (CH), 21.5 (CH_3), 20.7 (CH_3), 20.6 (CH_3), 20.5 (CH_2), 18.8 (CH_3), 8.1 (CH_3); HRMS (ESI-TOF) *m*/*z*: $[M + Na]^+$ Calcd for $C_{16}H_{21}NO_6Na$ 346.1267; Found 346.1267.



(+)-**10o**

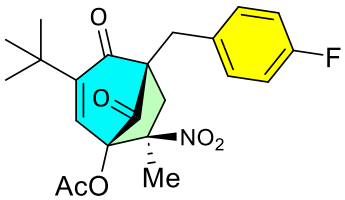
(1*R*,5*S*,7*R*)-5-Benzyl-3-(*tert*-butyl)-7-methyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10p): The title compound was prepared following the procedure **C** and purified by column chromatography using EtOAc/hexanes (1.0:9.0 to 1.5:8.5) and isolated as a white solid; Yield: 93% (55.7 mg); Mp.: 162-164 °C; The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak ID column (hexane/2-propanol = 95:5, flow rate 0.5 mL/min, λ = 254 nm), t_R = 10.315 min (major), t_R = 17.764 min (minor) [for minor isomer], t_R = 16.727 min (major), 31.700 (minor) [for major isomer]; $[\alpha]_D^{20}$ = +194.0° (*c* = 0.100, $CHCl_3$, 95% major *ee*, >99.9%



(+)-**10p**

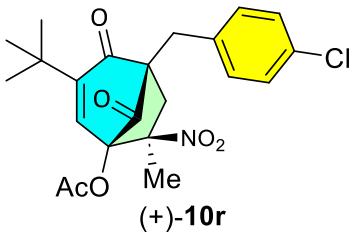
minor *ee* and 8.7:1 *dr*); IR (Neat): ν_{max} 2957, 1785, 1762, 1688, 1553, 1364, 1202, 1007 and 704 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, 7.1:1 *dr*, major isomer): δ 7.32 (2H, td, *J* = 7.0, 1.5 Hz), 7.28 (2H, tt, *J* = 7.0, 2.5 Hz), 7.21 (1H, tt, *J* = 7.5, 2.5 Hz), 6.95 (1H, s), 3.49 (1H, d, *J* = 14.5 Hz), 3.33 (1H, d, *J* = 14.5 Hz), 2.64 (1H, d, *J* = 15.5 Hz), 2.16 (3H, s), 1.61 (3H, s), 1.58 (1H, d, *J* = 15.5 Hz), 1.25 (9H, s, 3 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, 7.1:1 *dr*, major isomer): δ 194.7 (C, *C*=O), 193.1 (C, *C*=O), 168.1 (C, O-*C*=O), 147.0 (C), 140.9 (CH), 136.1 (C), 131.2 (2 x CH), 128.3 (2 x CH), 126.8 (CH), 89.6 (C), 88.9 (C), 67.2 (C), 38.2 (CH_2), 35.0 (C), 31.8 (CH_2), 28.5 (3 x CH_3), 20.7 (CH_3), 18.6 (CH_3); HRMS (ESI-TOF) *m/z*: $[M + NH_4]^+$ Calcd for $C_{22}H_{29}N_2O_6$ 417.2026; Found 417.2024.

(1*R*,5*S*,7*R*)-3-(*tert*-Butyl)-5-(4-fluorobenzyl)-7-methyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10q): The title compound was prepared following the procedure **C** and purified by column chromatography using EtOAc/hexanes (1.0:9.0 to 1.5:8.5) and isolated as a white solid; Mp.: 145-147 °C; Yield: 96% (60 mg); The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 1.0 mL/min, λ = 254 nm), t_R = 4.024 min (major), t_R = 7.679 min (minor) [for minor isomer], t_R = 6.311 min (major), 14.004 (minor) [for major isomer]; $[\alpha]_D^{25}$ = +108.4° (*c* = 0.118, $CHCl_3$, 97% major *ee*, 69% minor *ee* and 14:1 *dr*); IR (Neat): ν_{max} 2961, 1786, 1689, 1553, 1509, 1365, 1262, 1219, 1029, 848, 799 and 733 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, 17:1 *dr*, major isomer): δ 7.30-7.28 (2H, m), 6.98-6.94 (3H, m), 3.43 (1H, d, *J* = 14.5 Hz), 3.32 (1H, d, *J* = 15.0 Hz), 2.60 (1H, d, *J* = 15.0 Hz), 2.17 (3H, s), 1.62 (3H, s), 1.59 (1H, d, *J* = 15.0 Hz), 1.25 (9H, s, 3 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135, 17:1 *dr*, major isomer): δ 194.6 (C, *C*=O), 193.1 (C, *C*=O), 168.0 (C, O-*C*=O), 161.8 (C, d, *J* = 244.0 Hz, *C*-F), 146.9 (C), 141.1 (CH), 132.7 (2 x CH, d, *J* = 8.0 Hz), 131.6 (C, d, *J* = 3.0 Hz), 115.0 (2 x CH, d, *J* = 21.0 Hz), 89.6 (C), 88.8 (C), 67.1 (C), 38.1 (CH_2), 34.9 (C), 31.1 (CH_2), 28.4 (3 x CH_3), 20.6 (CH_3), 18.5 (CH_3); ^{19}F NMR ($CDCl_3$, 470 MHz): δ = –116.0; HRMS (ESI-TOF) *m/z*: $[M + NH_4]^+$ Calcd for $C_{22}H_{28}FN_2O_6$ 435.1932; Found 435.1934.



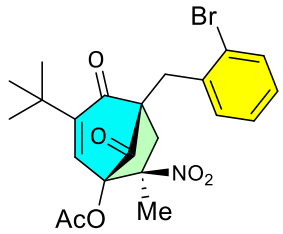
(+)-**10q**

(1*R*,5*S*,7*R*)-3-(*tert*-Butyl)-5-(4-chlorobenzyl)-7-methyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10r): The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 2.0:8.0) and was isolated white solid; Yield: 86% (56 mg); Mp.: 165-167 °C; The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10 flow rate 1.0 mL/min, λ = 254 nm), t_R = 4.229 min (major), t_R = 8.708 min (minor) [For minor isomer]; t_R = 6.174 min (major), t_R = 14.963 min (minor) [For major isomer]; $[\alpha]_D^{25}$ = +231.0° [*c* = 0.100, $CHCl_3$, 94% major *ee*, >99.9% minor *ee*, and 4.5:1 *dr*]; IR (Neat): ν_{max} 2960, 1777, 1749, 1685, 1554, 1492, 1438, 1361, 1222, 1134, 1010, 847, 822, 590 and 484 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, 4:1 *dr*, major isomer): δ 7.27-7.24 (4H, m), 6.96 (1H, s), 3.44 (1H, d, *J* = 14.5 Hz), 3.30 (1H, d, *J* = 14.5 Hz), 2.58 (1H, d, *J* = 15.5 Hz), 2.17 (3H, s). 1.62 (3H, s), 1.59 (1H, d, *J* = 15.5 Hz), 1.24 (9H, s, 3 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, 4:1 *dr*, major isomer): δ 194.5 (C, *C*=O), 193.0 (C, *C*=O), 168.1 (C, O-*C*=O), 147.0 (C), 141.0 (CH), 134.5 (C), 132.8 (C), 132.5 (2 x CH), 128.4 (2 x CH), 89.6 (C), 88.8 (C), 66.9 (C), 38.2 (CH_2), 35.0 (C), 31.3 (CH_2), 28.5 (3 x CH_3), 20.7 (CH_3), 18.6 (CH_3); HRMS (ESI-TOF) *m*/*z*: $[M + NH_4]^+$ Calcd for $C_{22}H_{28}ClN_2O_6$ 451.1638; Found 451.1638.



(+)-**10r**

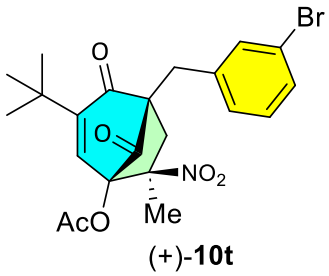
(1*R*,5*S*,7*R*)-5-(2-Bromobenzyl)-3-(*tert*-butyl)-7-methyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10s): The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 2.0:8.0) and was isolated as yellow semisolid; Yield: 91% (65.3 mg); The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak OJ-H column (hexane/2-propanol = 97:3, flow rate 0.5 mL/min, λ = 254 nm), t_R = 12.173 min (major), t_R = 14.632 min (minor) [For minor isomer]; t_R = 26.890 min (minor), t_R = 37.154 min (major) [For major isomer]; $[\alpha]_D^{25}$ = +52.5° [*c* = 0.100, $CHCl_3$, 96 major *ee*, >99.9% minor *ee*, and 5.3:1 *dr*]; IR (Neat): ν_{max} 2927, 1763, 1690, 1551, 1436, 1361, 1276, 1210, 1069, 1020, 761 and 602 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, 12.5:1 *dr*, major isomer): δ 7.61 (1H, dd, *J* = 8.0 Hz, 1.5 Hz), 7.47 (1H, br d, *J* = 8.0 Hz), 7.27 (1H, br t, *J* = 7.5 Hz), 7.09 (1H, tt, *J* = 7.5, 1.5 Hz), 6.97 (1H, s), 3.81 (1H, d, *J* = 14.5 Hz), 3.52 (1H, d, *J* = 15.0 Hz), 2.53 (1H, d, *J* = 15.5 Hz), 2.16 (3H, s), 1.79 (1H, d, *J* = 16.0 Hz), 1.61 (3H, s), 1.26 (9H, s, 3 x CH_3); $^{13}C\{^1H\}$ NMR



(+)-**10s**

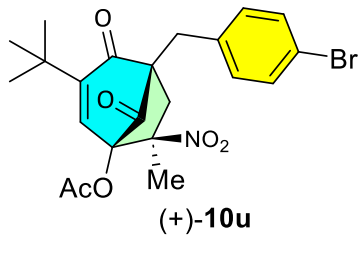
($CDCl_3$, 125 MHz, DEPT-135, 12.5:1 *dr*, major isomer) δ 193.6 (C, *C*=O), 193.2 (C, *C*=O), 168.2 (C, O-*C*=O), 146.8 (C), 141.2 (CH), 135.7 (C), 134.1 (CH), 132.5 (CH), 128.8 (CH), 127.6 (CH), 126.1 (C), 89.6 (C), 88.7 (C), 67.3 (C), 38.0 (CH_2), 35.0 (C), 30.7 (CH_2), 28.5 (3 x CH_3), 20.7 (CH_3), 18.6 (CH_3); HRMS (ESI-TOF) *m/z*: $[M + NH_4]^+$ Calcd for $C_{22}H_{28}BrN_2O_6$ 495.1131; Found 495.1131.

(1*R*,5*S*,7*R*)-5-(3-Bromobenzyl)-3-(*tert*-butyl)-7-methyl-7-nitro-4,8 dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10t): The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 2.0:8.0), and was isolated as a white solid; Yield: 76% (55 mg); Mp.:166-168 °C; The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak ID column (hexane/2-propanol = 95:5, flow rate 0.5 mL/min, λ = 254 nm), t_R = 9.116 min (major), t_R = 14.420 min (minor) [For minor isomer]; t_R = 15.022 min (major), t_R = 36.013 min (minor) [For major isomer]; $[\alpha]_D^{25}$ = +187.0° [*c* = 0.100, $CHCl_3$, 95% major *ee*, 84% minor *ee*, and >20:1 *dr*]; IR (Neat): ν_{max} 2954, 1779, 1754, 1683, 1594, 1551, 1440, 1363, 1330, 1223, 1070, 877, 825 and 710 cm^{-1}. ^1H NMR ($CDCl_3$, 500 MHz, >20:1 *dr*, major isomer): δ 7.47 (1H, t, *J* = 2.0 Hz), 7.36 (1H, qd, *J* = 8.0, 1.0 Hz), 7.28 (1H, br d, *J* = 7.5 Hz), 7.15 (1H, t, *J* = 8.0 Hz), 6.96 (1H, s), 3.44 (1H, d, *J* = 15.0 Hz), 3.30 (1H, d, *J* = 14.5 Hz), 2.58 (1H, d, *J* = 15.5 Hz), 2.17 (3H, s), 1.63 (3H, s), 1.61 (1H, d, *J* = 15.5 Hz), 1.25 (9H, s, 3 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, >20:1 *dr*, major isomer): δ 194.4 (C, *C*=O), 192.9 (C, *C*=O), 168.1 (C, O-*C*=O), 147.0 (C), 141.0 (CH), 138.5 (C), 134.0 (CH), 130.0 (CH), 129.9 (CH), 129.8 (CH), 122.3 (C), 89.6 (C), 88.8 (C), 67.0 (C), 38.2 (CH_2), 35.0 (C), 31.6 (CH_2), 28.5 (3 x CH_3), 20.7 (CH_3), 18.6 (CH_3); HRMS (ESI-TOF) *m/z*: $[M + NH_4]^+$ Calcd for $C_{22}H_{28}BrN_2O_6$ 495.1131; Found 495.1131.



(+)-**10t**

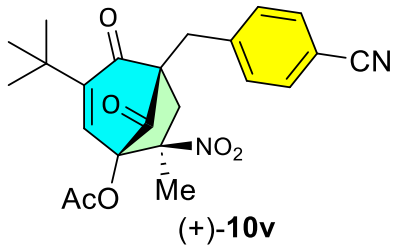
(1*R*,5*S*,7*R*)-5-(4-Bromobenzyl)-3-(*tert*-butyl)-7-methyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10u): The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 2.0:8.0) and was isolated as a white solid; Yield: 90% (64.6 mg); Mp.: 152-154 °C; The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 1.0



(+)-**10u**

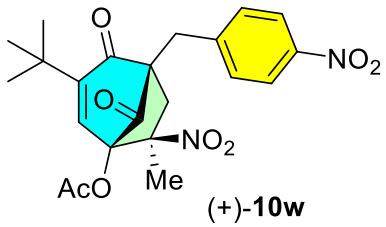
mL/min, λ = 254 nm), t_R = 4.222 min (major), t_R = 9.466 min (minor) [For minor isomer]; t_R = 6.475 min (major), t_R = 17.202 min (minor) [For major isomer]; $[\alpha]_D^{25}$ = +197.0° [*c* = 0.100, $CHCl_3$, 96% major *ee*, >99.9% minor *ee*, and 9.9:1 *dr*]; IR (Neat): ν_{max} 2960, 2360, 1777, 1686, 1593, 1554, 1360, 1278, 1218, 1136, 1069, 1008, 846, 815 and 422 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, 7.7:1 *dr*, major isomer): δ 7.39 (2H, td, *J* = 8.5, 2.5 Hz), 7.21 (2H, td, *J* = 8.5, 2.5 Hz), 6.96 (1H, s), 3.43 (1H, d, *J* = 14.5 Hz), 3.28 (1H, d, *J* = 14.5 Hz), 2.58 (1H, d, *J* = 15.5 Hz), 2.17 (3H, s), 1.62 (3H, s), 1.59 (1H, d, *J* = 15.5 Hz), 1.24 (9H, s, 3 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, 7.7:1 *dr*, major isomer): δ 194.5 (C, *C*=O), 193.0 (C, *C*=O), 168.1 (C, O-*C*=O), 147.0 (C), 141.0 (CH), 135.1 (C), 132.9 (2 x CH), 131.4 (2 x CH), 120.9 (C), 89.6 (C), 88.8 (C), 66.9 (C), 38.2 (CH_2), 35.0 (C), 31.4 (CH_2), 28.5 (3 x CH_3), 20.7 (CH_3), 18.6 (CH_3); HRMS (ESI-TOF) *m*/*z*: $[M + NH_4]^+$ Calcd for $C_{22}H_{28}BrN_2O_6$ 495.1131; Found 495.1129.

(1*R*,5*S*,7*R*)-3-(*tert*-Butyl)-5-(4-cyanobenzyl)-7-methyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10v): The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 1.5:8.5) and was isolated as a white solid; Yield: 74% (47 mg); Mp.: 152-154°C; The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 1.0 mL/min, λ = 254 nm), t_R = 17.294 min (major), t_R = 41.996 min (minor); $[\alpha]_D^{25}$ = +231.0° [*c* = 0.100, $CHCl_3$, 97% major *ee* and >20:1 *dr*]; IR (Neat): ν_{max} 2962, 2224, 1786, 1770, 1685, 1547, 1508, 1360, 1284, 1203, 1184, 1011, 903, 849, 547, 474 and 419 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, >20:1 *dr*, major isomer): δ 7.57 (2H, d, *J* = 8.5 Hz), 7.45 (2H, d, *J* = 8.5 Hz), 6.98 (1H, s), 3.47 (1H, d, *J* = 14.5 Hz), 3.41 (1H, d, *J* = 14.5 Hz), 2.54 (1H, d, *J* = 15.0 Hz), 2.17 (3H, s), 1.65 (1H, d, *J* = 15.5 Hz), 1.63 (3H, s), 1.25 (9H, s, 3 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, >20:1 *dr*, major isomer): δ 194.1 (C, *C*=O), 192.8 (C, *C*=O), 168.1 (C, O-*C*=O), 146.9 (C), 141.8 (C), 141.3 (CH), 132.0 (4 x CH), 118.8 (C), 110.8 (C), 89.6 (C), 88.7 (C), 66.7 (C), 38.2 (CH_2), 35.0 (C), 32.3 (CH_2), 28.5 (3 x CH_3), 20.7 (CH_3), 18.5 (CH_3); HRMS (ESI-TOF) *m*/*z*: $[M + NH_4]^+$ Calcd for $C_{23}H_{28}N_3O_6$ 442.1974; Found 442.1974.



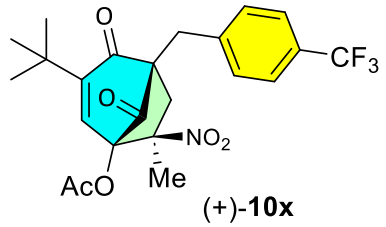
(+)-**10v**

(1*R*,5*S*,7*R*)-3-(*tert*-Butyl)-7-methyl-7-nitro-5-(4-nitrobenzyl)-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10w): The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.5:8.5 to 2.5:7.5), and was isolated as a white solid; Yield: 84% (56 mg); Mp.: 186-188 °C; The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 1.0 mL/min, λ = 254 nm), t_R = 7.286 min (major), t_R = 19.470 min (minor) [For minor isomer]; t_R = 15.742 min (major), t_R = 43.829 min (minor) [For major isomer]; $[\alpha]_D^{25}$ = +201.0° [*c* = 0.100, $CHCl_3$, 98% major *ee*, >99.9% minor *ee*, and 5.2:1 *dr*]; IR (Neat): ν_{max} 2941, 1786, 1753, 1687, 1557, 1513, 1342, 1204, 1188, 1070, 850, 707, 565 and 482 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, 5:1 *dr*, major isomer): δ 8.13 (2H, d, *J* = 8.5 Hz), 7.51 (2H, d, *J* = 9.0 Hz), 6.98 (1H, s), 3.50 (1H, d, *J* = 14.0 Hz), 3.46 (1H, d, *J* = 14.5 Hz), 2.55 (1H, d, *J* = 15.5 Hz), 2.17 (3H, s), 1.67 (1H, d, *J* = 15.5 Hz), 1.62 (3H, s), 1.24 (9H, s, 3 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135, 5:1 *dr*, major isomer): δ 194.0 (C, *C*=O), 192.7 (C, *C*=O), 168.1 (C, O-*C*=O), 146.9 (C), 143.9 (C), 141.3 (CH), 132.1 (2 x CH and C), 123.4 (2 x CH), 89.5 (C), 88.6 (C), 66.6 (C), 38.2 (CH_2), 35.0 (C), 32.0 (CH_2), 28.5 (3 x CH_3), 20.7 (CH_3), 18.5 (CH_3); HRMS (ESI-TOF) *m*/*z*: $[M + NH_4]^+$ Calcd for $C_{22}H_{28}N_3O_8$ 462.1876; Found 462.1870.



(+)-**10w**

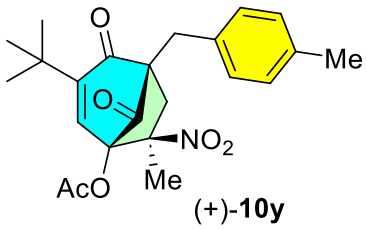
(1*R*,5*S*,7*R*)-3-(*tert*-Butyl)-7-methyl-7-nitro-4,8-dioxo-5-(4-(trifluoromethyl)benzyl)bicyclo[3.2.1]oct-2-en-1-yl acetate (10x): The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.5:8.5 to 2.5:7.5) and was isolated as a white solid; Yield: 94% (66 mg). Mp.: 130-132 °C; Yield: 94% (66 mg). The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 1.0 mL/min, λ = 254 nm), t_R = 4.925 min (major), t_R = 11.313 min (minor) [For major isomer]; $[\alpha]_D^{25}$ = +236.0° [*c* = 0.100, $CHCl_3$, >99.9% major and >20:1 *dr*]; IR (Neat): ν_{max} 2940, 1786, 1767, 1688, 1557, 1365, 1321, 1206, 1187, 1110, 1065, 1011, 849, 595 and 431 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, >20:1 *dr*, major isomer): δ 7.53 (2H, d, *J* = 8.0 Hz), 7.46 (2H, d, *J* = 8.0 Hz), 6.97 (1H, s), 3.54 (1H, d, *J* = 14.5 Hz), 3.39 (1H, d, *J* = 14.5 Hz), 2.57 (1H, d, *J* = 15.5 Hz), 2.17 (3H, s), 1.62 (3H, s), 1.61 (1H, d, *J* = 15.5 Hz), 1.25 (9H, s, 3 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135,



(+)-**10x**

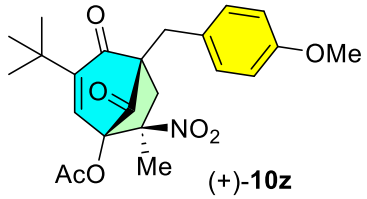
>20:1 *dr*, major isomer): δ 194.3 (C, *C*=O), 192.9 (C, *C*=O), 168.1 (C, O-*C*=O), 147.0 (C), 141.0 (CH), 140.3 (C), 131.5 (2 x CH), 129.1 (C, q, *J* = 33.0 Hz), 125.2 (2 x CH, q, *J* = 4.0 Hz), 124.2 (C, q, *J* = 274.0 Hz, *C*F_3), 89.6 (C), 88.8 (C), 66.8 (C), 38.3 (CH_2), 35.0 (C), 31.9 (CH_2), 28.5 (3 x CH_3), 20.7 (CH_3), 18.6 (CH_3); ^{19}F NMR ($CDCl_3$, 375 MHz): δ −62.5; HRMS (ESI-TOF) *m*/*z*: $[M + NH_4]^+$ Calcd for $C_{23}H_{28}F_3N_2O_6$ 485.1899; Found 485.1898.

(1*R*,5*S*,7*R*)-3-(*tert*-Butyl)-7-methyl-5-(4-methylbenzyl)-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10y): The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 2.0:8.0) and was isolated white solid; Yield: 80% (50 mg). Mp.: 156-158 °C. The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 1.0 mL/min, λ = 254 nm), t_R = 5.007 min (major), t_R = 9.440 min (minor) [For minor isomer]; t_R = 7.277 min (major), t_R = 17.321 min (minor) [For major isomer]; $[\alpha]_D^{25}$ = +263.0° [*c* = 0.100, $CHCl_3$, 95% major *ee*, >99.9% minor *ee*, and >20:1 *dr*]; IR (Neat): ν_{max} 2962, 1778, 1752, 1686, 1546, 1445, 1360, 1274, 1219, 1198, 1133, 1070, 848, 592 and 476 cm^{-1}; ^{1}H NMR ($CDCl_3$, 500 MHz, >20:1 *dr*, major isomer): δ 7.20 (2H, d, *J* = 8.0 Hz), 7.07 (2H, d, *J* = 8.0 Hz), 6.95 (1H, s), 3.46 (1H, d, *J* = 14.5 Hz), 3.28 (1H, d, *J* = 14.5 Hz), 2.64 (1H, d, *J* = 15.5 Hz), 2.30 (3H, s), 2.16 (3H, s), 1.61 (3H, s), 1.57 (1H, d, *J* = 15.5 Hz), 1.24 (9H, s, 3 x CH_3); ^{13}C{^{1}H} NMR ($CDCl_3$, 125 MHz, DEPT-135, >20:1 *dr*, major isomer): δ 194.8 (C, *C*=O), 193.2 (C, *C*=O), 168.1 (C, O-*C*=O), 147.0 (C), 140.8 (CH), 136.3 (C), 133.0 (C), 131.0 (2 x CH), 129.0 (2 x CH), 89.6 (C), 89.0 (C), 67.3 (C), 38.2 (CH_2), 35.0 (C), 31.4 (CH_2), 28.5 (3 x CH_3), 21.0 (CH_3), 20.7 (CH_3), 18.6 (CH_3); HRMS (ESI-TOF) *m*/*z*: $[M + NH_4]^+$ Calcd for $C_{23}H_{31}N_2O_6$ 431.2183; Found 431.2183.



(+)-**10y**

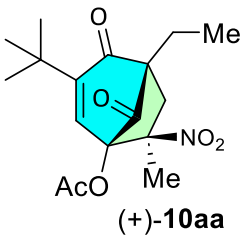
(1*R*,5*S*,7*R*)-3-(*tert*-Butyl)-5-(4-methoxybenzyl)-7-methyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10z): The compound was prepared following the procedure **C** and purified by column chromatography using EtOAc/hexanes (1.0:9.0 to 2.0:8.0) and isolated as a semi solid; Yield: 95% (61 mg); The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak ID column (hexane/2-propanol = 95:5, flow rate 0.7 mL/min, λ = 254 nm), t_R = 16.025 min (major), t_R = 33.048 min (minor) [for major isomer]; $[\alpha]_D^{25}$ = +108.2° (*c* = 0.085,



(+)-**10z**

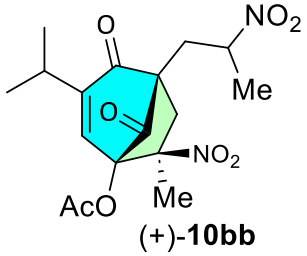
$CHCl_3$, 95% *ee* major, 84% *ee* minor and 6.3:1 *dr*); IR (Neat): ν_{max} 2960, 1777, 1756, 1685, 1612, 1553, 1511, 1439, 1361, 1280, 1180, 1036, 845 and 416 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, 6:1 *dr*, major isomer): δ 7.23 (2H, td, *J* = 8.5, 2.5 Hz), 6.95 (1H, s, olefinic-*H*), 6.81 (2H, td, *J* = 9.0, 2.5 Hz), 3.77 (3H, s, OC*H*$_3$), 3.43 (1H, d, *J* = 14.5 Hz), 3.27 (1H, d, *J* = 15.0 Hz), 2.64 (1H, d, *J* = 15.5 Hz), 2.16 (3H, s), 1.61 (3H, s), 1.56 (1H, d, *J* = 15.5 Hz), 1.24 (9H, s, 3 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, 6:1 *dr*, major isomer): δ 194.8 (C, *C*=O), 193.3 (C, *C*=O), 168.1 (C, O-*C*=O), 158.4 (C), 147.0 (C), 140.9 (CH), 132.2 (2 x CH), 128.0 (C), 113.7 (2 x CH), 89.6 (C), 88.9 (C), 67.3 (C), 55.1 (O*C*H_3), 38.1 (CH_2), 35.0 (C), 31.0 (CH_2), 28.5 (3 x CH_3), 20.7 (CH_3), 18.6 (CH_3); HRMS (ESI-TOF) *m*/*z*: $[M + NH_4]^+$ Calcd for $C_{23}H_{31}N_2O_7$ 447.2132; Found 447.2131.

(1*R*,5*S*,7*R*)-3-(*tert*-Butyl)-5-ethyl-7-methyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10aa): The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 2.0:8.0) and was isolated as white solid; Mp.:148-150 °C; Yield: 84% (42.5 mg). The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 1.0 mL/min, λ = 254 nm), t_R = 5.818 min (major), t_R = 7.717 min (minor); $[\alpha]_D^{25}$ = +163.5° [*c* = 0.100, $CHCl_3$, 94% major *ee* and >20:1 *dr*]; IR (Neat): ν_{max} 2941, 1786, 1760, 1677, 1552, 1459, 1390, 1364, 1280, 1191, 1060, 872 and 591 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, >20:1 *dr*, major isomer): δ 6.94 (1H, s), 2.71 (1H, d, *J* = 15.5 Hz), 2.17 (3H, s), 2.02 (2H, q, *J* = 7.5 Hz), 1.75 (1H, d, *J* = 15.5 Hz), 1.69 (3H, s), 1.23 (9H, s, 3 x CH_3), 1.07 (3H, t, *J* = 7.5 Hz); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135, >20:1 *dr*, major isomer): δ 195.2 (C, *C*=O), 193.7 (C, *C*=O), 168.1 (C), 147.1 (C), 140.8 (CH), 89.7 (C), 88.8 (C), 66.2 (C), 39.1 (CH_2), 34.9 (C), 28.5 (3 x CH_3), 20.7 (CH_3), 20.5 (CH_2), 18.8 (CH_3), 8.0 (CH_3); HRMS (ESI-TOF) *m*/*z*: $[M+NH_4]^+$ Calcd for $C_{17}H_{27}N_2O_6$ 355.1869; Found 355.1867.



(+)-**10aa**

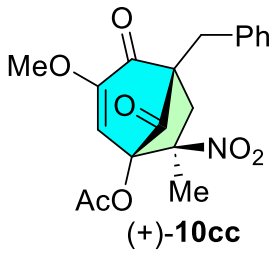
(1*R*,5*S*,7*R*)-3-Isopropyl-7-methyl-7-nitro-5-(2-nitropropyl)-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10bb): The title compound was prepared following the procedure **G**, **H** purified by column chromatography using EtOAc/hexane (0.9:9.1 to 1.4:8.6), and was isolated as a semi solid; Yield: 84% (32 mg); The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 1.0 mL/min, λ = 254 nm), t_R = 19.151 min (major),



(+)-**10bb**

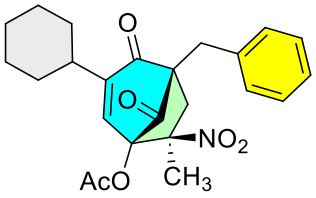
t_R = 24.316 min (minor) [For minor isomer]; t_R = 25.967 min (major), t_R = 28.551 min (minor) [For major isomer]; $[\alpha]_D^{25}$ = +311.0º [*c* = 0.100, $CHCl_3$, 79% major *ee*, 93% minor *ee* and 3.9:1 *dr*]; IR (Neat): ν_{max} 2964, 1788, 1764, 1686, 1550, 1446, 1388, 1356, 1200, 1009, 847, 735 and 591 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, 4.5:1 *dr*, major isomer): δ 6.90 (1H, s), 4.94-4.87 (1H, m), 3.00 (1H, dd, *J* = 16.0, 7.5 Hz), 2.93 (1H, sextet, *J* = 7.0 Hz), 2.78 (1H, d, *J* = 16.0 Hz), 2.34 (1H, dd, *J* = 16.0, 2.5 Hz), 2.16 (3H, d, *J* = 1.0 Hz), 1.89 (1H, d, *J* = 16.0 Hz), 1.69 (3H, d, *J* = 7.0 Hz), 1.68 (3H, s), 1.11 (3H, d, *J* = 7.0 Hz), 1.05 (3H, d, *J* = 6.5 Hz); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, 4.5:1 *dr*, major isomer): δ 194.0 (C, *C*=O), 193.5 (C, *C*=O), 168.0 (C, O-*C*=O), 145.6 (C), 140.4 (CH), 89.8 (C), 88.3 (C), 79.3 (CH), 64.4 (C), 39.3 (CH_2), 31.9 (CH_2), 27.0 (CH), 22.0 (CH_3), 21.3 (CH_3), 20.6 (CH_3), 20.5 (CH_3), 18.5 (CH_3); HRMS (ESI-TOF) *m*/*z*: $[M + Na]^+$ Calcd for $C_{17}H_{22}N_2O_8Na$ 405.1274; Found 405.1271.

(1*R*,5*S*,7*R*)-5-Benzyl-3-methoxy-7-methyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate (10cc): The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 1.5:8.5) and was isolated as white solid; Yield: 86% (48 mg); Mp.: 148-150 ºC; The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 1.0 mL/min, λ = 254 nm), t_R = 27.953 min (major), t_R = 36.892 min (minor); $[\alpha]_D^{25}$ = +257.0° [*c* = 0.100, $CHCl_3$, 87% major *ee*, and >20:1 *dr*]; IR (Neat): ν_{max} 2921, 1782, 1760, 1695, 1610, 1550, 1387, 1347, 1267, 1203, 1064, 1011, 733 and 402 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, >20:1 *dr*, major isomer): δ 7.33 (2H, d, *J* = 7.5 Hz), 7.27 (2H, t, *J* = 7.5 Hz), 7.22 (1H, t, *J* = 7.5 Hz), 6.14 (1H, s), 3.76 (3H, s, O*CH*$_3$), 3.57 (1H, d, *J* = 14.5 Hz), 3.34 (1H, d, *J* = 14.5 Hz), 2.70 (1H, d, *J* = 15.5 Hz), 2.16 (3H, s), 1.67 (1H, d, *J* = 15.0 Hz), 1.67 (3H, s); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, >20:1 *dr*, major isomer): δ 192.9 (C, *C*=O), 190.2 (C, *C*=O), 168.1 (C, O-*C*=O), 151.4 (C), 135.6 (C), 131.2 (2 x CH), 128.3 (2 x CH), 126.9 (CH), 114.0 (CH), 90.1 (C), 88.1 (C), 65.1 (C), 56.3 (O*CH*$_3$), 38.3 (CH_2), 31.5 (CH_2), 20.9 (CH_3), 18.7 (CH_3); HRMS (ESI-TOF) *m*/*z*: $[M + NH_4]^+$ Calcd for $C_{19}H_{23}N_2O_7$ 391.1505; Found 391.1505.



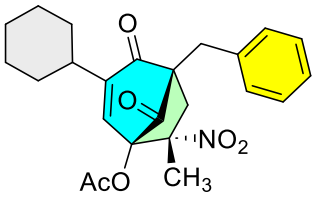
(+)-**10cc**

(1*R*,5*S*,7*R*)-5-Benzyl-3-cyclohexyl-7-methyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate [(+)-10dd]: The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 2.0:8.0) and was isolated as a yellow solid; Yield: 63% (40 mg); Mp.: 154-156 °C; The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 1.0 mL/min, λ = 254 nm), t_R = 9.565 min (major), t_R = 16.426 min (minor) [For major isomer]; $[\alpha]_D^{27}$ = +182.0° [*c* = 0.100, $CHCl_3$, 87% *ee*]; IR (Neat): ν_{max} 3002, 2969, 2926, 2854, 1739, 1688, 1555, 1444, 1371, 1209, 736, 704 and 525 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, major isomer): δ 7.37-7.31 (2H, m), 7.31-7.25 (2H, m), 7.22 (1H, tt, *J* = 7.5 Hz), 6.86 (1H, d, *J* = 1.0 Hz, olefinic-*H*), 3.52 (1H, d, *J* = 14.5 Hz), 3.33 (1H, d, *J* = 14.5 Hz), 2.67-2.61 (1H, m), 2.65 (1H, d, *J* = 15.5 Hz), 2.17 (3H, s, COC*H*$_3$), 1.85-1.71 (5H, m), 1.61 (3H, s), 1.58 (1H, d, *J* = 15.0 Hz), 1.46-1.31 (2H, m), 1.25-1.12 (2H, m), 1.02 (1H, dq, *J* = 12.5, 3.5 Hz); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 100 MHz, DEPT-135, major isomer): δ 195.2 (C, *C*=O), 193.5 (C, *C*=O), 168.1 (C, O-*C*=O), 144.9 (C), 140.5 (CH), 136.1 (C), 131.2 (2 x CH), 128.3 (2 x CH), 126.8 (CH), 89.7 (C), 89.0 (C), 66.4 (C), 38.4 (CH_2), 36.6 (CH), 32.4 (CH_2), 31.8 (CH_2), 31.4 (CH_2), 26.3 (CH_2), 26.1 (CH_2), 26.0 (CH_2), 20.7 (CH_3), 18.6 (CH_3); HRMS (ESI-TOF) *m*/*z*: $[M + Na]^+$ Calcd for $C_{24}H_{27}NO_6Na$ 448.1736; Found 448.1740.



(+)-**10dd**

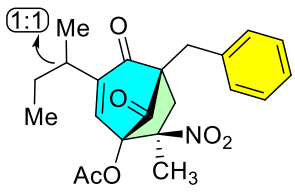
(1*R*,5*S*,7*S*)-5-Benzyl-3-cyclohexyl-7-methyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate [(+)-11dd]: The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.0:9.0) and was isolated as a white solid; Yield: 33% (21 mg); Mp.: 152-154 °C; The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 1.0 mL/min, λ = 254 nm), t_R = 5.13 min (major), t_R = 7.48 min (minor) [For minor isomer]; $[\alpha]_D^{25}$ = +45.5° [*c* = 0.138, $CHCl_3$, 99.9% *ee*]; IR (Neat): ν_{max} 3015, 2969, 2928, 2952, 1739, 1548, 1444, 1367, 1216, 1093, 1031, 897, 763, 708, and 527 cm-1; ^1H NMR ($CDCl_3$, 500 MHz, minor isomer): δ 7.33-7.28 (2H, m), 7.27-7.22 (3H, m), 6.85 (1H, d, *J* = 1.0 Hz, olefinic-*H*), 3.42 (1H, d, *J* = 14.5 Hz), 3.20 (1H, d, *J* = 14.5 Hz), 2.59-2.54 (1H, m), 2.55 (1H, d, *J* = 15.0 Hz), 2.27 (3H, s, COC*H*$_3$), 2.22 (1H, d, *J* = 15.0 Hz), 1.82-1.67 (5H, m), 1.39-1.35 (1H, m), 1.35-1.32 (1H, m), 1.25 (3H, s), 1.20-1.12 (2H, m), 0.97-0.90 (1H, m); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, minor isomer): δ



(+)-**11dd**

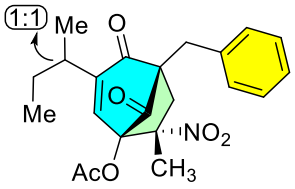
194.5 (C, *C*=O), 193.5 (C, *C*=O), 168.3 (C, O-*C*=O), 143.2 (C), 142.0 (CH), 135.8 (C), 131.1 (2 x CH), 128.6 (2 x CH), 127.1 (CH), 89.3 (C), 87.5 (C), 67.3 (C), 36.5 (CH_2), 32.4 (CH_2), 31.2 (CH_2), 31.1 (CH_2), 26.4 (CH_2), 26.2 (CH_2), 26.0 (CH_2), 22.1 (CH), 22.1 (CH_3), 20.8 (CH_3); HRMS (ESI-TOF) *m*/*z*: $[M + Na]^+$ Calcd for $C_{24}H_{27}NO_6Na$ 448.1736; Found 448.1740.

(1*R*,5*S*,7*R*)-5-Benzyl-3-(*sec*-butyl)-7-methyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate [(+)-10ee]: The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 2.0:8.0) and was isolated as a white solid; Yield: 67% (40 mg); Mp.: 132-134 °C; The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 91:09, flow rate 0.9 mL/min, λ = 254 nm), t_R = 9.054 min (major), t_R = 16.730 min (minor) [For major isomer]; t_R = 9.054 min (major), t_R = 18.165 min (minor) [For minor isomer]; $[\alpha]_D^{25}$ = +99.5° [*c* = 0.200, $CHCl_3$, 98% *ee* for major isomer, 98% *ee* for minor isomer, and 1:1 *dr*]; IR (Neat): ν_{max} 2965, 1788, 1764, 1688, 1555, 1206, 906, 729 and 704 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, 1:1 *dr* for major isomer): δ 7.27-7.25 (4H, m), 7.22-7.18 (4H, m), 7.14 (2H, tt, *J* = 7.0, 2.5 Hz), 6.81 (1H, br s, olefinic-*H*), 6.80 (1H, s, olefinic-*H*), 3.45 (1H, d, *J* = 14.5 Hz), 3.45 (1H, d, *J* = 14.5 Hz), 3.27 (1H, d, *J* = 14.5 Hz), 3.26 (1H, d, *J* = 14.5 Hz), 2.72 (2H, sextet, *J* = 6.5 Hz), 2.59 (1H, d, *J* = 15.5 Hz), 2.58 (1H, d, *J* = 15.5 Hz), 2.09 (6H, s, 2 x COC*H*$_3$), 1.55 (3H, s), 1.54 (3H, s), 1.50-1.52 (2H, m), 1.49-1.43 (2H, m), 1.43-1.38 (1H, m), 1.34-1.24 (1H, m), 1.05 (3H, d, *J* = 7.0 Hz), 0.98 (3H, d, *J* = 7.0 Hz), 0.81 (3H, t, *J* = 7.5 Hz), 0.80 (3H, t, *J* = 7.5 Hz); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, 1:1 *dr* for major isomer): δ 195.5 (C, *C*=O), 195.2 (C, *C*=O), 193.6 (C, *C*=O), 193.4 (C, *C*=O), 168.1 (C, O-*C*=O), 168.1 (C, O-*C*=O), 145.1 (C), 144.8 (C), 141.1 (CH), 141.0 (CH), 136.1 (C), 136.1 (C), 131.2 (2 x CH), 131.2 (2 x CH), 128.3 (2 x CH), 128.3 (2 x CH), 126.8 (CH), 126.8 (CH), 89.8 (C), 89.7 (C), 89.1 (C), 88.9 (C), 66.5 (C), 66.4 (C), 38.5 (CH_2), 38.4 (CH_2), 33.8 (CH), 33.7 (CH), 31.8 (CH_2), 31.8 (CH_2), 28.8 (CH_2), 28.0 (CH_2), 20.7 (CH_3), 20.7 (CH_3), 19.4 (CH_3), 18.6 (CH_3), 18.6 (CH_3), 18.1 (CH_3), 11.9 (CH_3), 11.4 (CH_3); HRMS (ESI-TOF) *m*/*z*: $[M + Na]^+$ Calcd for $C_{22}H_{25}NO_6Na$ 422.1580; Found 422.1580.



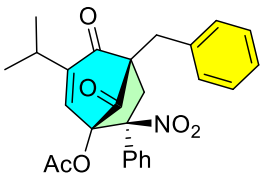
(+)-**10ee**

(1*R*,5*S*,7*S*)-5-Benzyl-3-(*sec*-butyl)-7-methyl-7-nitro-4,8-dioxobicyclo[3.2.1]oct-2-en-1-yl acetate [(+)-11ee]: The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.0:9.0) and was isolated as a white solid; Yield: 17% (10 mg); Mp.: 130-132 °C; The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 93:07, flow rate 0.7 mL/min, λ = 254 nm), t_R = 7.226 min (major), t_R = 11.022 min (minor) [For major isomer]; t_R = 7.226 min (major), t_R = 11.775 min (minor) [For minor isomer]; $[\alpha]_D^{27}$ = +57.4° [*c* = 0.100, $CHCl_3$, 85% *ee* for major isomer, 88% *ee* for minor isomer, and 1:1 *dr*]; IR (Neat): ν_{max} 2900, 1785, 1690, 1688, 1551, 1372, 1264, 1217, 906, 729 and 650 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, 1:1 *dr* for minor isomer): δ 7.33-7.28 (4H, m), 7.27-7.26 (3H, m), 7.25-7.22 (3H, m), 6.88 (1H, s, olefinic-*H*), 6.87 (1H, s, olefinic-*H*), 3.43 (1H, d, *J* = 14.5 Hz), 3.43 (1H, d, *J* = 14.5 Hz), 3.21 (1H, d, *J* = 14.5 Hz), 3.19 (1H, d, *J* = 14.5 Hz), 2.72 (2H, sextet, *J* = 5.0 Hz), 2.56 (1H, d, *J* = 15.0 Hz), 2.55 (1H, d, *J* = 14.5 Hz), 2.27 (6H, s, 2 x COCH_3), 2.26-2.22 (2H, m), 1.47-1.41 (2H, m), 1.35-1.27 (2H, m), 1.25 (3H, s), 1.25 (3H, s), 1.07 (3H, d, *J* = 7.0 Hz), 0.98 (3H, d, *J* = 7.0 Hz), 0.85 (3H, t, *J* = 7.5 Hz), 0.80 (3H, t, *J* = 7.5 Hz); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, 1:1 *dr* for minor isomer): δ 194.7 (C, *C*=O), 194.6 (C, *C*=O), 193.6 (C, *C*=O), 193.5 (C, *C*=O), 168.3 (2 x C, 2 x O-*C*=O), 143.1 (C), 142.9 (C), 142.6 (CH), 142.4 (CH), 135.8 (2 x C), 131.1 (4 x CH), 128.6 (4 x CH), 127.1 (2 x CH), 89.3 (C), 89.2 (C), 87.6 (C), 87.4 (C), 67.4 (C), 67.2 (C), 36.6 (2 x CH_2), 33.6 (CH), 33.5 (CH), 31.2 (2 x CH_2), 28.6 (CH_2), 27.8 (CH_2), 22.1 (CH_3), 22.0 (CH_3), 20.8 (CH_3), 19.5 (CH_3), 18.1 (2 x CH_3), 11.4 (2 x CH_3); HRMS (ESI-TOF) *m*/*z*: $[M + H]^+$ Calcd for $C_{22}H_{26}NO_6$ 400.1760; Found 400.1752.



(+)-**11ee**

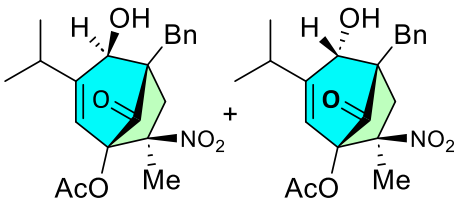
(1*R*,5*S*,7*S*)-5-Benzyl-3-isopropyl-7-nitro-4,8-dioxo-7-phenylbicyclo[3.2.1]oct-2-en-1-yl acetate [(-)-10ff]: The title compound was prepared following the procedure **C**, purified by column chromatography using EtOAc/hexane (1.0:9.0 to 2.0:8.0) and was isolated as a white solid; Yield: 70% (47 mg); Mp.: 150-152 °C; The enantiomeric excess (*ee*) was determined by chiral stationary phase HPLC using a Daicel Chiralpak IG column (hexane/2-propanol = 90:10, flow rate 1.0 mL/min, λ = 254 nm), t_R = 8.456 min (major), t_R = 12.898 min (minor) [For major isomer]; $[\alpha]_D^{27}$ = -260.8° [*c* = 0.05, $CHCl_3$, 88% major *ee*, and >20:1 *dr*]; IR (Neat): ν_{max} 2969, 2926, 2854, 1741, 1688, 1558, 1435, 1366, 1228, 1216, 895, 702 and 527 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, for major isomer): δ 7.49-7.38 (7H, m), 7.32



(-)-**10ff**

(2H, t, *J* = 7.5 Hz), 7.27-7.24 (1H, m), 6.70 (1H, s, olefinic-*H*), 3.58 (1H, d, *J* = 14.5 Hz), 3.45 (1H, d, *J* = 14.5 Hz), 3.02 (1H, d, *J* = 15.5 Hz), 2.79 (1H, septet, *J* = 7.0 Hz), 2.45 (1H, d, *J* = 15.5 Hz), 2.30 (3H, s, COC*H*$_3$), 0.94 (3H, d, *J* = 6.5 Hz), 0.63 (3H, d, *J* = 7.0 Hz); ^{13}C{^{1}H} NMR ($CDCl_3$, 125 MHz, DEPT-135, >20:1 *dr*, for major isomer): *δ* 194.9 (C, *C*=O), 193.2 (C, *C*=O), 167.9 (C, O-*C*=O), 144.4 (C), 140.7 (CH), 136.0 (C), 132.2 (C), 131.3 (2 x CH), 130.4 (CH), 128.9 (2 x CH), 128.8 (2 x CH), 128.4 (2 x CH), 127.0 (CH), 93.6 (C), 90.1 (C), 66.0 (C), 37.0 (CH_2), 31.8 (CH_2), 26.8 (CH_3), 21.2 (CH_3), 21.1 (CH), 20.4 (CH_3); HRMS (ESI-TOF) *m*/*z*: [M + Na]$^+$ Calcd for $C_{26}H_{25}NO_6Na$ 470.1580; Found 470.1580.

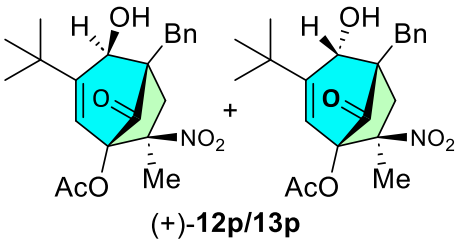
(1*R*,4*R*,5*S*,7*R*)-5-Benzyl-4-hydroxy-3-isopropyl-7-methyl-7-nitro-8-oxobicyclo[3.2.1]oct-2-en-1-yl acetate (12c/13c): The title compound was prepared following the procedure **D** and



(+)-**12c/13c**

was isolated as white semi solid; Yield: 95% (110 mg); $[\alpha]_D^{25}$ = +46.5° [*c* = 0.100, $CHCl_3$, 1.6:1 *dr*]; IR (Neat): ν_{max} 3464, 2961, 1778, 1547, 1451, 1385, 1297, 1205, 1033, and 755 cm^{-1}; ^{1}H NMR ($CDCl_3$, 500 MHz, 1.6:1 *dr*, major isomer): δ 7.33 (1H, d, *J* = 7.0 Hz), 7.29-7.27 (1H, m), 7.22-7.20 (3H, m), 5.58 (1H, s, olefinic-*H*), 4.18 (1H, s), 3.62 (1H, br s, O*H*), 3.57 (1H, d, *J* = 14.0 Hz), 2.81 (1H, d, *J* = 14.0 Hz), 2.61 (1H, d, *J* = 15.0 Hz), 2.53-2.50 (1H, m), 2.09 (3H, s), 1.58 (3H, s), 1.35 (1H, d, *J* = 15.0 Hz), 1.07 (3H, d, *J* = 6.5 Hz), 0.96 (3H, d, *J* = 7.0 Hz); ^{13}C NMR ($CDCl_3$, 125 MHz, DEPT-135, 1.6:1 *dr*, major isomer): δ 204.1 (C, *C*=O), 168.1 (C, O-*C*=O), 146.4 (C), 135.9 (C), 130.4 (2 x CH), 128.5 (2 x CH), 126.8 (CH), 122.5 (CH), 91.2 (C), 86.6 (C), 81.4 (CH), 52.6 (C), 40.7 (CH_2), 34.4 (CH_2), 30.2 (CH), 22.0 (CH_3), 21.0 (2 x CH_3), 17.5 (CH_3); ^{1}H NMR ($CDCl_3$, 500 MHz, 1.6:1 *dr*, minor isomer): δ 7.33 (1H, d, *J* = 7.0 Hz), 7.29-7.27 (1H, m), 7.22-7.20 (3H, m), 5.59 (1H, s, olefinic-*H*), 4.60 (1H, s), 3.62 (1H, br s, O*H*), 3.22 (1H, d, *J* = 14.0 Hz), 3.15 (1H, d, *J* = 14.0 Hz), 2.53-2.50 (1H, m), 2.34 (1H, d, *J* = 15.5 Hz), 2.05 (3H, s), 1.66 (3H, s), 1.23 (1H, d, *J* = 15.0 Hz), 1.04 (3H, d, *J* = 6.5 Hz), 0.98 (3H, d, *J* = 7.0 Hz); ^{13}C{^{1}H} NMR ($CDCl_3$, 125 MHz, DEPT-135, 1.6:1 *dr*, minor isomer): δ 199.2 (C, *C*=O), 168.5 (C, O-*C*=O), 146.6 (C), 136.9 (C), 130.3 (2 x CH), 128.8 (2 x CH), 127.1 (CH), 124.9 (CH), 91.8 (C), 86.2 (C), 79.5 (CH), 55.3 (C), 37.5 (CH_2), 37.3 (CH_2), 28.9 (CH), 21.6 (CH_3), 21.0 (2 x CH_3), 17.5 (CH_3); HRMS (ESI-TOF) *m*/*z*: [M + NH_4]$^+$ Calcd for $C_{21}H_{29}N_2O_6$ 405.2026; Found 405.2028.

(1*R*,4*S*,5*S*,7*R*)-5-Benzyl-3-(*tert*-butyl)-4-hydroxy-7-methyl-7-nitro-8-oxobicyclo[3.2.1]oct-2-en-1-yl acetate (12p/13p): The title compound was prepared following the procedure **E**, purified by column chromatography using EtOAc/hexane (2.0:8.0 to 3.0:7.0) and was isolated as a white solid; Yield: 80% (48 mg); Mp.: 105-107 °C; $[\alpha]_D^{25}$ = +85.0° [*c* = 0.100, $CHCl_3$, 6.25:1 *dr*]; IR (Neat): ν_{max} 3543, 2956, 1778, 1547, 1451, 1384, 1365, 1218, 1194, 1047, 1008, 755, 703 and 422 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz, 6.2:1 *dr*, major isomer): δ 7.34-7.27 (5H, m), 5.76 (1H, s, olefinic-*H*), 4.80 (1H, d, *J* = 4.5 Hz), 3.28 (1H, d, *J* = 14.0 Hz), 3.14 (1H, d, *J* = 14.0 Hz), 2.64 (1H, d, *J* = 15.0 Hz), 2.41 (1H, dd, *J* = 15.0, 1.5 Hz), 2.09 (3H, s), 1.70 (3H, *s*), 1.14 (9H, s, 3 x CH_3); $^{13}C\{^1H\}$ NMR ($CDCl_3$, 125 MHz, DEPT-135, 6.2:1 *dr*, major isomer): δ 198.9 (C, *C*=O), 168.1 (C, O-*C*=O), 147.6 (C), 137.0 (C), 130.0 (2 x CH), 129.1 (2 x CH), 126.8 (CH), 124.0 (CH), 91.6 (C), 86.3 (C), 80.3 (CH), 55.2 (C), 37.9 (CH_2), 37.8 (CH_2), 35.1 (C), 30.0 (3 x CH_3), 21.1 (CH_3), 17.6 (CH_3); HRMS (ESI-TOF) m/z: $[M + NH_4]^+$ Calcd for $C_{22}H_{31}N_2O_6$ 419.2182; Found 419.2183.



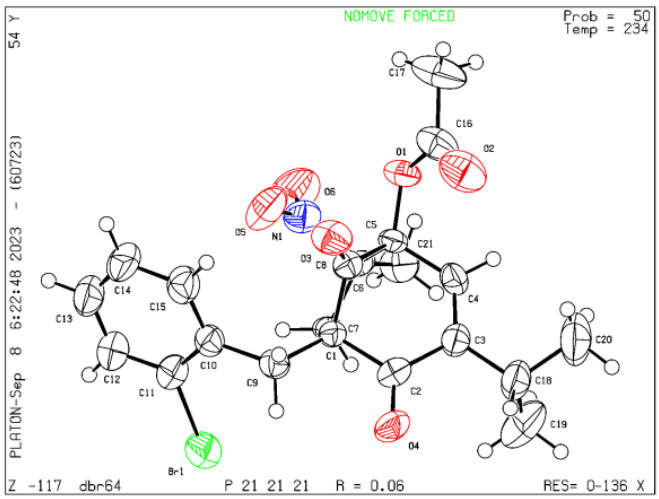
(+)-**12p/13p**

X-ray Single Crystal Data for 10g. The Ellipsoid Counter % Probability Levels are 50%
Crystallized from DCM-Hexane; $C_{21}H_{22}BrNO_6$; Mr = 464.30; orthorhombic; space group = $P\ 2_12_12_1$; A clear white crystal of 0.179 × 0.169 × 0.158 mm^3 was used.

Table S6. Crystal data and structure refinement for (+)-**10g** (CCDC-2360361)

```
Bond precision:   C-C = 0.0088 A          Wavelength=0.71073

Cell:              a=7.0203(7)     b=10.9547(10)     c=28.092(3)
                   alpha=90        beta=90           gamma=90
Temperature:       234 K

                  Calculated                Reported
Volume            2160.4(4)                 2160.4(4)
Space group       P 21 21 21                P 21 21 21
Hall group        P 2ac 2ab                 P 2ac 2ab
Moiety formula    C21 H22 Br N O6           C21 H22 Br N O6
Sum formula       C21 H22 Br N O6           C21 H22 Br N O6
Mr                464.30                    464.30
Dx,g cm-3         1.428                     1.428
Z                 4                         4
Mu (mm-1)         1.938                     1.938
F000              952.0                     952.0
F000'             951.32
h,k,lmax          9,14,36                   8,13,34
Nref              4803[ 2764]               4479
Tmin,Tmax         0.714,0.736               0.645,1.000
Tmin'             0.700

Correction method= # Reported T Limits: Tmin=0.645 Tmax=1.000
AbsCorr = MULTI-SCAN

Data completeness= 1.62/0.93        Theta(max)= 27.211

R(reflections)= 0.0605( 2591)                    wR2(reflections)=
                                                 0.1085( 4479)
S = 1.031                  Npar= 266
```

Ellipsoid plot for 10g



X-ray Single Crystal Data for 10y. The Ellipsoid Counter % Probability Levels are 50%

Crystallized from DCM-Hexane; $C_{23}H_{27}NO_6$; Mr = 413.45; orthorhombic; space group = $P\ 2_12_12_1$; A clear white crystal of 0.24×0.2×0.14 mm^3 was used.

Table S7. Crystal data and structure refinement for (+)-**10y** (CCDC-2360360)

Bond precision:	C-C = 0.0054 A	Wavelength=0.71073
Cell:	a=9.8373(7)	b=12.5432(11) c=18.3743(13)
	alpha=90	beta=90 gamma=90
Temperature:	296 K	
	Calculated	Reported
Volume	2267.2(3)	2267.2(3)
Space group	P 21 21 21	P 21 21 21
Hall group	P 2ac 2ab	P 2ac 2ab
Moiety formula	C23 H27 N O6	C23 H27 N O6
Sum formula	C23 H27 N O6	C23 H27 N O6
Mr	413.46	413.45
Dx,g cm-3	1.211	1.211
Z	4	4
Mu (mm-1)	0.087	0.087
F000	880.0	880.0
F000'	880.47	
h,k,lmax	12,16,23	12,16,23
Nref	5204[2942]	4922
Tmin,Tmax	0.979,0.988	0.632,0.746
Tmin'	0.979	

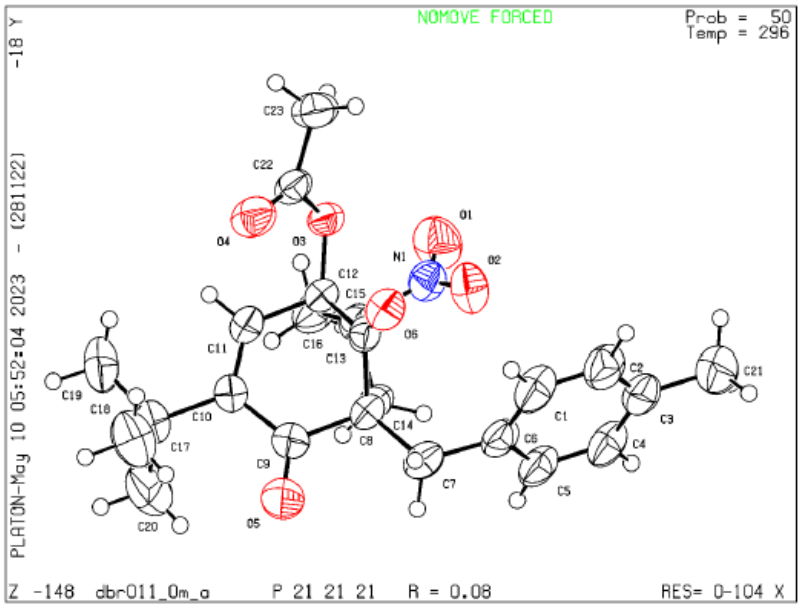
Correction method= # Reported T Limits: Tmin=0.632 Tmax=0.746
AbsCorr = MULTI-SCAN

Data completeness= 1.67/0.95 Theta(max)= 27.480

R(reflections)= 0.0780(4170) wR2(reflections)= 0.1819(4922)

S = 1.191 Npar= 277

Ellipsoid plot for (+)-10y:



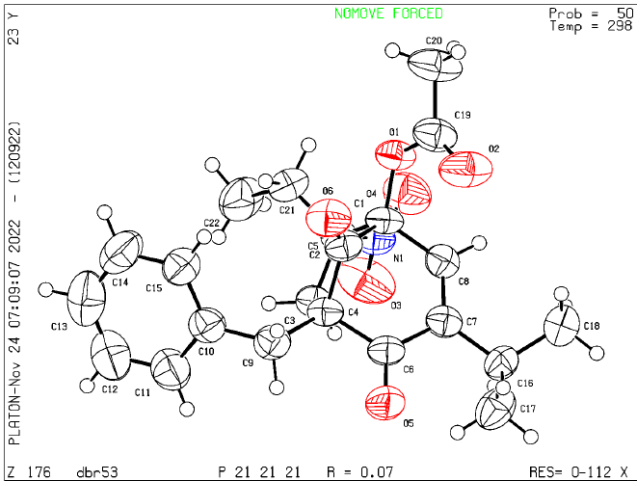
X-ray Single Crystal Data for 11a. The Ellipsoid Counter % Probability Levels are 50%

Crystallized from DCM-Hexane; $C_{22}H_{25}NO_6$; Mr = 399.43; orthorhombic; space group = $P\ 2_12_12_1$;
A clear white crystal of 0.2×0.19×0.13 mm^3 was used.

Table S8. Crystal data and structure refinement for (+)-**11a** (CCDC-2365952)

```
Bond precision:   C-C = 0.0073 A          Wavelength=0.71073

Cell:             a=10.5076(6)     b=12.7385(7)     c=15.5696(10)
                  alpha=90         beta=90          gamma=90
Temperature:      298 K

                  Calculated                Reported
Volume            2084.0(2)                 2084.0(2)
Space group       P 21 21 21                P 21 21 21
Hall group        P 2ac 2ab                 P 2ac 2ab
Moiety formula    C22 H25 N O6              C22 H25 N O6
Sum formula       C22 H25 N O6              C22 H25 N O6
Mr                399.43                    399.43
Dx,g cm-3         1.273                     1.273
Z                 4                         4
Mu (mm-1)         0.093                     0.093
F000              848.0                     848.0
F000'             848.46
h,k,lmax          13,16,19                  13,15,19
Nref              4523[ 2565]               4297
Tmin,Tmax         0.982,0.988               0.616,1.000
Tmin'             0.982

Correction method= # Reported T Limits: Tmin=0.616 Tmax=1.000
AbsCorr = MULTI-SCAN

Data completeness= 1.68/0.95        Theta(max)= 26.949

R(reflections)= 0.0653( 2518)                wR2(reflections)=
                                             0.1878( 4297)
S = 0.937                  Npar= 266
```

Ellipsoid plot for (+)-11a:



References:

1. Z. Huang, O. Kwon, K. V. N. Esguerra and J. -P. Lumb, A Divergent and Selective Synthesis of *ortho*- and *para*-Quinones from Phenols, *Tetrahedron* **2015**, *71*, 5871-5885.
2. (*a*) M. S. Manna and S. Mukherjee, Organocatalytic Enantioselective Formal C(sp^2)–H Alkylation, *J. Am. Chem. Soc*. **2015**, *137*, 1, 130-133; (*b*) Y. Chi, L. Guo, N. A. Kopf and S. H. Gellman, Enantioselective Organocatalytic Michael Addition of Aldehydes to Nitroethylene: Efficient Access to γ^2-Amino Acids, *J. Am. Chem. Soc*. **2008**, *130*, 17, 5608-5609; (*c*) N. V. G. Moorthy, R. Dyapa and S. V. Pansare, Formal Synthesis of (+)-Lasubine II and (−)-Subcosine II *via* Organocatalytic Michael Addition of a Ketone to an α-Nitrostyrene, *Org. Lett.* **2015**, *17*, 5312-5315; (*d*) R. A. Annadate, N. V. G. Moorthy and S. V. Pansare, Studies on the Organocatalytic Enantioselective Michael Addition of Cyclic Ketones and α, α-Disubstituted Aldehydes to α-Nitrostyrenes, *Curr. Organocatalysis*, **2018**, *5*, 66-73; (*e*) H. Weber, N. Drouve, L. Kortenbrede and S. E. Sheikh, A Broadly Applicable Diels−Alder Based Synthesis of Ketamine-Related Arylcyclohexylamines, *J. Org. Chem*. **2023**, *88*, 11372-11376.