Supporting Information for:

Metal-free synthesis of estetrol key intermediate under intensified continuous flow conditions

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1. Continuous flow setups

1.1 Lab-scale mesofluidic setup

All microfluidic setups were assembled with commercially available parts (details in Table S1).

1.1.1 Pumps

Knauer AZURA P 4.1S HPLC pumps or Chemyx Fusion 6000 High Force syringe pumps equipped with stainless steel syringes (20 mL) with Dupont Kalrez Spectrum AS-568 O-rings (0.549 x 0.103") were used to handle the liquid feeds.

1.1.2 Connectors, ferrules and mixers

Sections of the reactor that were not subjected to high temperatures were equipped with coned polyetheretherketone (PEEK) nuts, arrow-head micromixers, super Flangeless PEEK nuts, ETFE ferrules and SS rings. Sections of the reactor that were subjected to high temperatures were equipped with Valco or Swagelock 316 SS fittings, ferrules and unions. Connectors, ferrules and unions were purchased from IDEX/Upchurch Scientific.

1.1.3 Check-valves

A check-valve purchased from IDEX/Upchurch Scientific and embedded in a PEEK check-valve holder was inserted between the pumps and the reactor.

1.1.4 Back-pressure regulator

Back-pressure regulators were purchased from IDEX/Upchurch Scientific. A 500 psi spring-loaded backpressure regulator embedded in a SS check-valve holder was put after the reactor before the cooling loop.

1.1.5 Reactor setups

SS coil reactors were constructed with 316 SS tubing ([1/16", 1.59 mm outer diameter, 760 µm internal diameter] or [1/8", 3.17 mm outer diameter, 2.10 mm internal diameter]) of defined internal volumes. Other coil reactors and collection lines were constructed from perfluoroalkoxy (PFA) or polyetheretherketone (PEEK) tubing (1/16", 1.58 mm outer diameter, 750 µm internal diameter).

1.1.6 Thermoregulatory devices

1/16" SS coils were thermoregulated in the ThalesNano Phoenix Flow Reactor™. 1/8" SS coils were thermoregulated in a modified GC oven.

1.2 Pilot-scale mesofluidic setup

All microfluidic setups were assembled with commercially available parts (details in Table S1).

1.2.1 Pumps

A Knauer AZURA P 4.1S HPLC pump was used to handle the **DMAD** feed while the feed containing **4a** and NEt_3 was handled by a Teledyne ISCO 500D dual-pump.

1.2.2 Connectors, ferrules and mixers

Sections of the reactor that were not subjected to high temperatures were equipped with coned polyetheretherketone (PEEK) nuts, arrow-head micromixers, super Flangeless PEEK nuts, ETFE ferrules and SS rings. Sections of the reactor that were subjected to high temperatures were equipped with Valco or Swagelock 316 SS fittings, ferrules and unions. Connectors, ferrules and unions were purchased from IDEX/Upchurch.

1.2.3 Back-pressure regulator

Downstream pressure was regulated with a Swagelok adjustable back pressure regulator (up to 35 bar).

1.2.4 Reactor setups

Pilot scale flow experiments were performed using a Miprowa® Matrix System from Ehrfeld Mikrotechnik, (V = 134 mL, Alloy 625). Collection lines were constructed from PFA (1/8”, 3.17 mm outer diameter, 2.40 mm internal diameter) or 316 SS (1/8”, 3.17 mm outer diameter, 2.10 mm internal diameter) tubing.

1.2.5 Mass-flow meter

The flow rate was measured with a mini CORI-FLOW Mass Flow Meter (MFM) M13 (Measuring range: 0.3...33 g/min) from Bronkhorst®.

1.2.6 Thermoregulatory devices

Thermoregulation was done with a LAUDA Integral XT 280 thermostat (THERM 180 thermofluid) and a Huber Ministat thermostat (water/ethylene glycol) for heating and cooling respectively and monitored at four positions within the reactor by the LabVision® software made by HiTec Zang.

1.3 Part numbers & vendors

Standard fluidic elements and connectors were purchased from IDEX/Upchurch Scientific, from Valco Instruments Co. Inc or from Swagelock (Table S1).

Table S1. Connectors, ferrules and unions

Item	Details	Vendor	Reference
Connectors	One-Piece Fingertight 10-32 Coned, for 1/16" OD Natural	IDEX/ Upchurch Scientific	F-120
	Super Flangeless™ Nut PEEK 1/4-28 Flat-Bottom, for 1/16" & 1/32" OD Natural	IDEX/ Upchurch Scientific	P-255
	Super Flangeless™ Ferrule w/SST Ring, Tefzel™ (ETFE), 1/4-28 Flat-Bottom, for 1/16" OD Yellow	IDEX/ Upchurch Scientific	P-259
	1/16 in. Standard Nuts	VICI (Valco Ins. Co. Inc.)	ZN1-10
	1/16 in. Stainless Steel Ferrule	VICI (Valco Ins. Co. Inc.)	ZF1-10
	316 Stainless Steel Nut for 1/8 in. Swagelok Tube Fitting	Swagelock	SS-202-1
	316 Stainless Steel Front Ferrule for 1/8 in. Swagelok Tube Fitting	Swagelock	SS-203-1
	316 Stainless Steel Back Ferrule for 1/8 in. Swagelok Tube Fitting	Swagelock	SS-204-1
Mixer	PEEK Low Pressure Tee Assembly 1/16" PEEK 0.020 thru hole	IDEX/ Upchurch Scientific	P-712
	High Pressure Static Mixing Tee - Stainless Steel Frit	IDEX/ Upchurch Scientific	U-466S

Check-valve	Check-valve inline cartridge 1.5 psi	IDEX/ Upchurch Scientific	CV-3001
Spring-loaded BPR	BPR Cartridge 500 psi Gold Coating	IDEX/ Upchurch Scientific	P-765
	Stainless Steel BP Regulator, 0 to 500 psig (34.4 bar), A Configuration, FKM Seat, 1/4 in. FNPT, 0.20 Cv	Swagelock	KBP1J0A4A5 A20000
Cartridge holder	Stainless Steel BPR Cartridge Holder	IDEX/ Upchurch Scientific	U-469
Tubing	316 SS tubing (1.58 mm outer diameter, 750 µm internal diameter)	VICI (Valco Ins. Co. Inc.)	VC-TSS120
	PEEK tubing (green striped, 1.58 mm outer diameter, 750 µm internal diameter).	VICI (Valco Ins. Co. Inc.)	JR-T-6003-M3
	High-purity PFA tubing (1.58 mm outer diameter, 750 µm internal diameter)	VICI (Valco Ins. Co. Inc.)	JR-T-4002-M25
	PFA Tubing, (3.17 mm outer diameter, 2.40 mm internal diameter)	Swagelock	PFA-T2-030-100
	316 SS tubing (3.17 mm outer diameter, 2.10 mm internal diameter)	Swagelock	SS-T8-S-035-20

1.4 Detailed continuous flow setup

1.4.1 Lab-scale mesofluidic setup

Lab-scale trials have been performed using a Phoenix Flow Reactor™ from ThalesNano (V = 5 mL, 316 SS tubing, ID = 760 µm, pressure <200 bar and T <450 °C). The flow setup is presented in Figure S1.

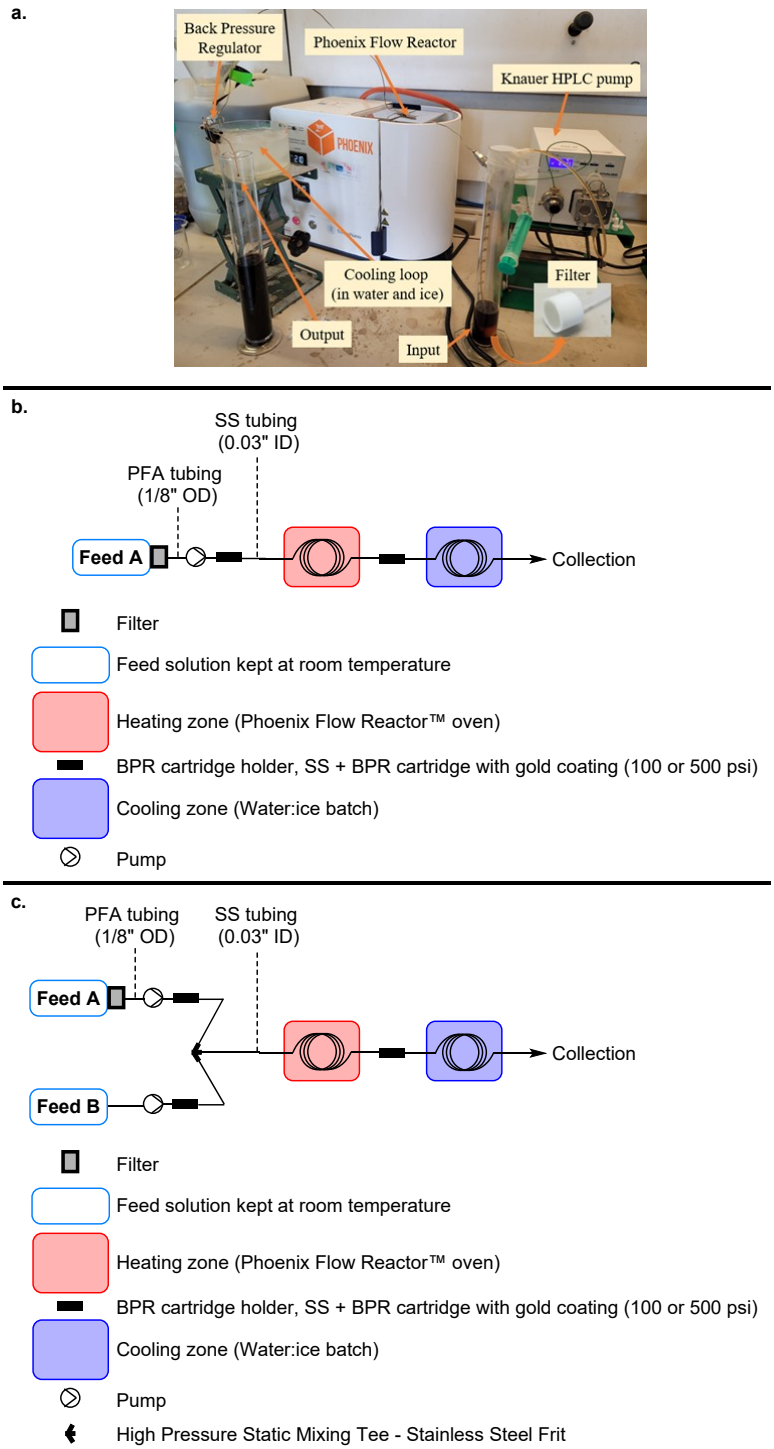


Figure S1. Detailed setup for the thermolysis experiments using a lab-scale flow commercial reactor. **a.** Picture of the system using one pump. **b.** Detail schemes of the system using one pump. **b.** Detail schemes of the system using two pumps.

1.4.2 Pilot-scale mesofluidic setup

Pilot-scale trials have been performed using a Miprowa® Matrix Reactor from Ehrfeld Mikrotechnik (V = 134 mL, Alloy 625, pressure <58 bar and T <250 °C). The flow setup is presented in Figure S2.

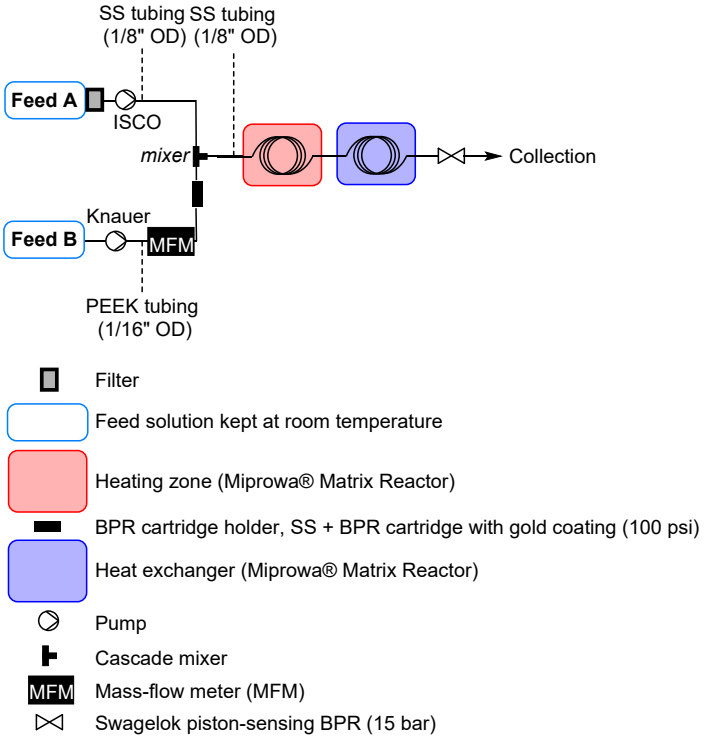


Figure S2. Detailed setup for the thermolysis experiments using a pilot-scale flow commercial reactor

2. Additional experimental details

2.1 Chemicals

Chemicals, purities, CAS numbers and suppliers are provided in Table S2.

Table S2. Solvents, chemicals and suppliers

Solvents	Purity (%)	CAS number	Supplier
Methanol	≥99.8	67-56-1	Fisher
2-Methyltetrahydrofuran	≥99	96-47-9	Merck
Dichloromethane	≥99.8	75-09-2	Fisher
Dimethylsulfoxide	≥99	67-68-5	VWR
o-Xylene	99	95-47-6	Acros
Toluene	≥99.8	108-88-3	Fisher
Chlorobenzene	>99	108-90-7	Acros
Anisole	99	100-66-3	Sigma Aldrich
Ethyl acetate	≥99.8	141-78-6	Fisher
Trichloroethene	98	79-01-6	Alfa Aesar
Chloroform	≥99.8	67-66-33	Fisher
Chemicals	**Purity (%)**	**CAS number**	**Supplier**
Sodium benzenesulfinate	98	873-55-2	Sigma Aldrich
Sulfuric acid	98	7664-93-9	Sigma Aldrich
Estrone	≥99	53-16-7	Sigma Aldrich
Potassium *tert*-butoxide	>97	865-47-4	TCI
Potassium bisulfate	>98	7646-93-7	Sigma Aldrich
Imidazole	>98	288-32-4	TCI
tert-Butyldimethylsilyl chloride	>98	18162-48-6	TCI
Dimethyl acetylenedicarboxylate	>96	762-42-5	TCI
Triethylamine	≥99	121-44-8	Sigma Aldrich
Cerium (III) chloride heptahydrate	99	18618-55-8	Alfa Aesar
Sodium borohydride	99	16940-66-2	Sigma Aldrich
Trimethyl phosphite	97	121-45-9	Alfa Aesar
Mercaptobenzothiazole	>98	149-30-4	TCI
Diethyl acetylenedicarboxylate	95	762-21-0	Sigma Aldrich
Diethyl fumarate	98	623-91-6	Sigma Aldrich
Diisopropyl azodicarboxylate	98	2446-83-5	Sigma Aldrich
Phenylacetylene	>98	536-74-3	TCI
Methyl propiolate	>98	922-67-8	TCI
p-Benzoquinone	>98	106-51-4	Sigma Aldrich
2-Cyclohexen-1-one	>96	930-68-7	TCI
Crotonaldehyde	>99	4170-30-3	Sigma Aldrich
2,6-Lutidine	≥99	108-48-5	Sigma Aldrich
Pyridine	>99	110-86-1	Fisher
4-Dimethylaminopyridine	≥99	1122-58-3	Sigma Aldrich
N,*N*-Diisopropylethylamine	≥99	7087-68-5	Sigma Aldrich
Triethylenediamine	≥99	280-57-9	Sigma Aldrich
1,2-Dimethoxybenzene	98	398-62-9	Fisher
(2,2,6,6-Tetramethylpiperidin-1-yl)oxyl	>99	2564-83-2	TCI
p-Toluenesulfonic acid	≥98	6192-52-5	Sigma Aldrich
1,8-Diazabicyclo[5.4.0]undec-7-ene	>98	6674-22-2	Fisher

2.2 Analytical method

HPLC analyses were performed on a Shimadzu LC-2050C spectrometer for determining yields and conversions. Coupling of this spectrometer with the Shimadzu LCMS-2020 Single Quadrupole MS was ensured for running LC-MS analyses.

- Eluent: A: Water; B: Acetonitrile
- Gradient of the eluents:

Time [min]	**A [%]**	**B [%]**
0.00	50	50
3.00	50	50
15.00	0	100
25.00	0	100
27.00	50	50
35.00	50	50

- Flow rate: 2 mL/min^{-1}
- Column: C18, 100 x 4.6 mm, 3 µm
- Oven Temperature: 40 °C
- Diode Array Detector: 180-800 nm
- Wavelength for analysis: 190 nm

2.3 Experimental procedures

2.3.1 Synthesis of 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-triene-17-one (**1a-red**)[S1]

To a solution of 3-hydroxy-estra-1,3,5(10)-triene-17-one (100 g, 0.370 mole) in dichloromethane (500 mL) were added *tert*-butyldimethylsilyl-chloride (58.3 g, 0.388 mole) and imidazole (26.4 g, 0.388 mole). The mixture was stirred for 24 hours at room temperature. Water (300 mL) was added and the organic layer was washed with 200 mL of water. After concentration the product was crystallized from a mixture of ethanol/diisopropyl ether, collected by filtration and dried. The product is isolated as a white solid (145 g, 95%).

2.3.2 Synthesis of 3-*tert*-butyldimethylsilyloxy-16-(phenylsulfinyl)-estra-1,3,5(10)-triene-17-one (**4a**)[S1]

3-*tert*-Butyldimethylsilyloxy-estra-1,3,5(10)-triene-17-one (250 mg, 0.650 mmol) was added to a suspension of sodium hydride (78.0 mg, 1.950 mmol, 60% in parafilm) in THF (7.1 mL) at room temperature under N_2 atmosphere. Methyl benzenesulfinate (152.3 mg, 0.975 mmol) was then added to the reaction mixture and the white mixture was stirred at room temperature for 60 min. The conversion of the starting material was controlled *via* TLC analysis [PE/EtOAc (8:2)]. The reaction was quenched with addition of a 5% aqueous solution of $NaHCO_3$ (15 mL) and extracted with toluene (2x15 mL). The organic layers were evaporated under reduced pressure and the crude product was purified by chromatography over silica gel (petroleum ether/EtOAc [8/2]) to afford the product as a white solid (139.5 mg, 42% yield).

1.1.1 Batch synthesis of 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-15-tetraene-17-one (**1a**)

To a solution of 3-*tert*-butyldimethylsilyloxy-16-(phenylsulfinyl)-estra-1,3,5(10)-triene-17-one (**4a**, 915.8 mg, 1.0 eq) in *o*-xylene (4.6 mL, 0.36 M) was added $CuSO_4$ (224.7 mg, 0.5 eq) and $NaHCO_3$ (680.4mg, 4.5 eq). The reaction mixture was stirred at 135 °C for 22 h and quenched with the addition of water (10mL). Toluene (10 mL) was added, and the organic layer was washed with a 5% NH_3 aqueous solution. After drying with $MgSO_4$, 1 mL of Et_3N was added and the volatiles were removed under reduced pressure. The crude product was purified by chromatography (PE:EtOAc [100:0 to 80:20]) to afford an off-white solid (376.9 mg, 97% HPLC purity, 55% yield).

1.1.2 Continuous flow synthesis of 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-15-tetraene-17-one (**1a**)

A feed containing 3-*tert*-butyldimethylsilyloxy-16-(phenylsulfinyl)-estra-1,3,5(10)-triene-17-one (**4a**, 0.23 M) and Et_3N (0.023 M) in toluene is pumped with a flow rate of 2.440 mL/min while another feed with 4 M **DMAD** in toluene is pumped with a flow rate of 0.220 mL/min. The streams are mixed in an arrow mixer to give initial concentrations of **4a** and **DMAD** of 0.22 M and 0.33 M respectively before reacting for 6 min in a ThalesNano Phoenix Flow Reactor™ (V = 16 mL) heated at 210 °C under 34 bar of counterpressure. The stream is then cooled to 0 °C in a PFA coil. The crude is washed with a 1 M aqueous solution of NaOH, the organic layer is separated and dried over $MgSO_4$. The solvent is removed under reduced pressure to give a brown crude mixture containing ~90% area by HPLC of 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-15-tetraene-17-one that can be optionally recrystallized to afford the product as an off-white solid (69% isolated yield, ~94% purity).

1.1.3 Synthesis of 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-15-tetraene-17-ol (**9a**)

The volatiles from the thermolysis step to afford **1a** were removed under reduced pressure and the residue was dissolved in THF (1 M) and a solution of cerium chloride heptahydrate (1.5 equiv.) in methanol (1 M) was added. The mixture was cooled to 0°C and sodium borohybride (2.1 equiv.) was added portion wise keeping the temperature below 9°C. At the end of the addition, the mixture was stirred for one hour and then quenched by the addition of a 2N HCl solution, extracted with ethyl acetate and washed with water. The organic layer was partly evaporated then diisopropylether was added. The precipitate was collected by filtration and dried. After crystallization from a mixture of ethanol/diisopropyl ether, **9a** was isolated as a beige solid (70% over two steps, 93% purity).

1.1.4 Synthesis of 3-*tert*-butyldimethylsilyloxy-16-phenylthio-estra-1,3,5(10)-15-tetraene-17-one (**1a-S**)[S2]

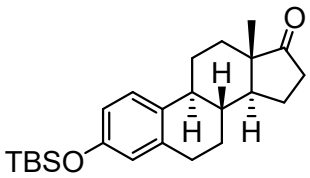
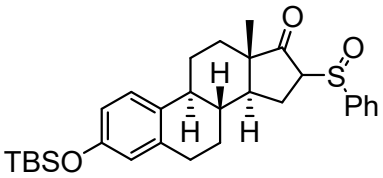
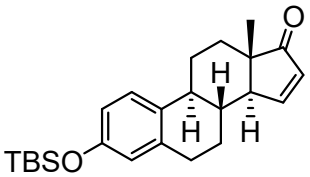
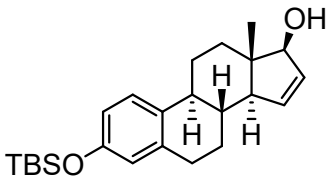
Acetic anhydride (1.39 mL, 2.0 eq) and methanesulfonic acid (177 µL, 0.25 eq) were added to a solution of 3-*tert*-butyldimethylsilyloxy-16-(phenylsulfinyl)-estra-1,3,5(10)-triene-17-one (**4a**, 4.00 g, 1.0 eq) in dry CH_2Cl_2 (22 mL) under nitrogen at room temperature. The solution

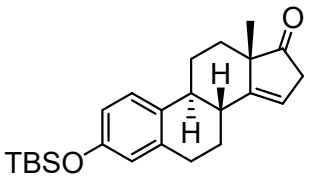
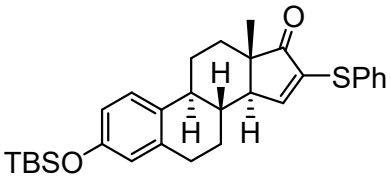
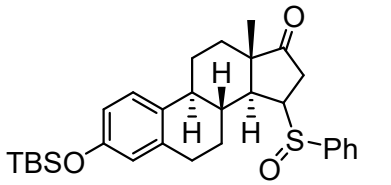
was stirred at 40°C overnight and quenched by the addition of a saturated solution of $NaHCO_3$ (50 mL). The organic layer was dried over $MgSO_4$ and the volatiles were removed under reduced pressure to afford the crude product that was finally purified by chromatography on silica gel using a gradient of petroleum ether:EtOAc ([100:0 to 60:40]). The product **1a-S** was obtained as a light orange solid (1.76 g, 49% yield, 87%$_{area}$ HPLC purity).

1.1.5 Continuous flow synthesis of 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-15-tetraene-17-one (**1a**) with a commercial pilot reactor

A feed containing 3-*tert*-butyldimethylsilyloxy-16-(phenylsulfinyl)-estra-1,3,5(10)-triene-17-one (**4a**, 0.23 M) and Et_3N (0.023 M) in toluene is pumped with a flow rate of 41.12 mL/min while another feed with 4 M DMAD in toluene is pumped with a flow rate of 3.61 mL/min . The streams are mixed in an arrow mixer to give initial concentrations of **4a** and DMAD of 0.22 M and 0.33 M respectively and react in an Ehrfeld Miprowa® Reactor (V = 134 mL) operated at 210 °C under 15 bar of counterpressure with a residence time of 3 min. The stream is then cooled to 0 °C in a PFA coil. The crude is washed with a 1M aqueous solution of NaOH, the organic layer is separated and dried over $MgSO_4$. The solvent is removed under reduced pressure to give a brown crude mixture containing ~90% area by HPLC of 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-15-tetraene-17-one that can be optionally recrystallized to give an isolated yield of ~67%.

1.2 Characterization of compounds

 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-triene-17-one (**1a-red**) $C_{24}H_{36}O_2Si$ MW = 384,63	**^{1}H-NMR (400 MHz, $CDCl_3$):** δ 0.20 (s, 6H, $(CH_3)_2$-Si-), 0.90 (s, 3H, CH_3 at C-18), 1.00 (s, 9H, $(CH_3)_3$-C-Si-), 1.20-2.60 (m, 13H), 2.75-2.95 (m, 2H), 5.65-5.75 (m, 1H), 6.58 (broad s, 1H, H4), 6.63 (dd, 1H, H2), 7.12 (d, 1H, H1). **^{13}C NMR (101 MHz, $CDCl_3$):** δ -4.2 (s, $(CH_3)_2$-Si-), 14.0 (s, C16), 21.7 (s, C-Si-), 25.8 (s, $(CH_3)_3$-Si-), 26.0 (s), 26.7 (s), 29.6 (s), 31.8 (s), 33.0 (s), 38.5 (s), 44.2 (s), 50.6 (s), 56.3 (s), 117.5 (s), 120.1 (s), 126.3 (s), 132.0 (s), 132.6 (s), 137.8 (s), 153.6 (s), 158.4 (s).
 3-*tert*-butyldimethylsilyloxy-16-(phenyl sulfinyl)-estra-1,3,5(10)-triene-17-one (**4a**) $C_{30}H_{40}O_3SSi$ MM = 508.79	**^{1}H-NMR (400 MHz, $CDCl_3$):** δ 0.17 (s, 6H, $(CH_3)_2$-Si-), 0.91 (s, 3H, H16), 0.97 (s, 9H, $(CH_3)_3$C-Si-), 1.08-2.92 (m, 12(20)H), 3.25-3.73 (m, 1H), 6.53-6.58 (m, 1H, H5), 6.62 (d, 1H, H3), 7.04-7.14 (m, 1H, H4), 7.47-7.58 (m, 3H, PhS(O)-), 7.59-7.68 (m, 2H, PhS(O)-). **^{13}C NMR (101 MHz, $CDCl_3$):** δ -4.3 (s, $(CH_3)_2$-Si-), 11.4 (s, C16), 14.7 (s), 17.9 (s, C-Si-), 20.7 (s), 24.0 (s), 25.8 (s, $(CH_3)_3$-Si-), 29.4 (s), 38.5 (s), 43.6 (s), 49.2 (s) 69.4 (s, -C-S-), 72.1 (s, -C-S-), 117.5-131.1 (all s, C3-C4-C5), 132.4 (s), 137.6 (s), 143.1 (s), 153.7 (s), 212.3 (s, C13).
 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-15-tetraene-17-one (**1a**) $C_{24}H_{34}O_2Si$ MW = 382.62	**^{1}H-NMR (400 MHz, $CDCl_3$):** δ 0.20 (s, 6H, $(CH_3)_2$-Si-), 1.00 (s, 9H, $(CH_3)_3$-C-Si-), 1.13 (s, 3H, CH_3 at C-18), 1.20-2.70 (m, 11 H), 2.80-3.00 (m, 2H), 6.10 (dd, 1 H, H15), 6.58 (broad s, 1 H, H4), 6.62 (dd, 1H, H2), 7.11 (d, 1H, H1), 7.63 (dd, 1H, H16). **^{13}C-NMR (101 MHz, $CDCl_3$):** δ -4.2 (s, $(CH_3)_2$-Si-), 18.3 (s, C-Si-), 21.1 (s), 25.5 (s), 25.8 (s, $(CH_3)_3$-Si-), 26.8 (s), 29.4 (s), 35.7 (s), 45.3 (s), 51.6 (s), 56.3 (s), 117.5 (s), 120.2 (s), 126.0 (s), 132.0 (s), 132.4 (s), 137.5 (s), 153.8 (s), 158.4 (s), 213.2 (s, C13).
 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-15-tetraene-17-ol (**9a**) $C_{24}H_{36}O_2Si$ MW = 384.63	**^{1}H-NMR (400 MHz, $CDCl_3$):** δ 0.20 (s, 6H, (CH_3)2-Si-), 0.89 (s, 3H, CH_3 at C-18), 1.00 (s, 9H, (CH_3)3-C-Si-), 1.20-2.40 (m, 10H), 2.75-2.95 (m, 2H), 4.40 (broad s, 1 H, H17), 5.65-5.75 (m, 1 H), 5.95-6.10 (m, 1H), 6.57 (broad s, 1H, H4), 6.60 (dd, 1H, H2), 7.13 (d, 1H, H1). **^{13}C NMR (101 MHz, $CDCl_3$):** δ -4.2 (s, $(CH_3)_2$-Si-), 12.4 (s), 18.3 (s, C-Si-), 25.8 (s, $(CH_3)_3$-Si-), 26.2 (s), 27.8 (s), 29.6 (s),

	34.8 (s), 36.45 (s), 44.6 (s), 51.5 (s), 56.9 (s), 85.8 (s, C13), 117.3 (s), 120.1 (s), 126.0 (s), 132.0 (s), 133.1 (s, C20), 134.7 (s), 137.8 (s, C6), 153.5 (s, C1).
 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-14-tetraene-17-one (**1a-iso**) $C_{24}H_{34}O_2Si$ MW = 382,62	**^{1}H-NMR (400 MHz, $CDCl_3$):** δ 0.20 (s, 6H, $(CH_3)_2$-Si-), 0.90 (s, 3H, CH_3 at C-15), 1.00 (s, 9H, $(CH_3)_3$-C-Si), 1.20-2.60 (m, 13H), 2.75-2.95 (m, 2H), 5.65-5.75 (m, 1H), 6.58 (broad s, 1H, H5), 6.63 (dd, 1H, H3), 7.12 (d, 1H, H4). **^{13}C NMR (101 MHz, $CDCl_3$):** δ -4.2 (s, $(CH_3)_2$-Si-), 14.0 (s, C16), 21.7 (s, C-Si-), 25.8 (s, $(CH_3)_3$-Si-), 26.0 (s), 26.7 (s), 29.6 (s), 31.8 (s), 33.0 (s), 38.5 (s), 44.2 (s), 50.6 (s), 56.3 (s), 117.5 (s), 120.2 (s), 126.3 (s), 132.0 (s), 132.6 (s), 137.8 (s), 153.6 (s), 158.4 (s).
 3-*tert*-butyldimethylsilyloxy-16-phenylthio-estra-1,3,5(10)-15-tetraene-17-one (**1a-S**) $C_{30}H_{38}O_2SSi$ MW = 490,78	**^{1}H-NMR (700 MHz, $CDCl_3$):** δ 0.19 (s, 6H, $(CH_3)_2$-Si-), 0.98 (s, 9H, $(CH_3)_3$C-Si-), 1.16 (d, 3H), 1.39-2.52 (m, 11H), 2.79-3.11 (m, 3H), 6.52-6.67 (m, 2H), 7.08-7.15 (m, 1H), 7.36 (m, 1H), 7.48 (m, 1H). **^{13}C NMR (176 MHz, $CDCl_3$):** δ -4.2 (s, $(CH_3)_2$-Si-), 18.3 (s, C-Si-), 20.2 (s, C16), 21.0 (s), 25.0 (s), 25.5 (s), 25.8 (s, $(CH_3)_3$-Si-), 26.0 (s), 26.6 (s), 26.8 (s), 29.2 (s), 29.5 (s), 29.7 (s), 33.4 (s), 25.7 (s), 39.0 (s), 41.7 (s), 44.9 (s), 45.1 (s), 51.1 (s), 52.1 (s), 55.1 (s), 113.3 (s), 117.5 (s), 120.2 (s), 126.0 (s), 126.6 (s), 128.3 (s), 129.5 (s), 132.3 (s), 133.0 (s), 137.4 (s), 140.5 (s), 150.5 (s), 153.7 (s), 153.8 (s), 207.7 (s, C13).
 3-*tert*-butyldimethylsilyloxy-15-(phenylsulfinyl)-estra-1,3,5(10)-triene-17-one (**4a-iso**) $C_{24}H_{36}O_2Si$ MW = 384.63	**^{1}H-NMR (400 MHz, DMSO):** δ 0.16 (s, 6H, $(CH_3)_2$-Si-), 0.94 (s, 9H, $(CH_3)_3$C-Si-), 1.12 (s, 3H, CH_3 at C-15), 1.26-1.49 (m, 3H), 1.62-1.87 (m, 2H), 2.03-2.41 (m, 4H), 2.55-3.01 (m, 4H), 4.05 (t, 1H), 6.55 (m, 1H, H5) , 6.61 (dd, 1H, H3), 7.11-7.43 (m, 5H, H27-H28-H29-H30-H31).**^{13}C NMR (101 MHz, DMSO):** δ -4.5 (s, $(CH_3)_2$-Si-), 16.7 (s, C16), 17.9 (s, C-Si-), 25.0 (s), 25.6 (s, $(CH_3)_3$-Si-), 25.9 (s), 28.7 (s), 32.6 (s), 36.1 (s), 42.8 (s), 43.6 (s), 46.2 (s), 47.1 (s), 52.1 (s), 117.1 (s), 119.6 (s), 120.2 (s), 126.1 (s), 126.3 (s), 129.2 (s), 132.5 (s), 136.6 (s), 137.5 (s), 152.9 (s), 217.6 (s, C13).

1.3 LC and NMR traces

1.3.1 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-triene-17-one (**1a-red**)

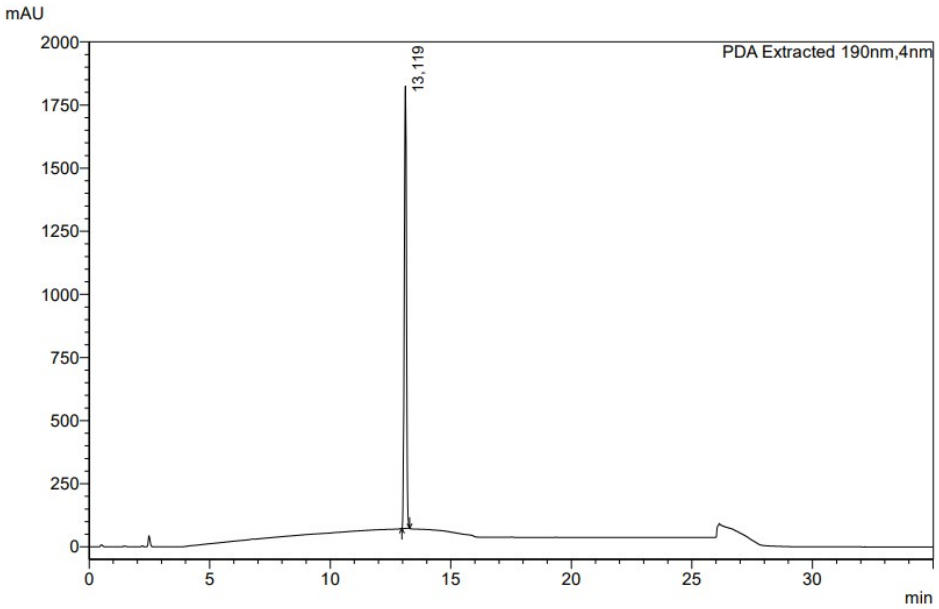


Figure S3. HPLC chromatogram (190 nm) of 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-triene-17-one (**1a-red**)

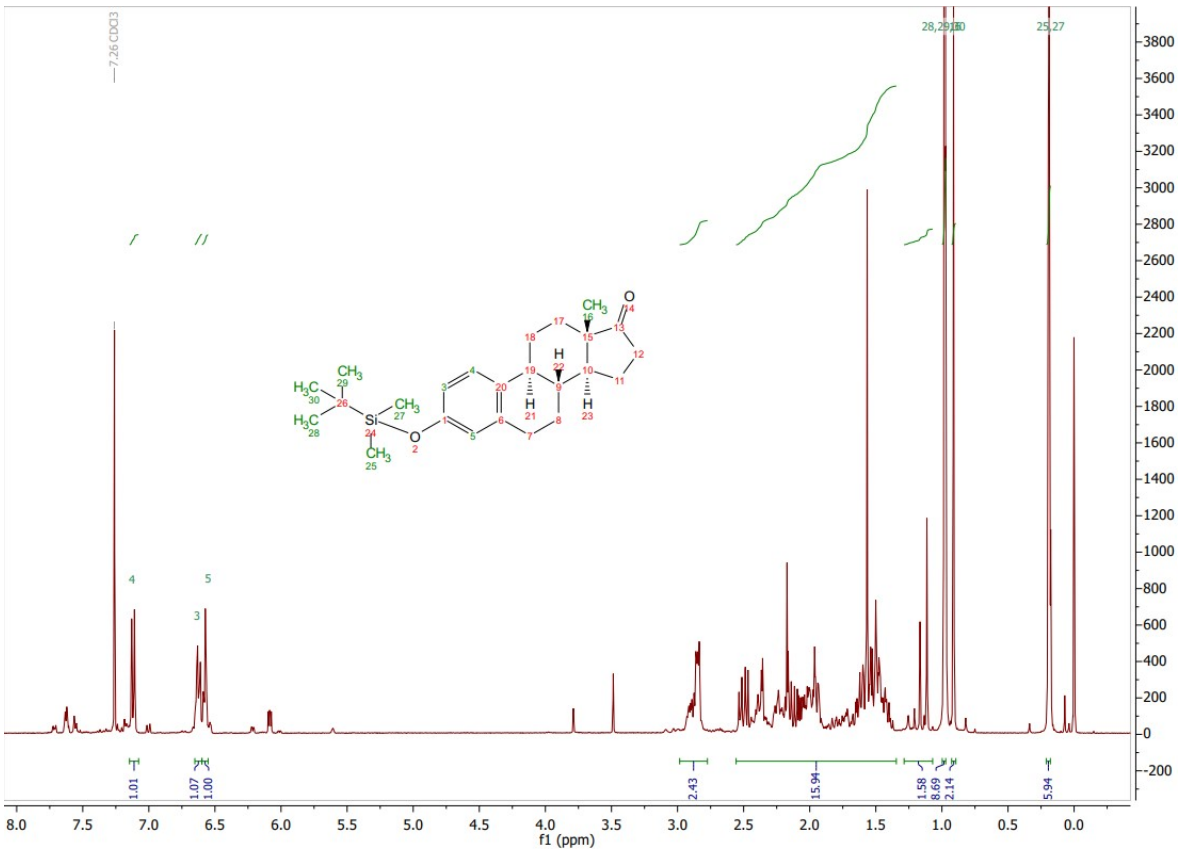


Figure S4. ^{1}H NMR spectrum (400 MHz) of 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-triene-17-one (**1a-red**) in $CDCl_3$

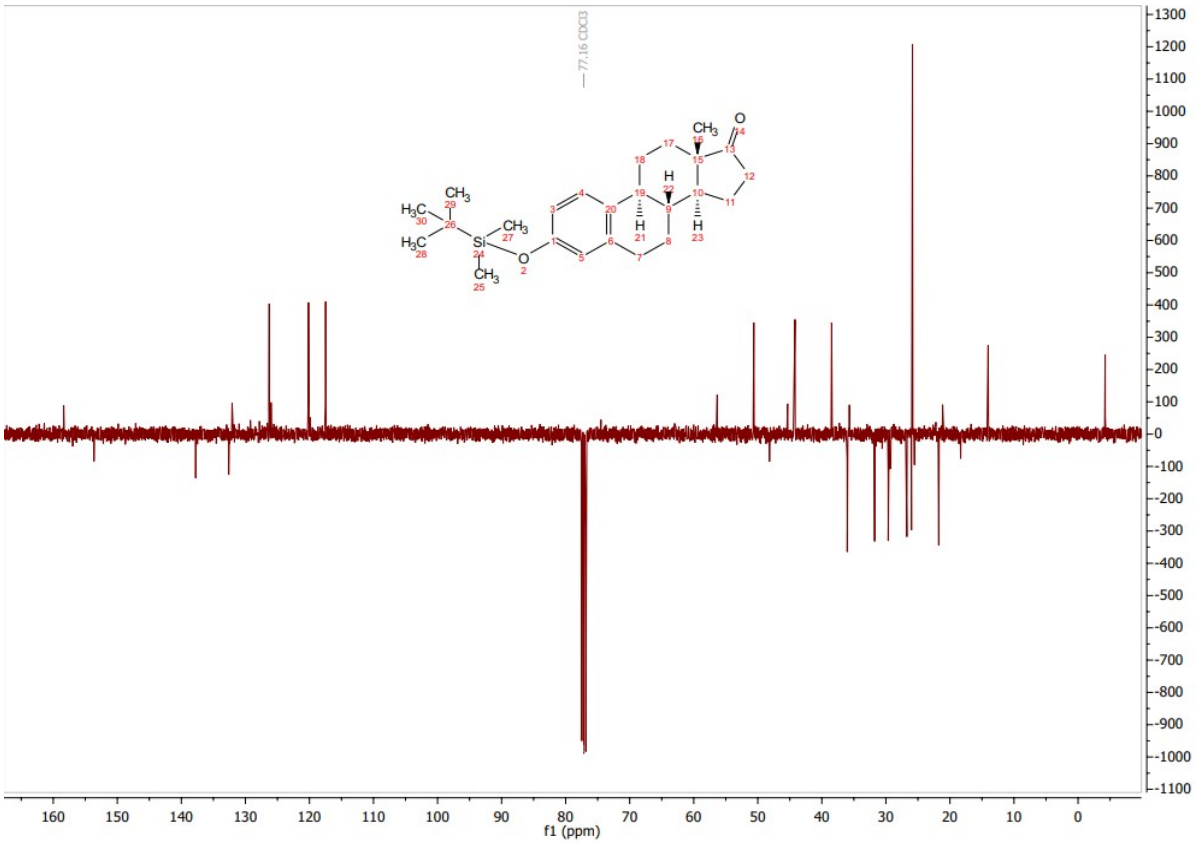


Figure S5. ^{13}C ATP NMR spectrum (101 MHz) of 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-triene-17-one (**1a-red**) in $CDCl_3$

1.3.2 3-*tert*-butyldimethylsilyloxy-16-(phenylsulfinyl)-estra-1,3,5(10)-triene-17-one (**4a**)

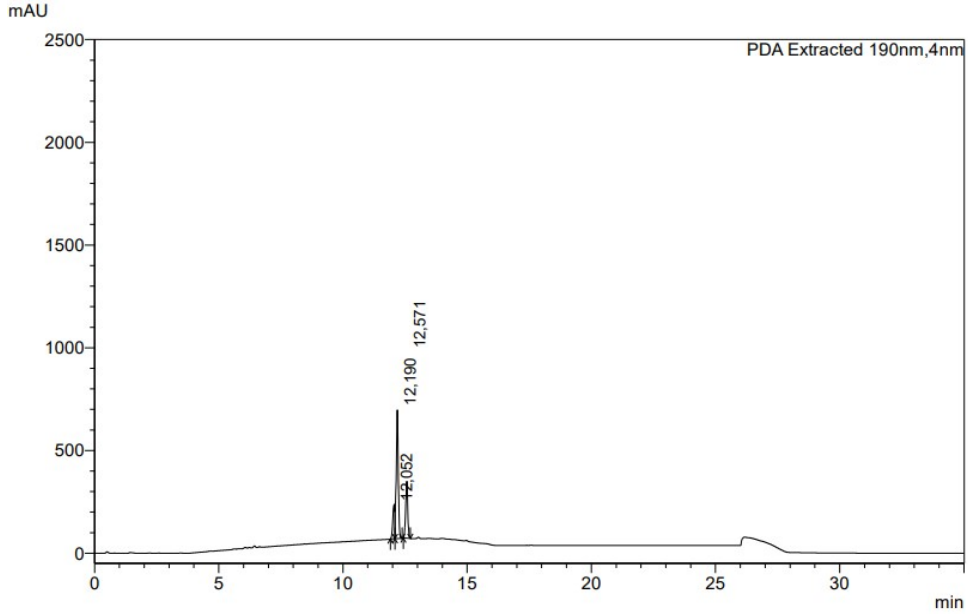


Figure S6. HPLC chromatogram (190 nm) of 3-*tert*-butyldimethylsilyloxy-16-(phenylsulfinyl)-estra-1,3,5(10)-triene-17-one (**4a**)

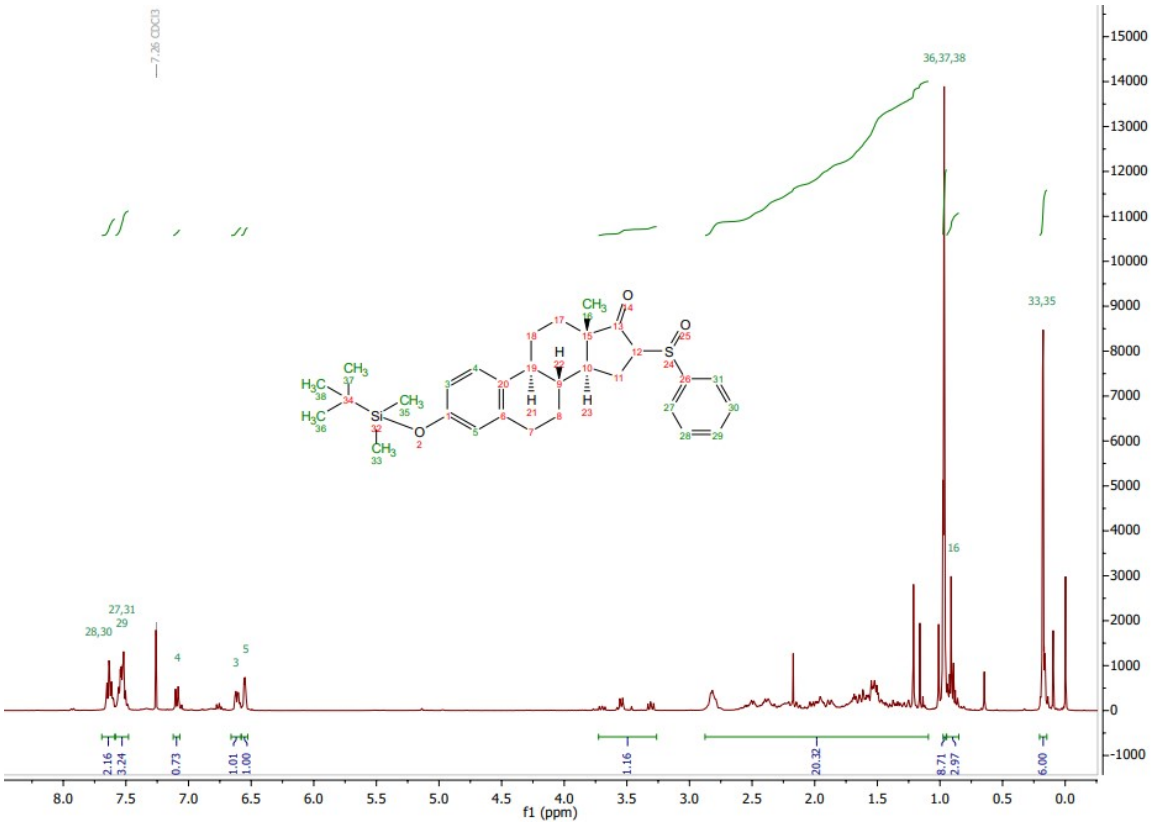


Figure S7. ^{1}H NMR spectrum (400 MHz) of 3-*tert*-butyldimethylsilyloxy-16-(phenylsulfinyl)-estra-1,3,5(10)-triene-17-one (**4a**) in $CDCl_3$

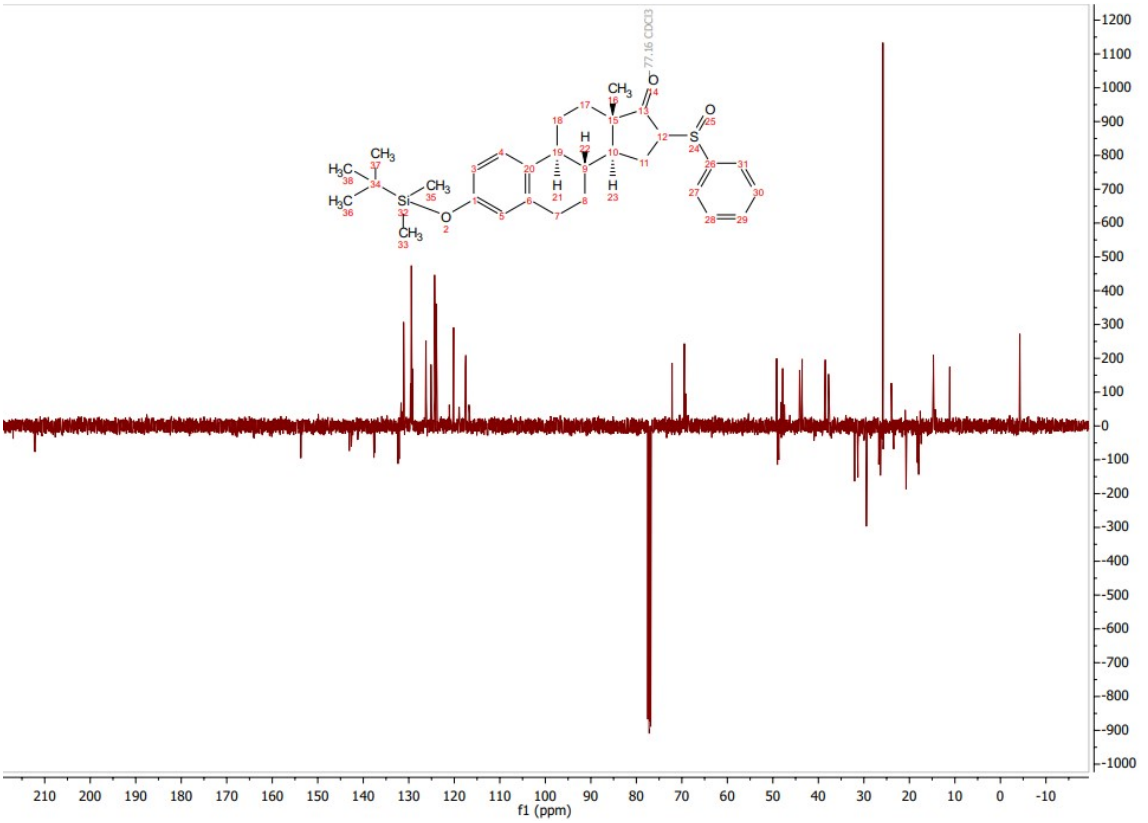


Figure S8. ^{13}C ATP NMR spectrum (101 MHz) of 3-*tert*-butyldimethylsilyloxy-16-(phenylsulfinyl)-estra-1,3,5(10)-triene-17-one (**4a**) in $CDCl_3$

1.3.3 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-15-tetraene-17-one (**1a**)

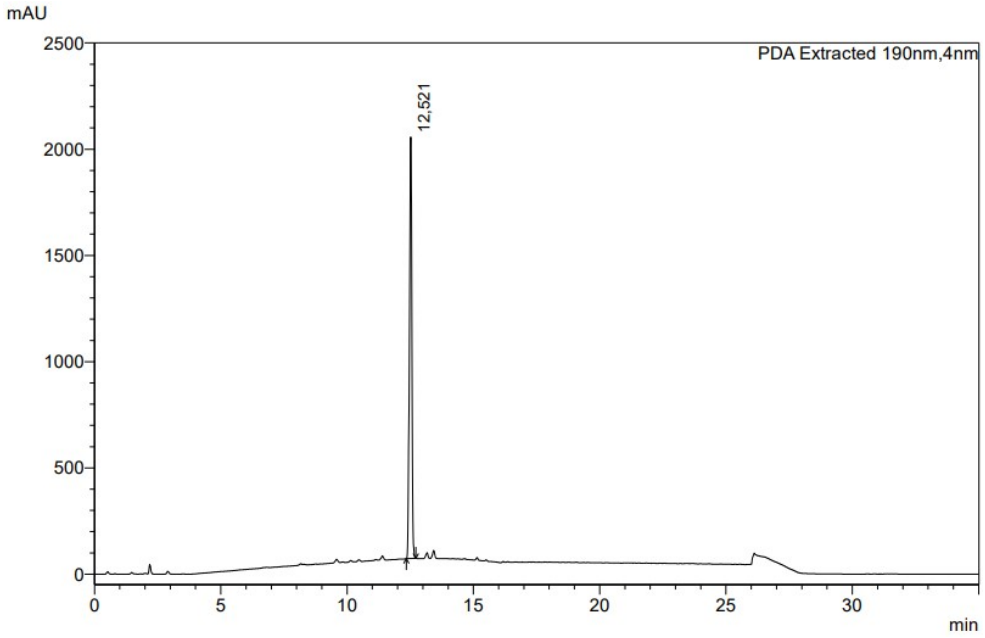


Figure S9. HPLC chromatogram (190 nm) of 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-15-tetraene-17-one (**1a**)

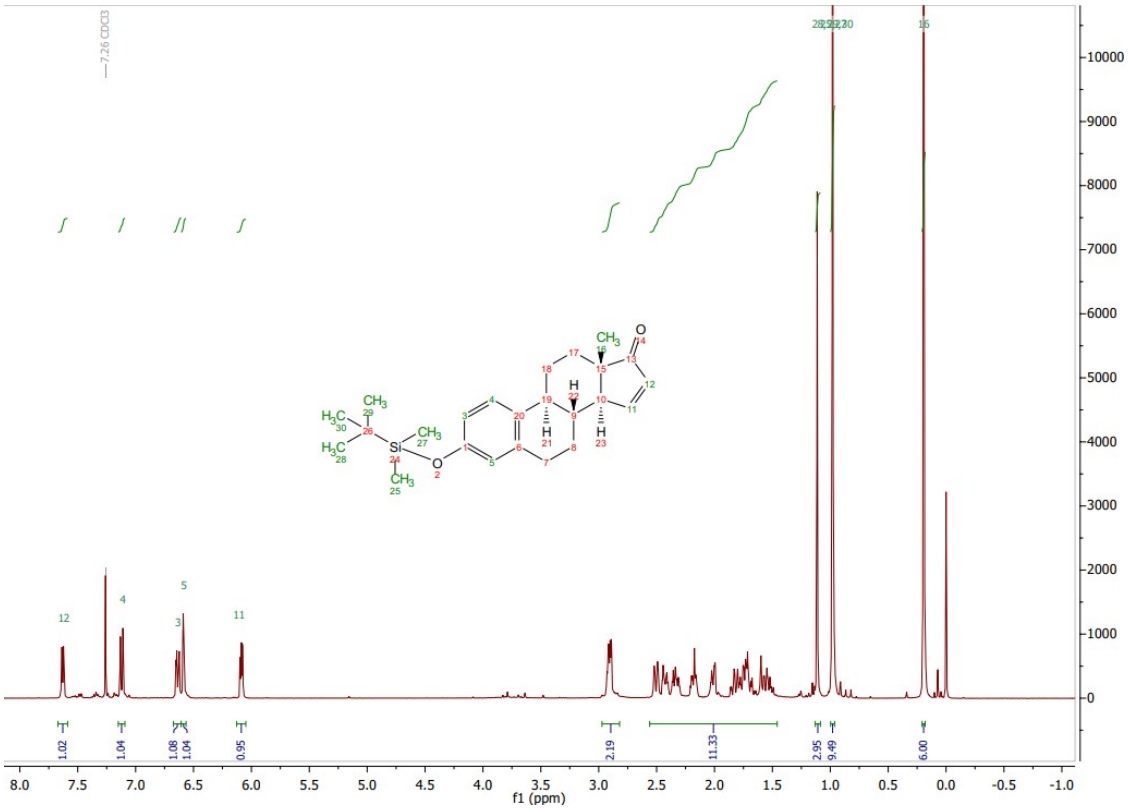


Figure S10. ^{1}H NMR spectrum (400 MHz) of 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-15-tetraene-17-one (**1a**) in $CDCl_3$

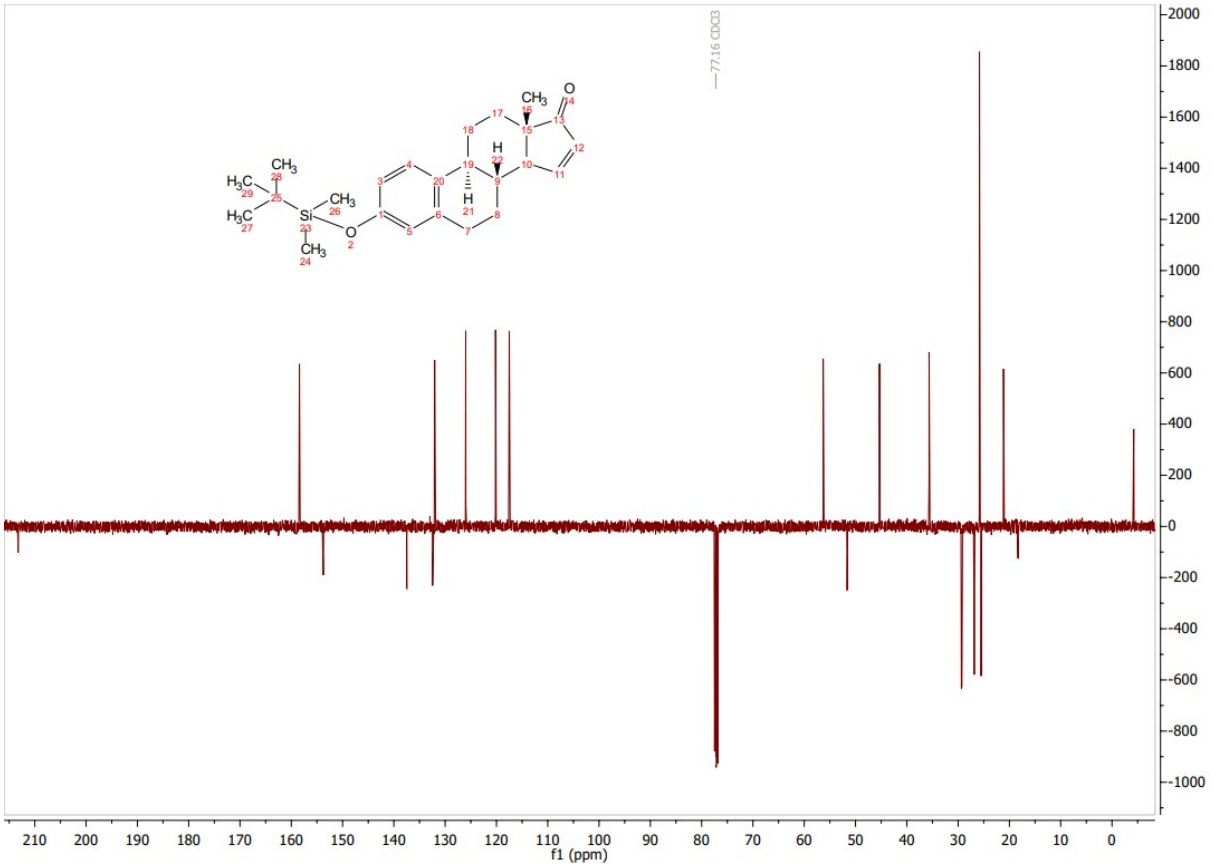


Figure S11. ^{13}C ATP NMR spectrum (101 MHz) of 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-15-tetraene-17-one (**1a**) in $CDCl_3$

1.3.4 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-15-tetraene-17-ol (**9a**)

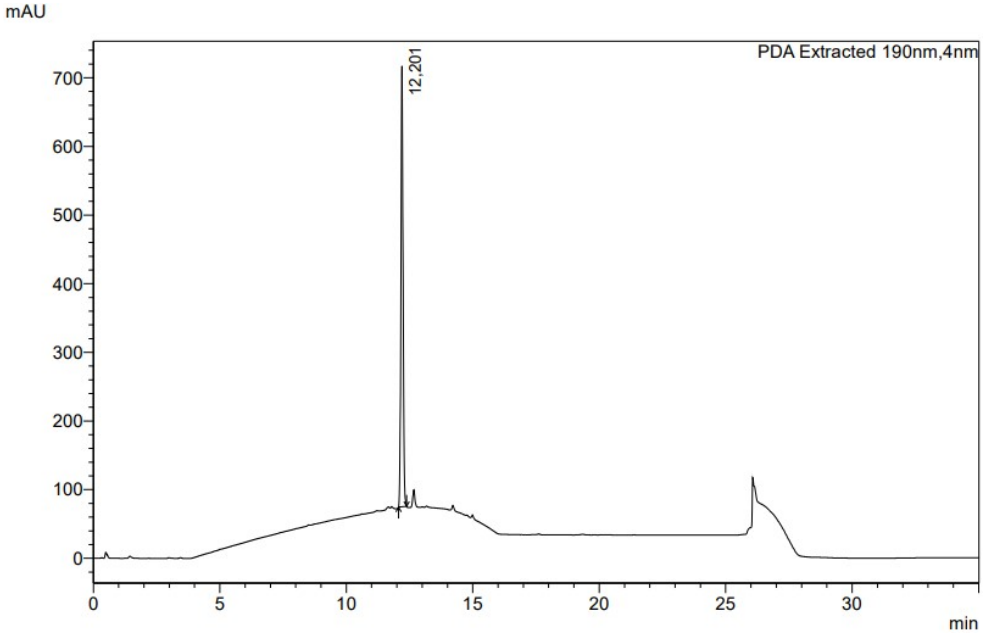


Figure S12. HPLC chromatogram (190 nm) of 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-15-tetraene-17-ol (**9a**)

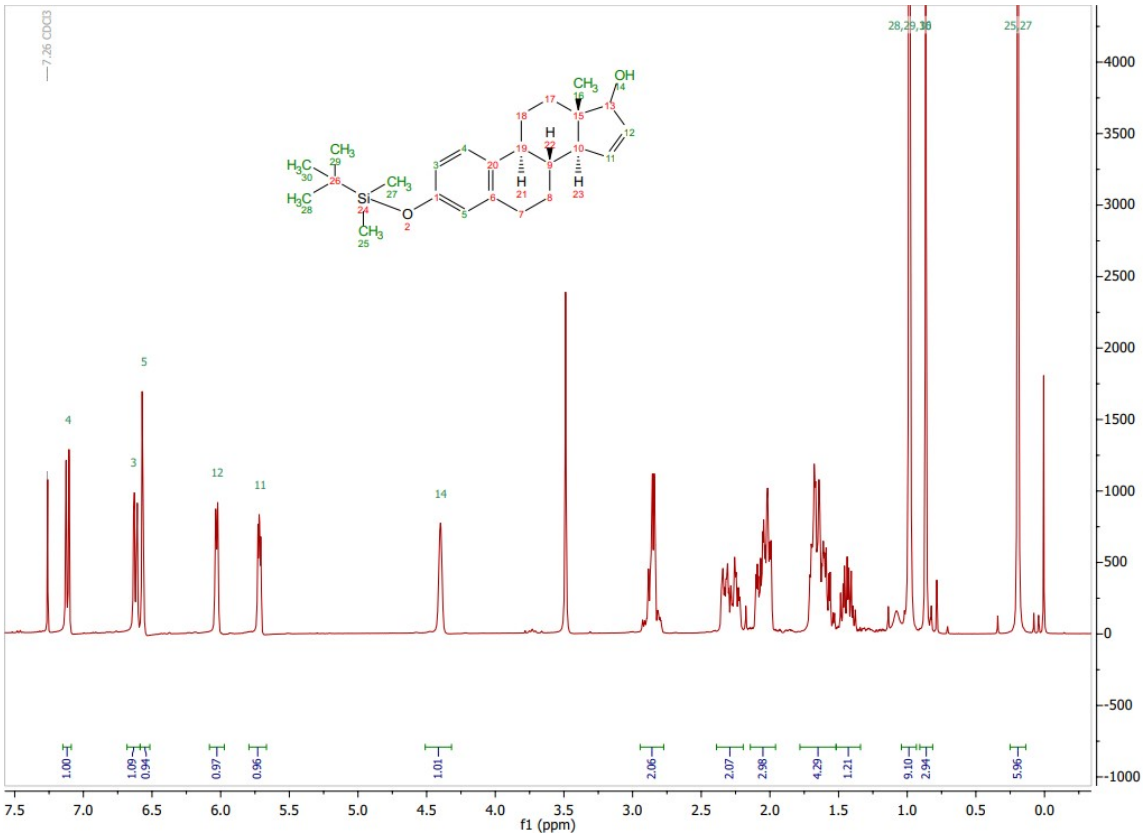


Figure S13. ^{1}H NMR spectrum (400 MHz) of 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-15-tetraene-17-ol (**9a**) in $CDCl_3$

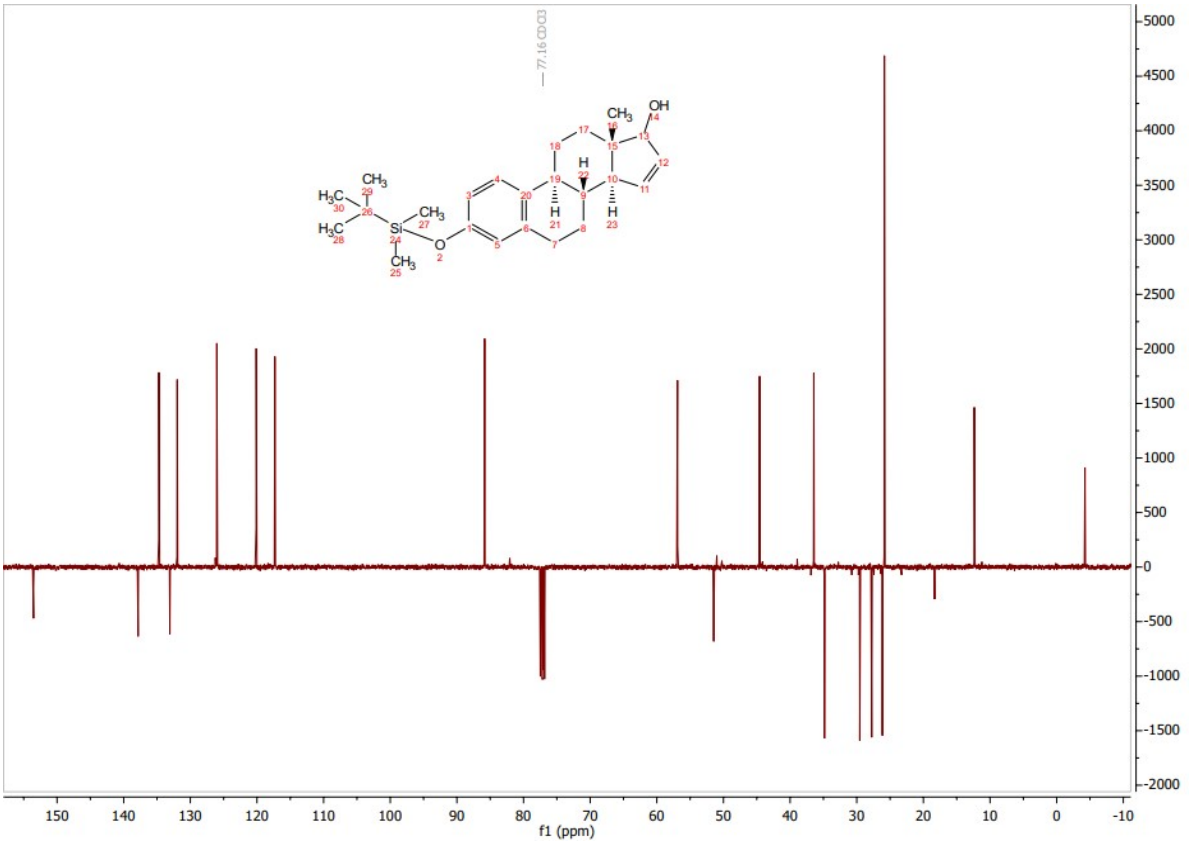


Figure S14. ^{13}C ATP NMR spectrum (101 MHz) of 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-15-tetraene-17-ol (**9a**) in $CDCl_3$

1.3.5 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-14-tetraene-17-one (**1a-iso**)

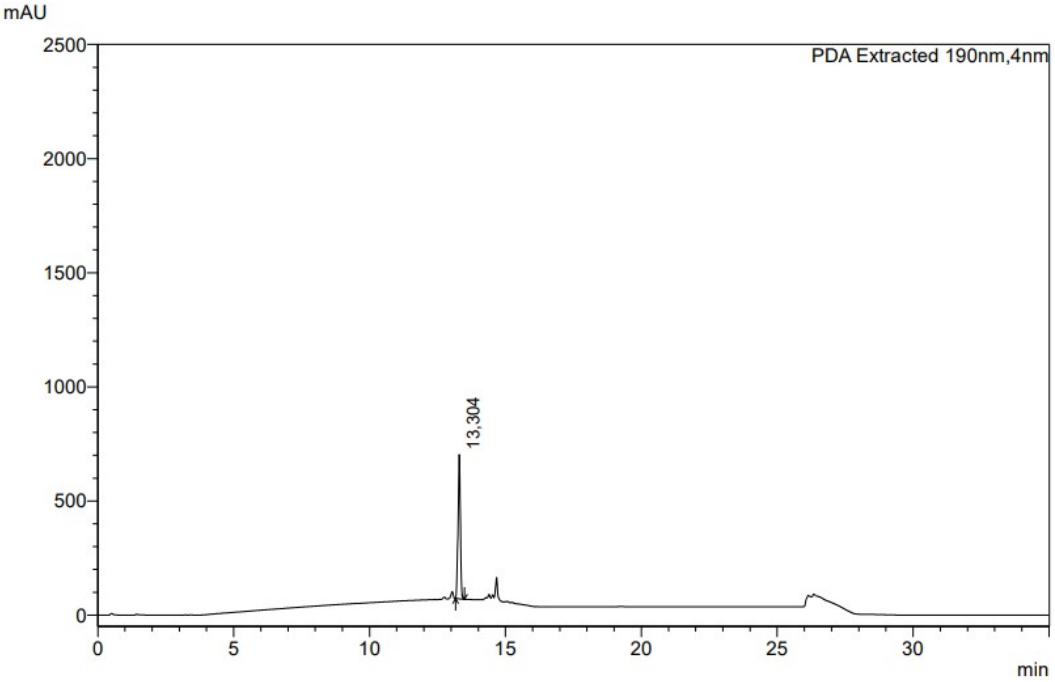


Figure S15. HPLC chromatogram (190 nm) of 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-14-tetraene-17-one (**1a-iso**)

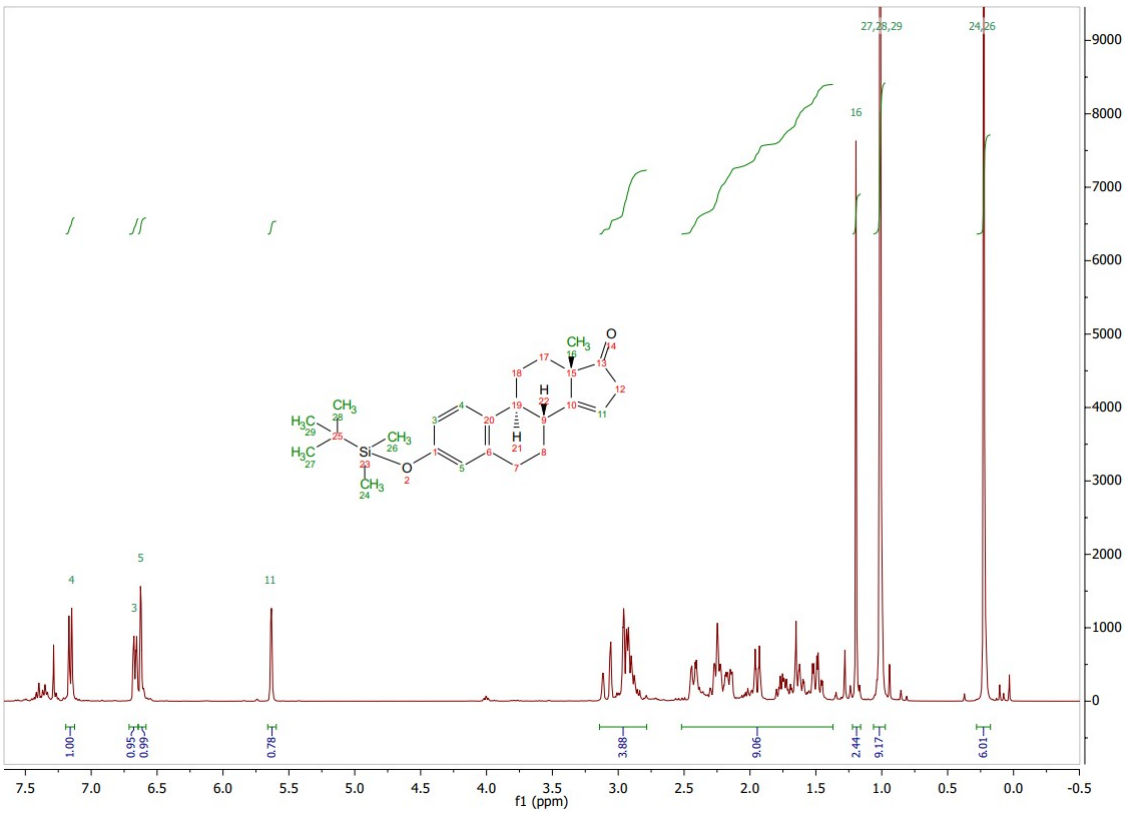


Figure S16. ^{1}H NMR spectrum (400 MHz) of 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-14-tetraene-17-one (**1a-iso**) in $CDCl_3$

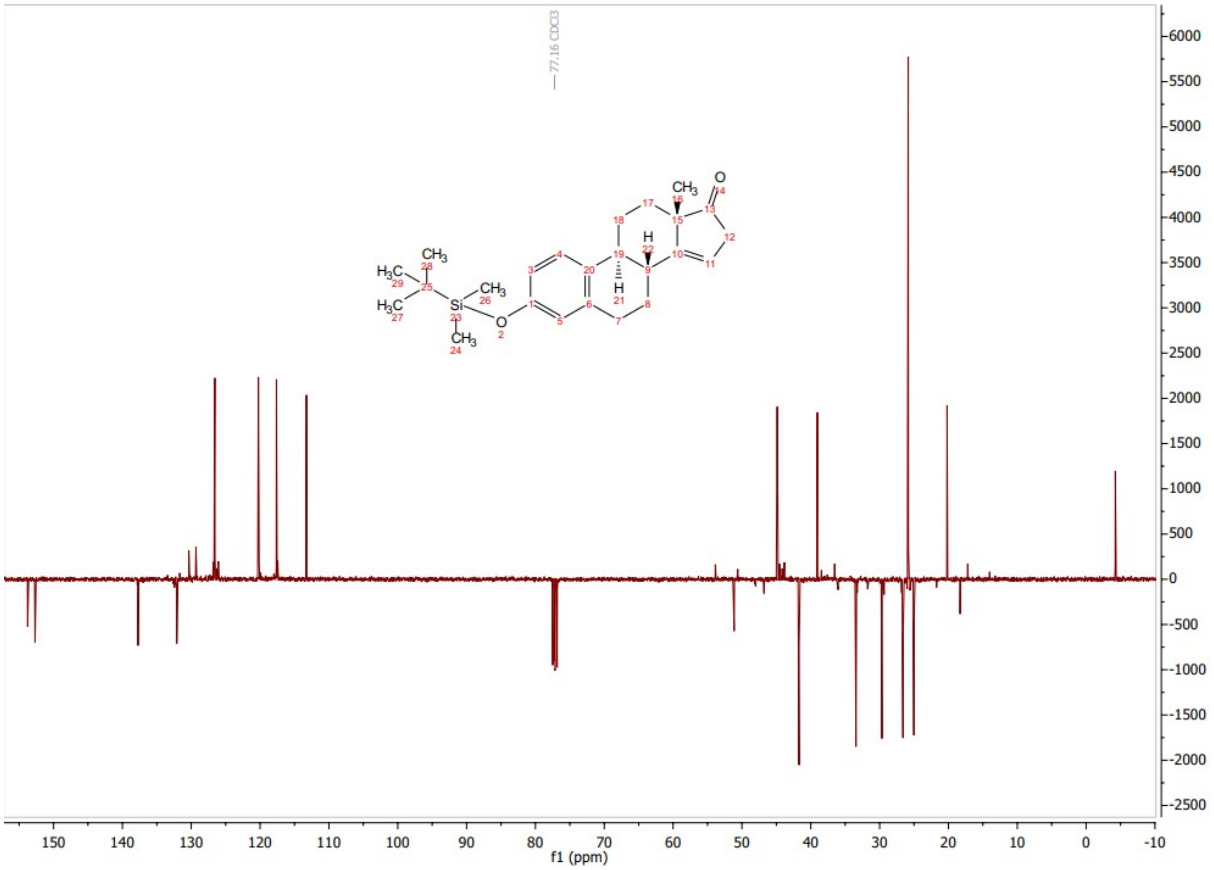


Figure S17. ^{13}C ATP NMR spectrum (101 MHz) of 3-*tert*-butyldimethylsilyloxy-estra-1,3,5(10)-14-tetraene-17-one (**1a-iso**) in $CDCl_3$

1.3.6 3-*tert*-butyldimethylsilyloxy-16-phenylthio-estra-1,3,5(10)-15-tetraene-17-one (**1a-S**)

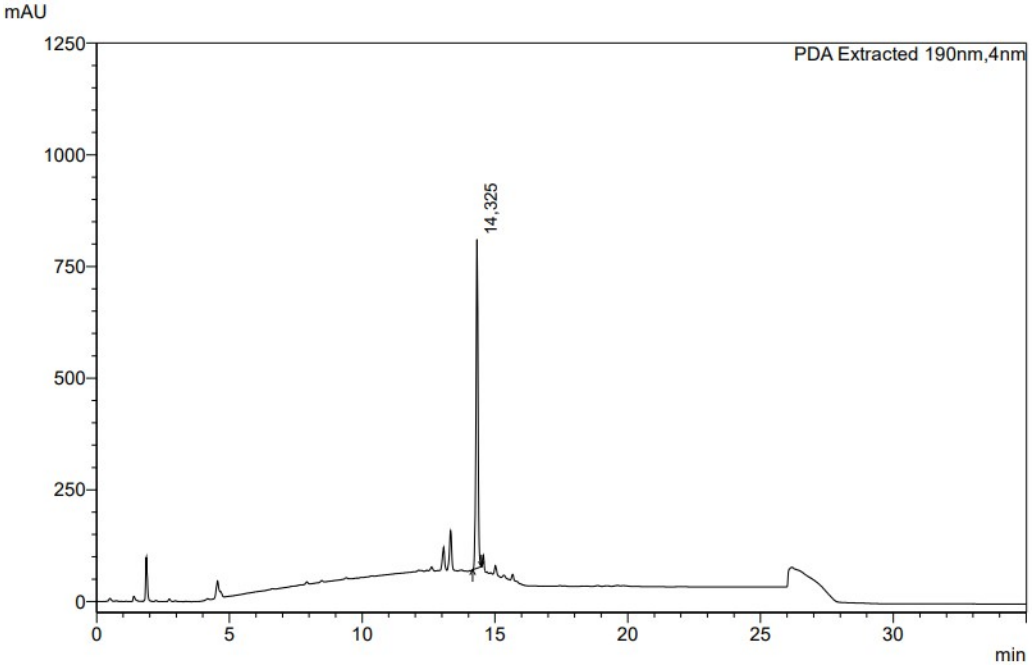


Figure S18. HPLC chromatogram (190 nm) of 3-*tert*-butyldimethylsilyloxy-16-phenylthio-estra-1,3,5(10)-15-tetraene-17-one (**1a-S**)

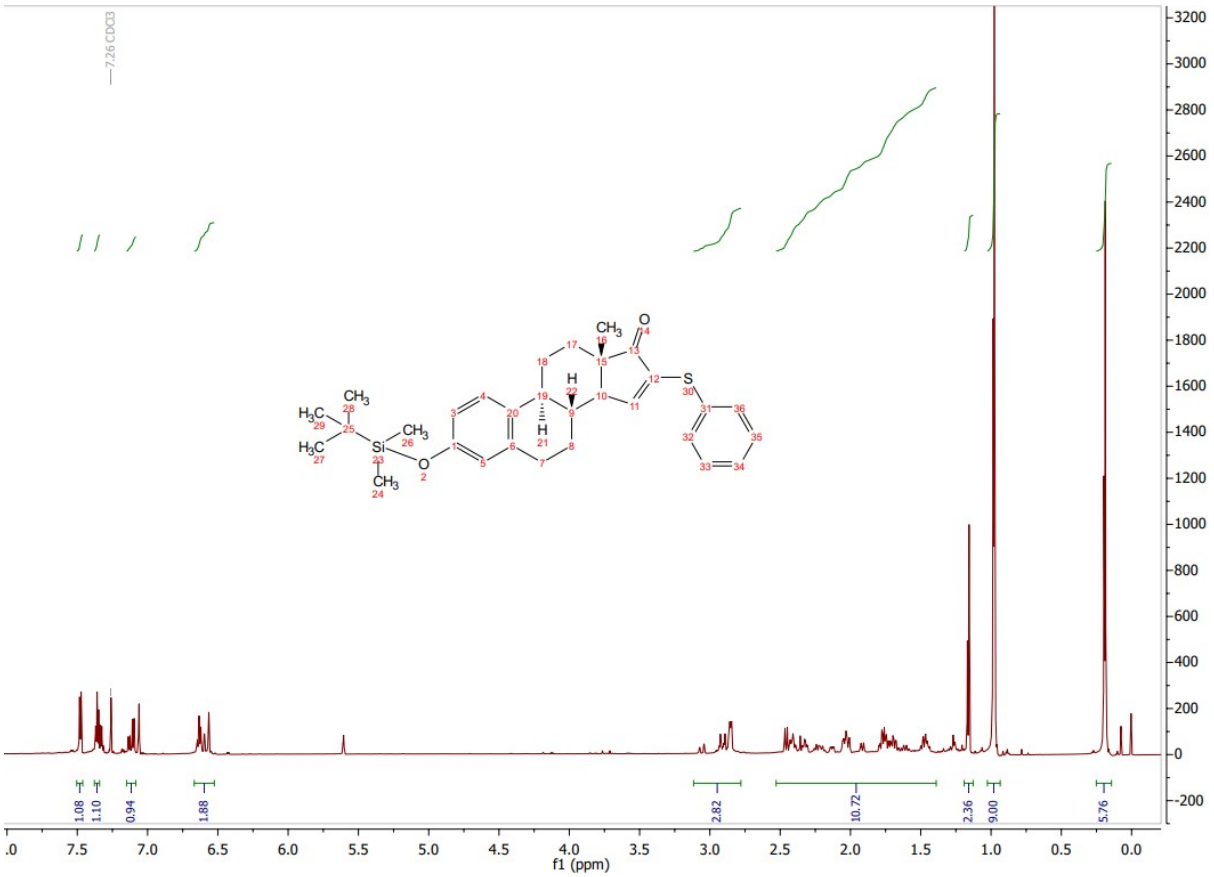


Figure S19. ^{1}H NMR spectrum (700 MHz) of 3-*tert*-butyldimethylsilyloxy-16-phenylthio-estra-1,3,5(10)-15-tetraene-17-one (**1a-S**) in $CDCl_3$

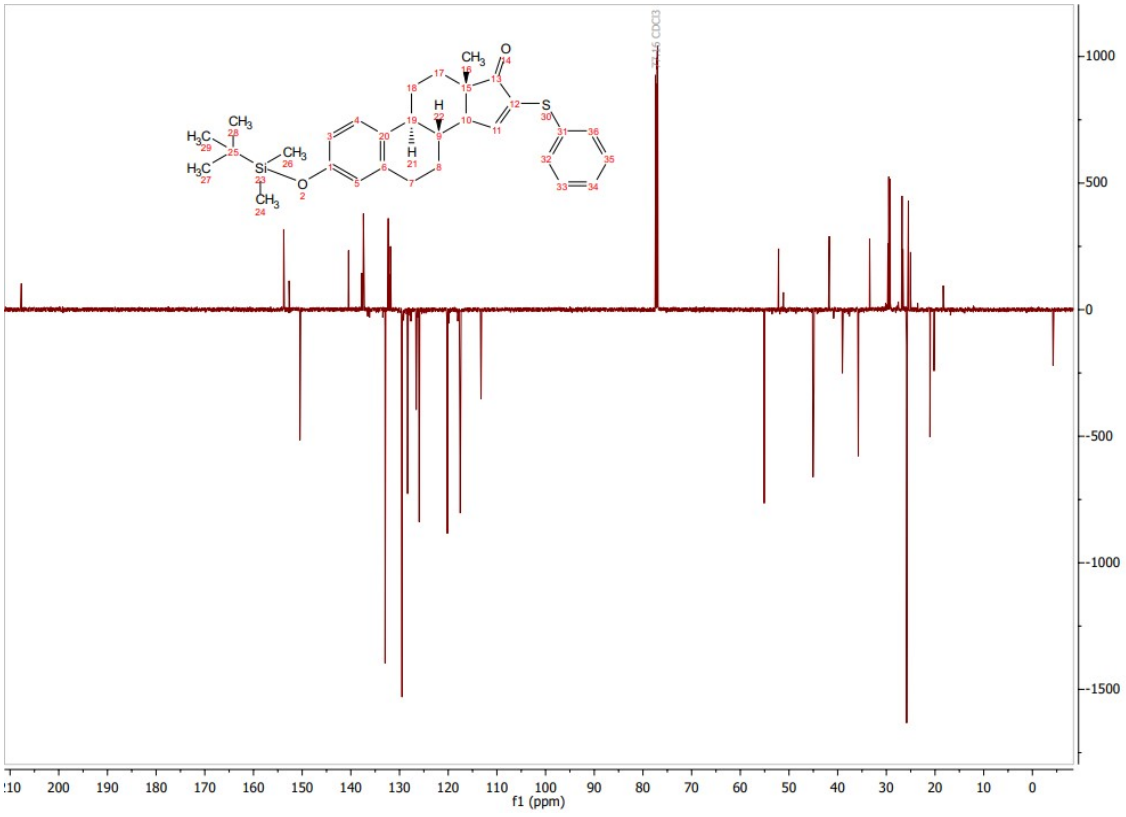


Figure S20. ^{13}C ATP NMR spectrum (176 MHz) of 3-*tert*-butyldimethylsilyloxy-16-phenylthio-estra-1,3,5(10)-15-tetraene-17-one (**1a-S**) in $CDCl_3$

1.3.7 3-*tert*-butyldimethylsilyloxy-15-(phenylsulfinyl)-estra-1,3,5(10)-triene-17-one (**4a-iso**)

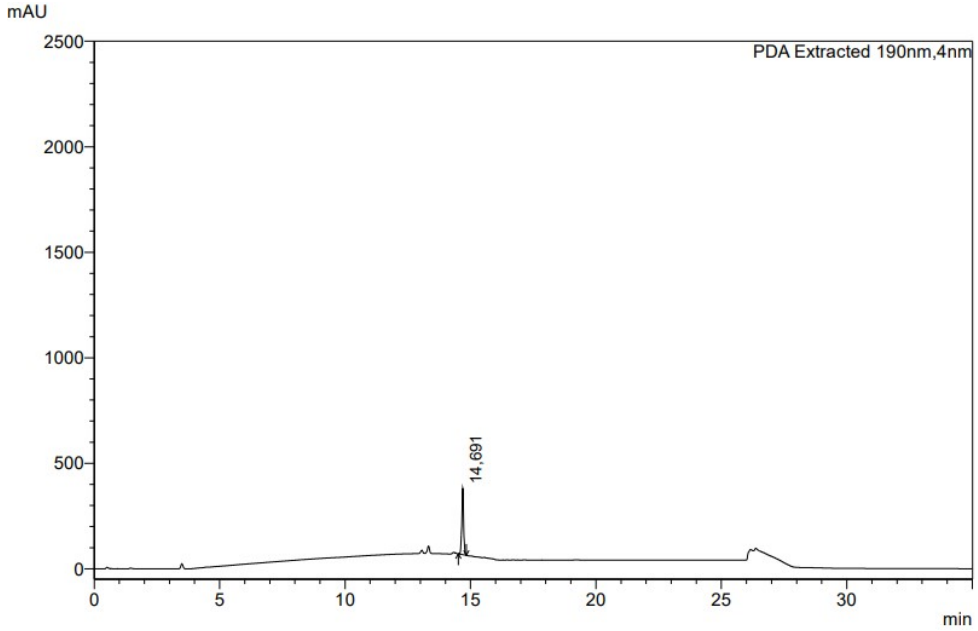


Figure S21. HPLC chromatogram (190 nm) of 3-*tert*-butyldimethylsilyloxy-15-(phenylsulfinyl)-estra-1,3,5(10)-triene-17-one (**4a-iso**)

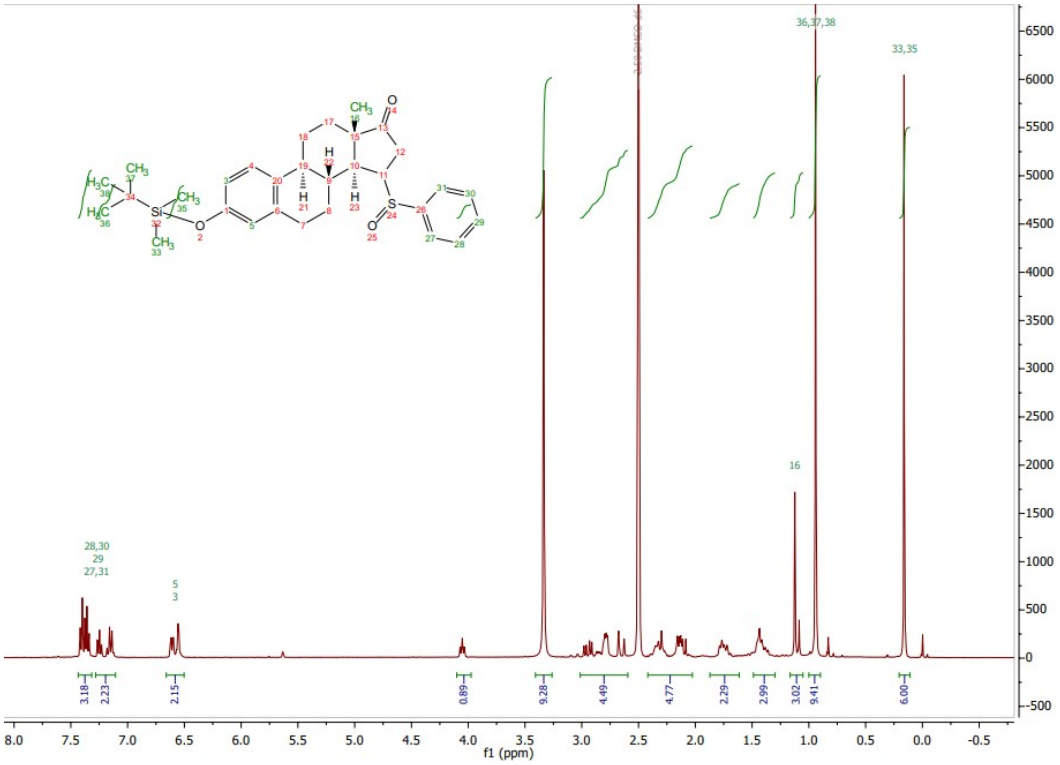


Figure S22. ^{1}H NMR spectrum (400 MHz) of 3-*tert*-butyldimethylsilyloxy-15-(phenylsulfinyl)-estra-1,3,5(10)-triene-17-one (**4a-iso**) in DMSO-d_6

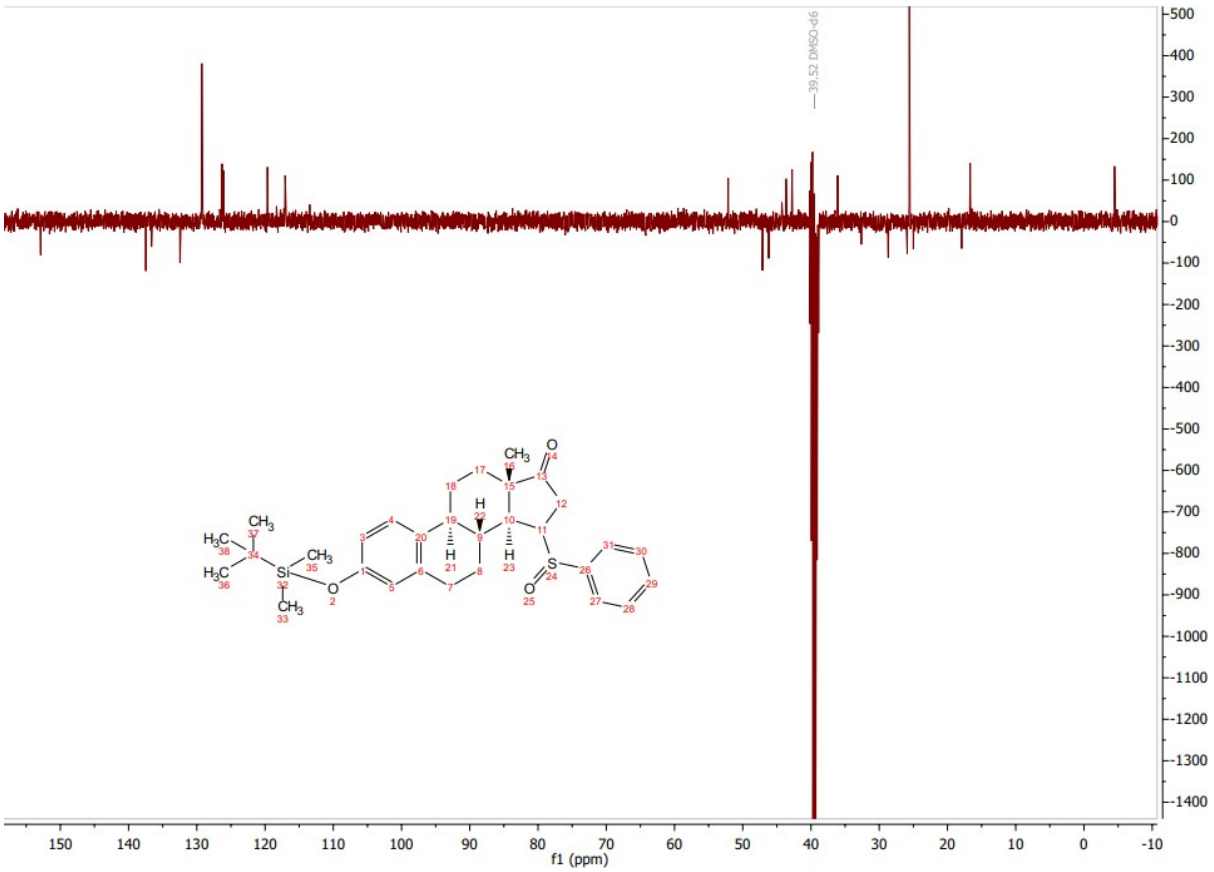


Figure S23. ^{13}C ATP NMR spectrum (101 MHz) of 3-*tert*-butyldimethylsilyloxy-15-(phenylsulfinyl)-estra-1,3,5(10)-triene-17-one (**4a-iso**) in DMSO-d_6

3. Detailed data on the thermolysis trials

Overview of the thermolysis tests where residence time, thermolysis, scavenger nature and amount, solvent, concentration, pH, scalability, and comparison with batch have been investigated. Results are presented in Table S3. Yields were determined by HPLC at 190 nm.

To determine the minimal pressure to apply for keeping a solvent liquid at a given temperature, the Clausius-Clapeyron equation has been used (1).

$$\ln\left(\frac{P_2}{P_1}\right) = \frac{-\Delta H_{vap}}{R} * \left(\frac{1}{T_2} - \frac{1}{T_1}\right) \quad (1)$$

For toluene, ΔH_{vap} = 38.1 kJ mol^{-1}, T_1 = 380,05 K and P_1 = 1 atm. Therefore, the minimal pressure to apply to keep toluene liquid at 210 °C is 12 bars.

Table S3. Results of thermolysis trials of **4a**

Entry	Effect	C (mol/L)	Solvent	Scavenger(s) (equiv.)	T (°C)	t (min)	Yield (%)
1	Residence time and temperature with **TMP**	0.06	*o*-xylene	TMP (3)	180	5	25
2		0.06	*o*-xylene	TMP (3)	180	10	43
3		0.06	*o*-xylene	TMP (3)	180	15	53
4		0.06	*o*-xylene	TMP (3)	190	5	39
5		0.06	*o*-xylene	TMP (3)	190	10	53
6		0.06	*o*-xylene	TMP (3)	190	15	52
7		0.06	*o*-xylene	TMP (3)	200	5	48
8		0.06	*o*-xylene	TMP (3)	200	10	52
9		0.06	*o*-xylene	TMP (3)	200	15	47
10		0.06	*o*-xylene	TMP (3)	210	5	47
11		0.06	*o*-xylene	TMP (3)	210	10	44
12		0.06	*o*-xylene	TMP (3)	210	15	41
13		0.06	*o*-xylene	TMP (3)	220	5	43
14		0.06	*o*-xylene	TMP (3)	220	10	38
15		0.06	*o*-xylene	TMP (3)	220	15	33
16	Scavenger	0.06	*o*-xylene	DMAD (1)	190	15	76
17		0.06	*o*-xylene	DMAD (1)	200	10	76
18		0.06	*o*-xylene	DMAD (1)	210	5	74
19		0.06	*o*-xylene	TMP (1)	190	15	50
20		0.06	*o*-xylene	TMP (1)	200	10	51
21		0.06	*o*-xylene	TMP (1)	210	5	46
22		0.06	*o*-xylene	DEF (1)	190	15	58
23		0.06	*o*-xylene	DEF (1)	200	10	39
24		0.06	*o*-xylene	DEF (1)	210	5	20
25		0.06	*o*-xylene	2,6-lutidine (1)	190	15	67
26		0.06	*o*-xylene	2,6-lutidine (1)	200	10	68
27		0.06	*o*-xylene	2,6-lutidine (1)	210	5	67
28		0.06	*o*-xylene	MBT (1)	190	15	50
29		0.06	*o*-xylene	MBT (1)	200	10	51
30		0.06	*o*-xylene	MBT (1)	210	5	53

31		0.06	toluene	DIAD (1)	190	15	67
32		0.06	toluene	DIAD (1)	200	10	62
33		0.06	toluene	DIAD (1)	210	6	62
34		0.06	toluene	methyl propiolate (2)	190	15	48
35		0.06	toluene	methyl propiolate (2)	200	10	56
36		0.06	toluene	methyl propiolate (2)	210	6	61
37		0.06	toluene	phenyl acetylene (2)	190	15	43
38		0.06	toluene	phenyl acetylene (2)	200	10	39
39		0.06	toluene	phenyl acetylene (2)	210	6	41
40		0.06	toluene	2-cyclohexen-1-one (2)	190	15	58
41		0.06	toluene	2-cyclohexen-1-one (2)	200	10	49
42		0.06	toluene	2-cyclohexen-1-one (2)	210	6	42
43		0.06	toluene	crotonaldehyde (2)	190	15	32
44		0.06	toluene	crotonaldehyde (2)	200	10	25
45		0.06	toluene	crotonaldehyde (2)	210	6	27
46		0.06	toluene	NEt_3 (2)	190	15	73
47		0.06	toluene	NEt_3 (2)	200	10	76
48		0.06	toluene	NEt_3 (2)	210	6	76
49		0.06	toluene	DABCO (2)	210	6	72
50		0.06	toluene	TEMPO (2)	210	6	83
51		0.06	toluene	1,4-dimethoxybenzene (2)	210	6	73
52		0.06	toluene	DIPEA (2)	210	6	70
53	Amount of scavenger	0.06	*o*-xylene	DMAD (1.5)	190	15	74
54		0.06	*o*-xylene	DMAD (1.5)	200	10	74
55		0.06	*o*-xylene	DMAD (1.5)	210	5	73
56		0.06	*o*-xylene	2,6-lutidine (1.5)	190	15	71
57		0.06	*o*-xylene	2,6-lutidine (1.5)	200	10	68
58		0.06	*o*-xylene	2,6-lutidine (1.5)	210	5	70
59		0.06	toluene	DIAD (2)	190	15	40
60		0.06	toluene	DIAD (2)	200	10	37
61		0.06	toluene	DIAD (2)	210	6	42
62	Solvents	0.06	*o*-xylene	DMAD (1) + TMP (1)	190	15	83
63		0.06	*o*-xylene	DMAD (1) + TMP (1)	200	10	80
64		0.06	*o*-xylene	DMAD (1) + TMP (1)	210	5	81
65		0.06	toluene	DMAD (1) + TMP (1)	190	15	80 (83)
66		0.06	toluene	DMAD (1) + TMP (1)	200	10	80 (84)
67		0.06	toluene	DMAD (1) + TMP (1)	210	5	77 (82)
68		0.06	chlorobenzene	DMAD (1) + TMP (1)	190	15	79
69		0.06	chlorobenzene	DMAD (1) + TMP (1)	200	10	79
70		0.06	chlorobenzene	DMAD (1) + TMP (1)	210	5	80
71		0.06	2-MeTHF	DMAD (1) + TMP (1)	190	15	76
72		0.06	2-MeTHF	DMAD (1) + TMP (1)	200	10	76
73		0.06	2-MeTHF	DMAD (1) + TMP (1)	210	5	79
74		0.06	anisole	DMAD (1) + TMP (1)	190	15	79
75		0.06	anisole	DMAD (1) + TMP (1)	200	10	76
76		0.06	anisole	DMAD (1) + TMP (1)	210	5	78
77		0.06	EtOAc	DMAD (1) + TMP (1)	190	15	76
78		0.06	EtOAc	DMAD (1) + TMP (1)	200	10	78

79		0.06	EtOAc	DMAD (1) + TMP (1)	210	5	78
80	Residence time and temperature with **DMAD**	0.06	toluene	DMAD (1)	190	15	84
81		0.06	toluene	DMAD (1)	200	10	83
82		0.06	toluene	DMAD (1)	210	5	82
8		0.06	toluene	DMAD (1)	210	4	71
3		0.06	toluene	DMAD (1)	210	5	77
84		0.06	toluene	DMAD (1)	210	6	80
85		0.06	toluene	DMAD (1)	250	2	68
86		0.06	toluene	DMAD (1)	250	4	71
87		0.06	toluene	DMAD (1)	250	6	68
88	Concentration	0.11	toluene	DMAD (1)	210	6	77
89		0.11	toluene	DMAD (1) + 2,6-lutidine (1)	210	6	70
90		0.17	toluene	DMAD (1) + 2,6-lutidine (1)	210	6	55
91		0.20	toluene	DMAD (1) + 2,6-lutidine (1)	210	6	53
92		0.22	toluene	DMAD (1)	210	6	62
93		0.22	toluene	DMAD (1.1)	210	6	73
94		0.22	toluene	DMAD (1.25)	210	6	75
95		0.22	toluene	DMAD (1.5)	210	6	80
96		0.22	trichloroethene	DMAD (1)	210	7	41
97		0.22	toluene	DMAD (3)	210	5	81
98		0.22	toluene	DMAD (3)	210	6	71 (75,77, 81, 83)
99		0.22	toluene	DMAD (3)	210	7	83
100		0.22	toluene	DMAD (3)	210	8	79
101		0.22	toluene	DMAD (1) + TEMPO (1)	210	6	81 (cloggi ng)
102		0.22	toluene	DMAD (1) + 2,6-lutidine (1)	210	6	51
103		0.22	toluene	DMAD (2) + 2,6-lutidine (2)	210	6	71
104		0.22	toluene	DMAD (3) + 2,6-lutidine (3)	210	6	66
105		0.22	toluene	TMP (5)	210	6	42
106		0.22	toluene	DIPEA (1)	210	4	58
107		0.22	toluene	TEMPO (1)	210	4	83
108		0.22	toluene	NEt_3 (1)	210	4	66
109		0.22	toluene	NEt_3 (1)	210	6	62
110		0.22	toluene	NEt_3 (3)	210	4	65
111		0.22	toluene	NEt_3 (3)	210	6	43
112		0.22	toluene	NEt_3 (5)	210	1	63
113		0.22	toluene	NEt_3 (5)	210	2	67
114		0.22	toluene	NEt_3 (5)	210	3	68
115		0.22	toluene	NEt_3 (5)	210	4	58
116		0.22	toluene	NEt_3 (5)	210	6	34
117		0.28	toluene	DMAD (5) + 2,6-lutidine (5)	210	7	67
118		0.28	toluene	DMAD (3)	210	6	69
119		0.36	toluene	DMAD (3)	210	6	65
120		0.36	toluene	TEMPO (1)	210	4	81
121		0.36	DCE	TEMPO (1)	210	4	68

122		0.36	DCE	DMAD (1)	210	4	75
123		0.56	DCE	DMAD (1)	210	6	72
124		0.56	DCE	DMAD (1.5)	210	6	76
125		0.56	chloroform	DMAD (1)	210	6	51
126		0.56	chloroform	DMAD (1.5)	210	5	59
127		0.56	chloroform	DMAD (1.5)	210	6	55
128		0.56	chloroform	DMAD (2)	210	6	28
130	Scavenger – reducing **1a-S** impurity	0.06	toluene	DMAD (1) + MeOH (0.5)	210	6	74
131		0.06	toluene	DMAD (1) + 2,6-lutidine (1)	190	15	79
132		0.06	toluene	DMAD (1) + 2,6-lutidine (1)	200	10	76
133		0.06	toluene	DMAD (1) + 2,6-lutidine (1)	210	6	78
134		0.06	toluene	TMP (1) + 2,6-lutidine (1)	190	15	42
135		0.06	toluene	TMP (1) + 2,6-lutidine (1)	200	10	39
136		0.06	toluene	TMP (1) + 2,6-lutidine (1)	210	6	40
137		0.06	toluene	DMAD (1) + DMSO (5)	190	15	64
138		0.06	toluene	DMAD (1) + DMSO (5)	200	10	61
139		0.06	toluene	DMAD (1) + DMSO (5)	210	6	59
140		0.06	toluene	DMAD (1) + pyridine (1)	190	15	71
141		0.06	toluene	DMAD (1) + pyridine (1)	200	10	75
142		0.06	toluene	DMAD (1) + pyridine (1)	210	6	76
143		0.06	toluene	DMAD (1) + DMAP (1)	190	15	49
144		0.06	toluene	DMAD (1) + DMAP (1)	200	10	47
145		0.06	toluene	DMAD (1) + DMAP (1)	210	6	47
146		0.06	toluene	DMAD (1) + 2,6-lutidine (2)	190	15	78
147		0.06	toluene	DMAD (1) + 2,6-lutidine (2)	200	10	80
128		0.06	toluene	DMAD (1) + 2,6-lutidine (2)	210	6	79
149		0.06	toluene	DMAD (2) + 2,6-lutidine (1)	210	6	78
150		0.06	toluene	DMAD (2) + 2,6-lutidine (2)	210	6	81
151		0.06	toluene	DMAD (1) + pyridine (2)	210	6	68
152		0.06	toluene	DMAD (1) + TMP (2)	210	6	74
153		0.06	toluene	DMAD (1.5) + TMP (1)	190	15	73
154		0.06	toluene	DMAD (1.5) + TMP (1)	200	10	76
155		0.06	toluene	DMAD (1.5) + TMP (1)	210	5	76
156		0.06	chloroform	DMAD (1.5) + TMP (1)	210	5	79
157		0.06	*o*-xylene	DMAD (1.5) + TMP (1)	210	5	74
158		0.06	DCE	DMAD (1.5) + TMP (1)	210	5	77
159		0.06	toluene	NEt_3 (2) + TMP (1)	210	6	32
160		0.06	toluene	NEt_3 (1) + TMP (2)	210	6	36
161		0.06	toluene	NEt_3 (2) + TEMPO (1)	210	6	80
162		0.06	toluene	NEt_3 (1) + TEMPO (2)	210	6	81
163	pH effect	0.22	toluene	DMAD (1.5) + PTSA (0.05)	210	6	10
164		0.22	toluene	DMAD (1.5) + imidazole (0.05)	210	6	81
165		0.22	toluene	DMAD (1.5) + imidazole (0.1)	210	6	83
166		0.22	toluene	DMAD (1.5) + imidazole (0.2)	210	6	85
167		0.22	toluene	DMAD (1.5) + NEt_3 (0.01)	210	6	84

168		0.22	toluene	DMAD (1.5) + NEt_3 (0.025)	210	6	83
169		0.22	toluene	DMAD (1.5) + NEt_3 (0.05)	210	6	85
170		0.22	toluene	DMAD (1.5) + NEt_3 (0.1)	210	6	86
171		0.22	toluene	DMAD (1.5) + NEt_3 (0.2)	210	6	87
172		0.22	toluene	DMAD (1.5) + NEt_3 (0.5)	210	6	50
173		0.22	toluene	DMAD (1.5) + DBU (0.01)	210	6	75
174		0.22	toluene	DMAD (1.5) + DBU (0.025)	210	6	83
175		0.22	toluene	DMAD (1.5) + DBU (0.05)	210	6	90
176		0.22	toluene	DMAD (1.5) + DBU (0.1)	210	6	87
177		0.25	toluene	DMAD (1.5) + DBU (0.2)	210	6	82
178		0.22	toluene	DMAD (1.5) + DIPEA (0.1)	210	6	83
179		0.22	toluene	DMAD (1.5) + DABCO (0.1)	210	6	84
180		0.22	toluene	DMAD (1.5) + TEMPO (0.1)	210	6	67
181		0.22	toluene	DMAD (1.5) + 2,6-lutidine (0.1)	210	6	81
182		0.22	toluene	/	210	6	<10
183		0.22	toluene	DMAD (1.5) + NEt_3 (0.1)	210	6	91[a]
184	Scale-up	0.22	toluene	DMAD (1.5) + NEt_3 (0.1)	210	6	85[b]
185		0.22	toluene	DMAD (1.5) + NEt_3 (0.1)	210	6	85[c]
186		0.22	toluene	DMAD (1.5) + NEt_3 (0.1)	210	6	80[d]
187		0.22	toluene	DMAD (1.5) + NEt_3 (0.1)	210	6	86[e]
188		0.22	toluene	DMAD (1.5) + NEt_3 (0.1)	210	6	89-93[f]
189		0.22	toluene	DMAD (1.5) + NEt_3 (0.1)	210	6	86[g]
190		0.22	toluene	DMAD (1.5) + NEt_3 (0.1)	210	6	86[h]
191		0.22	toluene	DMAD (1.5) + NEt_3 (0.1)	210	3	87[i]
192		0.22	toluene	DMAD (1.5) + NEt_3 (0.1)	210	3	91[j]
193	Batch trials	0.22	*o*-xylene	DMAD (3)	135	1020	28[k]
194		0.22	*o*-xylene	DMAD (3) + $NaHCO_3$ (4.5)	135	1020	59
195		0.36	*o*-xylene	TEMPO (1) + $NaHCO_3$ (4.5)	135	1020	73
196		0.36	*o*-xylene	DMAD (1.5) + $NaHCO_3$(4.5)	135	1020	27
197		0.36	*o*-xylene	$CuSO_4$ (0.5) + $NaHCO_3$(4.5)	135	1020	87

[a] from purified **4a** (>99% purity after column chromatography); [b] with V = 16 mL; [c] with ID = 2.1 mm (1/8"); [d] two feeds using a T-mixer; [e] two feeds using an arrow mixer; [f] 8 h run (125 g of **4a**) using two feeds and an arrow mixer; [g] using a pilot reactor with optimized conditions at lab-scale; [h] using a pilot reactor at 15 bar instead of 35 bar; [i] using a pilot reactor; [j] 3 h run (975 g of **4a**) using a pilot reactor; [k] batch conditions with V = 10 mL

4. Computations

4.1 Stationary points

Calculations were performed using Gaussian[S3] package using implicit solvation (SMD, solvent = toluene). Stationary points were optimized at the B3LYP-D3BJ/6-311+G** level of theory. Electronic energies were computed at the M08HX/6-311+G** level whereas solvation energies and Gibbs free energy correction were obtained at the B3LYP-D3BJ/6-31+G* level. Concentration and quasi-harmonic factors (Grimme method for entropy and Head-Gordon method for enthalpy correction) were performed with the open access Python toolkit Goodvibes.[S4] Transition states (TSs) were determined with the Newton−Raphson technique before being checked with the Hessian matrix and the intrinsic reaction coordinate (IRC).

4.1.1 Finding the best model and the lowest energetical form

The first part of this computational study was to determine the fastest to compute but most adequate model of 3-TBS-SO-estrone (**4a**, R = H). Firstly, the protected silyl moiety was dropped. Four stationary points for the thermolysis TS and for the starting material could be determined, these ones depending on the sulfoxide stereochemistry (**4a-S-OH** or **4a-R-OH**) and on the position of the aromatic ring (internal or external). Secondly, only two rings of the steroid backbone were kept (**4a-9**), leading again to four stationary points for both species. Both models gave similar results (see Tables S4 and S5), and only the most stable form of **4a-9** (**4a-R-9 external**) was kept for the studies of the temperature (see section 4.1.2) and the aromatic substituents (see section 4.1.3) effects.

Table S4. Thermochemical data of the four geometries that could occurred during thermolysis of models **4a-OH** and **4a-9**

Entry	Sulfoxide stereochemistry	Aromatic ring position	Compound	$\Delta G^{\ddagger}$ (kcal mol^{-1})	$t_{99\%conv.}$ (min)
1	S	external	**4a-9**	28.9	1771236188
2			**4a-OH**	28.9	1904463829
3		internal	**4a-9**	28.6	1047350815
4			**4a-OH**	30.9	55796721125
5	R	external	**4a-9**	28.0	379527620
6			**4a-OH**	28.9	1760236722
7		internal	**4a-9**	29.7	6725648468
8			**4a-OH**	30.2	15871503700

Table S5. Geometries of the most stable stationary points of the sulfoxide derived from unprotected estrone (**4a-OH**), its models for the computational study (**4a-9**) and their corresponding TS during thermolysis

4a-S-OH external							
$\Delta G^{\ddagger}$(298 K) = 28.9 kcal mol^{-1}							
Reagent				**TS**			
0 1				0 1			
C	0.00000000	0.00000000	0.00000000	C	0.00000000	0.00000000	0.00000000
C	0.00000000	0.00000000	1.39678000	C	0.00000000	0.00000000	1.39653700
C	1.21965400	0.00000000	2.10113000	C	1.22100300	0.00000000	2.09959900
C	2.40367900	-0.00287500	1.35463900	C	2.40478900	-0.00897800	1.35327700
C	2.40446600	0.00087200	-0.03616700	C	2.40465900	-0.01039600	-0.03767100
C	1.18960500	0.00290900	-0.71863200	C	1.18946400	-0.00485300	-0.71921500
C	1.25053700	-0.05398500	3.62590500	C	1.24569600	-0.03315400	3.62420800
C	-0.08830499	0.42342000	4.23806500	C	-0.08006800	0.51360700	4.21574100
C	-1.24319900	-0.33767300	3.59110400	C	-1.25012400	-0.25239100	3.60555201
C	-1.33718500	0.02156700	2.10957900	C	-1.33910200	0.03864200	2.10791200
C	-0.00197899	0.24902000	5.74831300	C	0.04026100	0.38552900	5.72477000
C	1.14818601	1.08111400	6.36333800	C	1.17394100	1.27881700	6.27856800
C	2.47948101	0.59909500	5.79140200	C	2.50294100	0.70461000	5.78227300
C	2.46131201	0.66981500	4.25302300	C	2.50425400	0.62642700	4.23894600
C	-1.21813900	0.55077300	6.63950700	C	-1.12711100	0.59792900	6.70126300
C	-0.59198200	0.56944200	8.03929599	C	-0.56055200	0.94260000	7.94641200
C	0.91333501	0.84977700	7.84656699	C	0.89491299	1.22234300	7.78462900
O	1.72497301	0.86163800	8.74092699	O	1.70106399	1.34808000	8.68610300
C	0.97688101	2.60966200	6.17452700	C	1.05807300	2.77042900	5.87551500
O	1.10927600	0.00422000	-2.08595800	O	1.10851400	-0.00531800	-2.08669500
S	-1.34411400	1.81893000	9.20605300	S	-1.62684000	3.25706800	8.08130800
C	-2.97661400	1.01376600	9.29429000	C	-2.83324000	2.68615000	9.27511300
C	-3.14072300	-0.12908499	10.07358999	C	-2.49325900	2.76116400	10.62757901
C	-4.39838000	-0.72238499	10.14198499	C	-3.40665101	2.32497900	11.58273501
C	-5.47332000	-0.16532100	9.44730099	C	-4.64542501	1.81777200	11.18974001
C	-5.29449600	0.98942400	8.68793299	C	-4.97149101	1.74940400	9.83606001
C	-4.03866500	1.59055900	8.61094199	C	-4.06767900	2.18482700	8.86934301
O	-1.54050700	3.09338700	8.40211300	O	-2.25428600	2.90049900	6.67465500
H	-1.64631400	1.52856300	6.40429900	H	-1.77450800	1.72418500	6.43482300
H	-0.22139300	1.48769700	4.00810600	H	-0.19045400	1.56877300	3.94052500
H	1.34085800	-1.11483000	3.90711100	H	1.27411400	-1.09218100	3.92332600
H	3.38985101	0.22828400	3.88570700	H	3.39164299	0.06717000	3.93396700
H	3.30929601	1.19234700	6.18421700	H	3.34641300	1.31366800	6.11893000
H	2.46651101	1.71333200	3.92299600	H	2.62244600	1.62829400	3.81699200
H	2.65134901	-0.43642700	6.10605300	H	2.64355500	-0.29535700	6.20537600
H	0.25959600	-0.80532200	5.92631799	H	0.36052400	-0.65095500	5.90475000
H	0.05227601	2.98739800	6.61502400	H	0.04201100	3.15128200	5.95947500
H	1.80816301	3.12316700	6.66399600	H	1.70877900	3.37170000	6.51562300
H	0.98617401	2.87982800	5.11883300	H	1.37144900	2.92885400	4.84429800
H	-0.68970900	-0.38022300	8.57077300	H	-0.97376100	0.71782800	8.92016200
H	-2.00679599	-0.19575400	6.55828800	H	-1.96844901	-0.09254100	6.67977000

H	-2.30564800	-0.55007799	10.62360799	H	-1.52548600	3.14556000	10.93230600
H	-3.87134900	2.49477801	8.03816099	H	-4.30999700	2.14537100	7.81500200
H	-4.54117400	-1.61312800	10.74254700	H	-3.14794801	2.37806500	12.63381901
H	-6.13260900	1.42701300	8.15796999	H	-5.93534701	1.36022300	9.52860401
H	-6.45172200	-0.62752399	9.50725599	H	-5.35345601	1.47799500	11.93633101
H	-2.18977000	-0.10154300	4.08503300	H	-2.19065600	0.02853900	4.08831200
H	-1.07857200	-1.41570400	3.71149900	H	-1.10884600	-1.32654000	3.77781301
H	-1.76052800	1.02974300	2.01536600	H	-1.77104400	1.03737200	1.96645200
H	-2.03271300	-0.64733400	1.59438100	H	-2.02742000	-0.65830300	1.62070600
H	3.36020200	-0.01074900	1.86097300	H	3.36080900	-0.01652100	1.86043900
H	3.34232400	0.00005700	-0.58328699	H	3.34218700	-0.01593300	-0.58529700
H	-0.93880600	-0.00179900	-0.54345400	H	-0.93892300	0.00345600	-0.54324200
H	1.99787200	0.00071000	-2.46030800	H	1.99715900	-0.01369500	-2.46085400

4a-S-9 external

$\Delta G^{\ddagger}$(298 K) = 28.9 kcal mol^{-1}

Reagent				**TS**			
0 1				0 1			
S	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
O	0.00000000	0.00000000	1.51964400	O	0.00000000	0.00000000	1.58021500
C	1.79241500	0.00000000	-0.52483300	C	2.54551600	0.00000000	0.22398700
C	2.69747300	0.93153900	0.29125300	C	2.56467800	-0.00527000	1.63513600
H	2.28209799	1.07823900	1.29147500	H	1.26445900	-0.04436500	1.86946900
C	2.38653200	-1.41914600	-0.39085700	C	2.93947900	-1.34089900	-0.29523100
C	3.56844999	-1.33332200	0.56072300	C	2.96918800	-2.29425600	0.90519900
C	4.01028099	0.13563700	0.34970600	C	3.25134400	-1.31021700	2.06582900
C	4.74787800	-2.26623600	0.28069300	C	4.05796901	-3.37351700	0.92162800
C	5.93823500	-1.89398200	1.18590500	C	4.07692001	-4.07580000	2.29872200
C	6.31770700	-0.40355400	1.10510600	C	4.09010001	-3.11640000	3.50873101
C	5.11930999	0.54404000	1.30920900	C	3.05643400	-1.97025700	3.42115900
C	2.96162899	-1.59734400	1.96190600	C	1.56856100	-2.95289000	0.96963600
O	1.96119000	-2.39230900	-0.96590900	O	3.21355400	-1.60557500	-1.45003200
C	-0.33791700	1.71538900	-0.51341300	C	-0.01663900	1.73205200	-0.45531600
C	-0.50549200	2.00966000	-1.86478400	C	0.06871700	2.04810300	-1.81295800
C	-0.78353800	3.32156101	-2.23871900	C	0.05806800	3.38471999	-2.20056500
C	-0.90496300	4.31532901	-1.26593400	C	-0.03616200	4.39367400	-1.24170599
C	-0.75294100	3.99850701	0.08258700	C	-0.12031100	4.06312100	0.11009600
C	-0.47139700	2.68825201	0.46797900	C	-0.11275100	2.72938000	0.51212600
H	4.76481799	0.50362300	2.34422800	H	2.03552800	-2.34643400	3.53648300
H	6.75016200	-0.20157400	0.11702300	H	5.08487600	-2.66085600	3.58663701
H	6.80476100	-2.50412000	0.91358200	H	4.95303500	-4.72921500	2.35352300
H	4.46157100	-3.30996400	0.43483000	H	3.89401501	-4.10879500	0.12891000
H	5.69945700	-2.15233700	2.22255400	H	3.20932300	-4.73747401	2.37613100
H	5.04098200	-2.16747100	-0.77089300	H	5.02913101	-2.90640000	0.72746200
H	4.44348699	0.17092300	-0.66113801	H	4.32595901	-1.08598700	2.00476200
H	2.06633300	-1.00214200	2.15162600	H	0.78135800	-2.24401000	1.21765700
H	2.67899399	-2.65031801	2.03550100	H	1.33422600	-3.40994100	0.00477800
H	3.68165899	-1.38304400	2.75144300	H	1.53484500	-3.73721000	1.72438300
H	1.75649400	0.24898400	-1.58790800	H	2.58232200	0.87236200	-0.41370400
H	2.81184800	1.90857400	-0.17807400	H	2.80319100	0.91562700	2.16628700

H	-0.42636000	1.23121601	-2.61665000	H	0.14902400	1.26334900	-2.55798700
H	-0.35934200	2.40948401	1.50889800	H	-0.18513400	2.45696600	1.55735100
H	-0.91385000	3.56633001	-3.28642300	H	0.12517600	3.63727599	-3.25236500
H	-0.85725900	4.76941701	0.83737300	H	-0.19614100	4.84516300	0.85693800
H	-1.12700600	5.33431601	-1.56081700	H	-0.04443500	5.43311900	-1.54776099
H	5.42515599	1.57856800	1.12193500	H	3.22695600	-1.25715800	4.23402600
H	7.10094800	-0.18428800	1.83701500	H	3.94171300	-3.69312601	4.42671901

4a-S-OH internal

$\Delta G^{\ddagger}$(298 K) = 30.9 kcal mol^{-1}

Reagent				**TS**			
0 1				0 1			
S	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
O	0.00000000	0.00000000	1.52066600	O	0.00000000	0.00000000	1.58338100
C	1.80934700	0.00000000	-0.46466400	C	2.58342400	0.00000000	0.26344100
C	2.71992400	-0.93264500	0.34510200	C	2.55679400	0.14522100	1.66846700
H	2.23271900	-1.88799500	0.54956900	H	1.27140400	-0.02655800	1.88438600
C	-0.43418800	-1.68492700	-0.52322900	C	-0.41982700	-1.66822100	-0.49740900
C	-0.39911100	-2.71249999	0.41296600	C	-1.26618400	-2.44935300	0.29023300
C	-0.74742700	-4.00048999	0.01235700	C	-1.60722500	-3.72560200	-0.14305300
C	-1.13767100	-4.24233299	-1.30479100	C	-1.12471700	-4.20842200	-1.36085000
C	-1.19608400	-3.19511899	-2.22394600	C	-0.29464400	-3.41246500	-2.14735200
C	-0.85029800	-1.90363899	-1.83462400	C	0.06704000	-2.13757401	-1.71724500
C	3.89708500	-1.10286800	-0.62955300	C	3.40291000	-0.99837000	2.24576200
C	3.23144200	-1.30198100	-2.01026800	C	3.26087900	-2.13731200	1.21294900
C	2.09714700	-0.28445600	-1.94668000	C	3.10413800	-1.34971700	-0.09413100
C	4.27707600	-1.08223000	-3.10393900	C	4.48098200	-3.04979400	1.34996400
C	5.48034999	-2.02106300	-2.89233200	C	4.59594300	-3.56672100	2.80167801
C	6.07137599	-1.95519700	-1.46697200	C	4.48121900	-2.47193500	3.88956800
C	4.98989200	-2.13108100	-0.37211400	C	3.27800400	-1.51794300	3.66831600
C	7.24536000	-2.90431400	-1.24417700	C	4.49486500	-3.01967200	5.31282400
C	7.51225200	-3.44234300	0.02985000	C	3.84753000	-2.33262500	6.35882000
C	6.61507099	-3.17006100	1.22071300	C	3.04923500	-1.06607100	6.11631800
C	5.64261800	-2.01249000	1.00306600	C	3.29351600	-0.43676000	4.74484000
C	8.12102199	-3.23023800	-2.28639400	C	5.18749400	-4.19302200	5.63261300
C	9.22001899	-4.06202600	-2.09938000	C	5.24420500	-4.69058600	6.93031901
C	9.46747199	-4.59104700	-0.83426601	C	4.59496200	-4.00273400	7.95323601
C	8.61608399	-4.27703100	0.21845500	C	3.90386100	-2.83244301	7.66180901
C	2.55183900	-2.68274099	-2.17599900	C	1.95969100	-2.95519400	1.37989000
O	1.52171400	0.23122600	-2.87672401	O	3.37554000	-1.73289100	-1.21663700
O	10.52770500	-5.41754100	-0.57280001	O	4.60652500	-4.43022000	9.25465701
H	4.56394700	-3.13864000	-0.45437900	H	2.34493500	-2.08243400	3.77651300
H	6.45507799	-0.93162000	-1.33563900	H	5.37246400	-1.83447400	3.78403500
H	6.24661699	-1.75239000	-3.62237600	H	5.55860500	-4.07353600	2.89917401
H	3.84570800	-1.24488800	-4.09520100	H	4.41690400	-3.89784700	0.66264000
H	5.19600400	-3.05380199	-3.11583100	H	3.83531300	-4.33066800	2.98514601
H	4.61592500	-0.04089200	-3.07050800	H	5.38349899	-2.48986700	1.08321600
H	4.39897000	-0.12449400	-0.67386900	H	4.43751400	-0.63642200	2.15729800
H	1.84893300	-2.90608199	-1.37441400	H	1.09852800	-2.32099800	1.57215600
H	2.00115900	-2.70407699	-3.11848200	H	1.76470800	-3.53102600	0.47311300

H	3.29253000	-3.48119599	-2.19952600	H	2.03573200	-3.65803000	2.20841100
H	2.07531900	1.04670500	-0.28322300	H	2.58609600	0.79615500	-0.46678800
H	3.00674300	-0.49202700	1.29746600	H	2.66587200	1.14276800	2.09240100
H	-0.89334500	-1.08415598	-2.54190600	H	0.74316300	-1.53353300	-2.31006400
H	-0.11655100	-2.49006899	1.43488100	H	-1.62924400	-2.06582200	1.23554800
H	-1.51458000	-3.38151699	-3.24284300	H	0.09077000	-3.78812800	-3.08790400
H	-0.72006200	-4.81295999	0.72925300	H	-2.25535000	-4.34322900	0.46794899
H	-1.41006200	-5.24555099	-1.61155400	H	-1.39474900	-5.20393600	-1.69332400
H	4.88791000	-2.01591000	1.79414101	H	2.52625799	0.31739900	4.54750500
H	6.17109000	-1.05351800	1.06958500	H	4.26199400	0.07842400	4.72908000
H	6.04082100	-4.08125400	1.43164800	H	1.98379299	-1.31151700	6.20833300
H	7.23274200	-2.99182200	2.10578000	H	3.26199799	-0.34655500	6.91245600
H	7.95354600	-2.82807400	-3.27717600	H	5.70251200	-4.74387101	4.85623300
H	9.87889699	-4.29451800	-2.93045500	H	5.79073600	-5.60437001	7.14320601
H	8.82206799	-4.69232700	1.19914500	H	3.40424200	-2.30684901	8.46856701
H	11.04162700	-5.54650700	-1.37841101	H	5.12422600	-5.24094000	9.32151001

4a-S-9 internal

$\Delta G^{\ddagger}$(298 K) = 28.6 kcal mol^{-1}

Reagent				**TS**			
0 1				0 1			
S	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
O	0.00000000	0.00000000	1.52072474	O	0.00000000	0.00000000	1.58377700
C	1.80939529	0.00000000	-0.46521879	C	2.58109400	0.00000000	0.26169500
C	2.72295232	-0.92842390	0.34750771	C	2.55853400	0.15563600	1.66537400
H	2.23741028	-1.88402220	0.55544597	H	1.27127600	-0.02065200	1.88396200
C	-0.43402829	-1.68594377	-0.52026627	C	-0.41753900	-1.66948900	-0.49635100
C	-0.85197980	-1.90788121	-1.83054777	C	0.07499800	-2.14238400	-1.71245100
C	-1.20150556	-3.19986391	-2.21501641	C	-0.28715000	-3.41731600	-2.14226700
C	-1.14546140	-4.24375745	-1.29186423	C	-1.12339800	-4.20996700	-1.35911600
C	-0.75344117	-3.99866200	0.02405803	C	-1.61123500	-3.72393400	-0.14467500
C	-0.40052722	-2.71024762	0.41953657	C	-1.26960200	-2.44773300	0.28817300
C	3.89787434	-1.10241103	-0.62638343	C	3.40820100	-0.98058100	2.24926900
C	3.23004417	-1.31336260	-2.00647476	C	3.25581300	-2.13232500	1.22955100
C	2.09569332	-0.29516018	-1.94665668	C	3.09427900	-1.35631500	-0.08440000
C	4.99627031	-2.12300401	-0.36272680	C	3.30572700	-1.47699800	3.68216099
C	6.05647983	-1.98570759	-1.47387534	C	4.48100300	-2.45881600	3.89311699
C	5.46767501	-2.04899796	-2.89629623	C	4.59029200	-3.56036300	2.81595399
C	4.27131260	-1.09976068	-3.10982813	C	4.47507700	-3.05157900	1.36062800
O	1.51838211	0.21457578	-2.87874501	O	3.35832900	-1.75127900	-1.20460400
C	2.55075152	-2.69607523	-2.15183732	C	1.95163900	-2.93907700	1.41910200
H	4.58425289	-3.13704575	-0.34213851	H	2.34285800	-1.96147400	3.86846799
H	6.56407926	-1.02209177	-1.34274095	H	5.40780399	-1.87189700	3.89213899
H	6.25023993	-1.80972064	-3.62261445	H	5.54497700	-4.08138400	2.93694699
H	3.83041851	-1.25784609	-4.09770333	H	4.40303100	-3.89839000	0.67244100
H	5.15779042	-3.07571779	-3.11434407	H	3.81754300	-4.31333699	2.99451799
H	4.61578795	-0.06017546	-3.07670336	H	5.37757800	-2.49374100	1.08859300
H	4.39542686	-0.12307950	-0.68492259	H	4.44294500	-0.62547100	2.14062600
H	1.82833643	-2.89607446	-1.36145513	H	1.09108300	-2.29571400	1.58049900
H	2.02319181	-2.74333230	-3.10639555	H	1.76042700	-3.55062200	0.53512599

H	3.28851203	-3.49731655	-2.13295239	H	2.02055900	-3.60610900	2.27705400
H	2.07423623	1.04798684	-0.29027126	H	2.58437700	0.78868700	-0.47654500
H	3.01610463	-0.48718534	1.29884494	H	2.66376300	1.15497300	2.08786000
H	-0.89314666	-1.09062817	-2.54028059	H	0.75579200	-1.54106200	-2.30255300
H	-0.11673068	-2.48468939	1.44044539	H	-1.63707700	-2.06162999	1.23073401
H	-1.52100429	-3.38941316	-3.23298214	H	0.10267200	-3.79546500	-3.08000500
H	-0.72834485	-4.80846536	0.74404777	H	-2.26424600	-4.33895200	0.46379000
H	-1.42205578	-5.24704097	-1.59457682	H	-1.39409100	-5.20535500	-1.69146500
H	5.45644352	-1.94940452	0.61505864	H	3.38746900	-0.64763700	4.39224999
H	6.82400199	-2.75755890	-1.36197971	H	4.41321900	-2.92708400	4.87964900

4a-R-OH internal

$\Delta G^{\ddagger}(298\ K) = 28.9\ kcal\ mol^{-1}$

Reagent				**TS**			
0 1				0 1			
S	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
O	0.00000000	0.00000000	1.51865900	O	0.00000000	0.00000000	1.57943200
C	1.82661200	0.00000000	-0.47764200	C	2.55004800	0.00000000	0.25282100
C	2.64815800	1.08068500	0.23855800	C	2.52547400	0.37050800	1.61296100
H	2.13033200	1.46387500	1.11885400	H	1.25851500	0.13936400	1.86901400
C	-0.42376200	1.69919900	-0.50070500	C	-0.32121000	1.70701200	-0.45404100
C	2.00791400	0.23480700	-1.98380300	C	2.91695800	1.16017000	-0.61048300
O	1.42125900	-0.36768700	-2.85361700	O	2.91153000	1.19374800	-1.82540899
C	3.05430400	1.32735700	-2.15487100	C	3.42455900	2.24668500	0.34268600
C	2.85494000	2.13938200	-0.85613000	C	2.65430300	1.90206500	1.64071400
C	-0.44979600	2.68835600	0.47545100	C	-0.79176700	2.61776300	0.49136700
C	-0.75072800	3.99626001	0.10177000	C	-1.03899700	3.93051501	0.10249500
C	-1.03311500	4.29642001	-1.23031800	C	-0.82924000	4.32574001	-1.21945100
C	-1.03789000	3.28545301	-2.19166600	C	-0.37296700	3.40216801	-2.15774400
C	-0.74184100	1.97374401	-1.82942100	C	-0.11482500	2.08631102	-1.78032300
C	2.89057200	2.25560900	-3.35719800	C	3.15446300	3.70596600	-0.00840500
C	3.85582600	3.45145100	-3.25047600	C	3.55800500	4.61570300	1.17176501
C	3.75426800	4.19727800	-1.90289900	C	2.96559600	4.18131600	2.53239101
C	3.89560300	3.23752000	-0.69671200	C	3.17136800	2.67453500	2.84077100
C	4.70108500	5.38759600	-1.78234000	C	3.41720800	5.04301200	3.70710401
C	5.21323400	5.78534300	-0.53187800	C	3.42732000	4.52411700	5.01733201
C	4.91474000	5.01470200	0.73875401	C	3.08660100	3.07639500	5.31353401
C	3.75258000	4.03398299	0.59864101	C	2.44226800	2.33954300	4.14064900
C	5.04864800	6.15202600	-2.90204500	C	3.79692100	6.37838700	3.53148301
C	5.87723400	7.26559800	-2.81267200	C	4.17338600	7.18919400	4.59780301
C	6.37997800	7.64353400	-1.56930600	C	4.17296400	6.66326100	5.88779600
C	6.04413300	6.90444400	-0.44107500	C	3.80128700	5.33884701	6.08796200
C	4.40735700	0.57543100	-2.21564200	C	4.94354400	1.97145900	0.46035400
O	7.20028300	8.72754100	-1.40162700	O	4.52922400	7.39870000	6.98691801
H	4.90067200	2.79675900	-0.71040000	H	4.24054300	2.47910000	2.98696100
H	2.72862000	4.59233900	-1.84163800	H	1.87552500	4.30507800	2.44366101
H	3.63265900	4.13520700	-4.07204900	H	3.22677100	5.63101800	0.94205001
H	3.06145000	1.71776700	-4.29363099	H	3.69918300	4.00405200	-0.90836700
H	4.88825300	3.12021500	-3.40122000	H	4.64836000	4.66226200	1.25143901
H	1.85958100	2.62290600	-3.38119600	H	2.08876000	3.83030700	-0.22302700

H	1.89369300	2.65108500	-0.97187200	H	1.64040900	2.28203700	1.47840200
H	4.56048500	-0.08096500	-1.35621000	H	5.14616300	0.95491800	0.80610801
H	4.44014700	-0.04102300	-3.11738700	H	5.41485201	2.09457000	-0.51819500
H	5.24537500	1.27083200	-2.25182300	H	5.42405201	2.66017600	1.15413701
H	2.10133700	-1.02432100	-0.21848000	H	2.62494500	-1.01221000	-0.12441800
H	3.59611001	0.66139500	0.58430100	H	2.97221800	-0.27409300	2.36870100
H	-0.23594900	2.42336400	1.50372900	H	-0.94892300	2.29637700	1.51320700
H	-0.74686000	1.18431701	-2.57070600	H	0.26767700	1.37612702	-2.50303400
H	-0.76585100	4.77952201	0.85079600	H	-1.39976300	4.64550001	0.83302500
H	-1.27739800	3.51560101	-3.22324100	H	-0.20155000	3.70541201	-3.18387300
H	-1.26442100	5.31556500	-1.51754100	H	-1.02132600	5.35026801	-1.51586300
H	3.72896200	3.36771499	1.46534401	H	2.45816700	1.26271000	4.33073200
H	2.79815800	4.57353999	0.58443001	H	1.38846301	2.62624600	4.04119500
H	5.81744100	4.45833700	1.02196501	H	4.01585600	2.56204900	5.58921801
H	4.72740200	5.71970899	1.55400700	H	2.44340800	3.02789100	6.19716400
H	4.66682200	5.88266500	-3.87824400	H	3.80403800	6.81092300	2.53952701
H	6.12755100	7.83450700	-3.70290100	H	4.46474400	8.22082900	4.42499701
H	6.43907500	7.21148500	0.52143600	H	3.81077400	4.94050101	7.09701900
H	7.34880000	9.15342000	-2.25387300	H	4.76048300	8.29407901	6.71395600

4a-R-9 internal

$\Delta G^{\ddagger}(298\ K) = 28.0\ kcal\ mol^{-1}$

Reagent				**TS**			
0 1				0 1			
S	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
O	0.00000000	0.00000000	1.51856000	O	0.00000000	0.00000000	1.57952100
C	1.82284000	0.00000000	-0.48481300	C	2.54359700	0.00000000	0.24779300
C	2.65602800	1.08703800	0.20996500	C	2.52878400	0.37779900	1.60611300
H	2.15241699	1.48889400	1.09129300	H	1.25938100	0.14804700	1.86772800
C	1.98734900	0.21936800	-1.99599400	C	2.89645000	1.15694300	-0.62574900
C	3.03307799	1.30723900	-2.19270400	C	3.40736000	2.25303399	0.31395300
C	2.85858900	2.13225400	-0.89652700	C	2.66246700	1.90773100	1.62993200
C	2.84919599	2.22338900	-3.40474800	C	3.12024600	3.71062399	-0.04403600
C	3.83886599	3.40284200	-3.33165800	C	3.54588000	4.62553399	1.12610801
C	3.79715099	4.15277900	-1.98653001	C	3.00150100	4.18537500	2.50242200
C	3.91210100	3.22163700	-0.76348700	C	3.20890700	2.68667600	2.81471300
C	4.38354199	0.55157500	-2.26200100	C	4.93000600	1.98682399	0.40629500
O	1.38838800	-0.39062200	-2.85199000	O	2.87970200	1.18132400	-1.84094500
C	-0.43463100	1.69493900	-0.50589300	C	-0.33260600	1.70359000	-0.45752300
C	-0.45524300	2.69101900	0.46345700	C	-0.79974300	2.61682800	0.48705100
C	-0.77851000	3.99252900	0.08590100	C	-1.05819800	3.92584700	0.09291600
C	-1.09022100	4.27913900	-1.24276100	C	-0.86220100	4.31506900	-1.23287400
C	-1.09947800	3.26124801	-2.19665200	C	-0.40852100	3.38907099	-2.17001400
C	-0.77906900	1.95625101	-1.83075600	C	-0.13982400	2.07682599	-1.78769600
H	4.91615299	2.78945400	-0.69668300	H	4.26522100	2.46141600	2.99077500
H	2.84637399	4.69468800	-1.91220701	H	1.92343600	4.38446899	2.53288600
H	3.62307500	4.10378300	-4.14360100	H	3.21226300	5.64766299	0.92267000
H	2.98336799	1.66976299	-4.33810701	H	3.64293900	4.00246299	-0.95917799
H	4.85506200	3.03701500	-3.51135400	H	4.63861700	4.67010499	1.16850701
H	1.82290700	2.60514600	-3.40207800	H	2.04896400	3.82541699	-0.23573300

H	1.90080399	2.65109800	-1.00849300	H	1.64830000	2.29284900	1.48483100
H	4.53056799	-0.12087200	-1.41367900	H	5.14353100	0.96877600	0.74108400
H	4.42122299	-0.04910500	-3.17403900	H	5.38524800	2.11965099	-0.57851100
H	5.22450099	1.24411200	-2.27885000	H	5.41820300	2.67229600	1.09775400
H	2.09979900	-1.02195300	-0.21879200	H	2.61591400	-1.01375300	-0.12577600
H	3.60522500	0.66647300	0.55072400	H	2.97783500	-0.26182500	2.36518299
H	-0.22458300	2.43544400	1.49053800	H	-0.94674400	2.29990300	1.51181400
H	-0.78773500	1.16131801	-2.56634400	H	0.23984000	1.36455600	-2.50983800
H	-0.79137300	4.78059100	0.83001400	H	-1.41692300	4.64286499	0.82245200
H	-1.36169300	3.48063401	-3.22506400	H	-0.24765700	3.68771599	-3.19918600
H	-1.34244200	5.29261000	-1.53260400	H	-1.06262500	5.33688500	-1.53307200
H	3.75369600	3.79410500	0.15617900	H	2.67104400	2.42448300	3.73155900
H	4.58902599	4.90764500	-1.96426801	H	3.45406200	4.80309300	3.28410700

4a-R-OH external

$\Delta G^{\ddagger}$(298 K) = 30.2 kcal mol^{-1}

Reagent				**TS**			
0 1				0 1			
C	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
C	0.00000000	0.00000000	1.39678000	O	0.00000000	0.00000000	1.57811600
C	1.21965400	0.00000000	2.10113000	C	2.52727000	0.00000000	0.21142100
C	2.40367900	-0.00287500	1.35463900	C	2.52918100	0.30390400	1.58832800
C	2.40446600	0.00087200	-0.03616700	H	1.26209400	0.07078300	1.85712900
C	1.18960500	0.00290900	-0.71863200	C	-0.03462200	-1.73234400	-0.46174600
C	1.25053700	-0.05398500	3.62590400	C	2.86881300	1.20961700	-0.60026000
C	-0.08830500	0.42342100	4.23806500	O	2.82078700	1.31379600	-1.80951100
C	-1.24319900	-0.33767300	3.59110400	C	3.40651700	2.23907500	0.39885500
C	-1.33718500	0.02156700	2.10957900	C	2.64926300	1.83196600	1.68787600
C	-0.00197900	0.24902000	5.74831300	C	0.04767200	-2.04723500	-1.81947000
C	1.14818700	1.08111400	6.36333800	C	0.01887600	-3.38329801	-2.20791600
C	2.47948100	0.59909500	5.79140200	C	-0.09154900	-4.39191500	-1.25019200
C	2.46131200	0.66981500	4.25302300	C	-0.17392600	-4.06163600	0.10166499
C	-1.21813900	0.55077400	6.63950700	C	-0.14788900	-2.72823800	0.50482900
C	-0.59198100	0.56944200	8.03929600	C	3.15990900	3.71951900	0.12785600
C	0.91333500	0.84977700	7.84656700	C	3.58759900	4.55818900	1.35050600
O	1.72497300	0.86163800	8.74092700	C	2.98781000	4.06656200	2.68699501
C	0.97688200	2.60966200	6.17452700	C	3.17982000	2.54503500	2.91976300
O	1.10927600	0.00422000	-2.08595800	C	3.44675700	4.86769999	3.90108800
S	-1.34411400	1.81893100	9.20605300	C	3.46251100	4.28588399	5.18416800
C	-2.97661400	1.01376700	9.29428900	C	3.12345000	2.82538699	5.40990200
C	-3.14072400	-0.12908300	10.07358900	C	2.46127500	2.15175200	4.20920000
C	-4.39838100	-0.72238300	10.14198400	C	3.81974800	6.21202099	3.79007400
C	-5.47332000	-0.16531699	9.44729900	C	4.19493100	6.97165999	4.89370300
C	-5.29449600	0.98942800	8.68793100	C	4.20006500	6.38355499	6.15661401
C	-4.03866500	1.59056100	8.61094100	C	3.83483300	5.04927199	6.29262001
O	-1.54050600	3.09338800	8.40211300	C	4.92333000	1.93589700	0.48038200
H	-1.64631300	1.52856400	6.40429900	O	4.55606200	7.06570699	7.28981400
H	-0.22139300	1.48769700	4.00810500	H	4.24869200	2.33332600	3.04486300
H	1.34085800	-1.11483000	3.90711100	H	1.89876700	4.20572800	2.60547801
H	3.38985100	0.22828300	3.88570701	H	3.28034800	5.59122000	1.17397800

H	3.30929701	1.19234700	6.18421700	H	3.70259200	4.05479600	-0.76013699
H	2.46651100	1.71333200	3.92299601	H	4.67900901	4.57426400	1.42946500
H	2.65134900	-0.43642800	6.10605300	H	2.09421601	3.87636600	-0.07175900
H	0.25959600	-0.80532100	5.92631800	H	1.62633801	2.21257500	1.55341200
H	0.05227700	2.98739900	6.61502400	H	5.11561800	0.89813100	0.76219500
H	1.80816400	3.12316700	6.66399600	H	5.38347100	2.11070800	-0.49555099
H	0.98617400	2.87982800	5.11883300	H	5.42250701	2.57582000	1.20691901
H	-0.68970900	-0.38022200	8.57077300	H	2.60730200	-0.99098900	-0.21636400
H	-2.00679599	-0.19575300	6.55828800	H	2.98779501	-0.37195300	2.30785200
H	-2.30564900	-0.55007700	10.62360700	H	-0.21793000	-2.45553600	1.55021900
H	-3.87134699	2.49478001	8.03816100	H	0.14393300	-1.26270900	-2.56254500
H	-4.54117600	-1.61312599	10.74254500	H	-0.26269500	-4.84313100	0.84767199
H	-6.13260800	1.42701600	8.15796900	H	0.08517700	-3.63585400	-3.25978700
H	-6.45172300	-0.62752099	9.50725400	H	-0.11389000	-5.43085300	-1.55736201
H	-2.18976999	-0.10154200	4.08503300	H	2.47169200	1.06673200	4.34621500
H	-1.07857200	-1.41570400	3.71149900	H	1.40871500	2.44985500	4.13489100
H	-1.76052800	1.02974300	2.01536600	H	2.49171900	2.73276199	6.29819000
H	-2.03271300	-0.64733300	1.59438100	H	4.05499500	2.29560499	5.64648000
H	3.36020200	-0.01074900	1.86097300	H	3.82113300	6.69404599	2.82108800
H	3.34232400	0.00005700	-0.58328699	H	4.48012100	8.01199199	4.77009300
H	-0.93880600	-0.00179900	-0.54345400	H	3.84636300	4.60286099	7.28125101
H	1.99787200	0.00071000	-2.46030800	H	4.77698900	7.97607699	7.06144700

4a-R-9 external

$\Delta G^{\ddagger}(298\ K) = 29.7\ kcal\ mol^{-1}$

Reagent				**TS**			
0 1				0 1			
C	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
C	0.00000000	0.00000000	1.53065500	O	0.00000000	0.00000000	1.57819200
C	1.45698000	0.00000000	2.04981500	C	2.52046400	0.00000000	0.20372900
C	2.22456600	-1.23848200	1.61506700	C	2.53446800	0.28047400	1.58553600
C	2.21809200	-1.30163400	0.07549800	H	1.26290100	0.06022200	1.85603900
C	0.80557700	-1.20279700	-0.52955500	C	-0.04117000	-1.73234600	-0.46134000
C	-0.53844000	1.24960300	2.21034900	C	-0.15495700	-2.72801199	0.50546000
C	0.23083900	1.42647400	3.53692700	C	-0.18540100	-4.06137099	0.10241200
C	1.34444800	0.36767100	3.53617900	C	-0.10699600	-4.39194599	-1.24959200
S	0.89160000	3.18034600	3.60198800	C	0.00399500	-3.38365599	-2.20759300
C	1.41580600	3.12288100	5.34501200	C	0.03720400	-2.04765499	-1.81922900
C	2.77242200	3.04592500	5.63163200	C	2.67538400	1.80315400	1.71589000
C	3.17977600	3.03772200	6.96539700	C	3.41520300	2.23220700	0.42086101
C	2.23565900	3.11657500	7.98710100	C	2.85814400	1.22431100	-0.58934400
C	0.87662000	3.21041900	7.68161400	C	3.24051700	2.48566800	2.95076000
C	0.45960500	3.22061100	6.35381900	C	3.07769700	4.00800601	2.75043800
C	-0.85529200	-1.16573600	2.08521200	C	3.64008100	4.52918401	1.41153100
O	-1.41075300	1.98924900	1.82255300	C	3.17540100	3.72202500	0.17905301
O	2.16492900	3.19299200	2.77387600	O	2.79411800	1.35085200	-1.79563400
H	2.28675100	0.75101000	3.92923400	C	4.93066000	1.91397000	0.47078801
H	1.77452800	-2.14217200	2.04050800	H	4.29067600	2.21910500	3.10615600
H	2.82547200	-0.47070600	-0.30333800	H	2.00643000	4.23871501	2.79644400
H	0.88131900	-1.13231900	-1.61894300	H	3.34968700	5.57661000	1.28620500

H	-1.02146500	-0.02241800	-0.38949500	H	3.70010900	4.06556901	-0.71674800
H	0.25736200	-2.12863600	-0.32465700	H	4.73385000	4.52388901	1.45351100
H	0.45713100	0.93080200	-0.35255300	H	2.10633100	3.88979100	0.00716701
H	1.94180700	0.86234200	1.57317700	H	1.65745200	2.20288400	1.60517000
H	-0.88352800	-1.18323900	3.17709500	H	5.11709200	0.86524301	0.71337401
H	-1.88290600	-1.06666000	1.72649800	H	5.37829700	2.11900100	-0.50503300
H	-0.47534400	-2.13151100	1.75286300	H	5.44714600	2.52264701	1.21179201
H	-0.46676500	1.37804500	4.37422200	H	2.59665700	-0.98272700	-0.24329700
H	1.05198400	-0.48654200	4.15130500	H	2.98858100	-0.41150800	2.29293900
H	3.48471700	3.00333100	4.81615900	H	-0.22183200	-2.45511799	1.55101300
H	-0.59441700	3.30810900	6.11130800	H	0.13346100	-1.26341899	-2.56263200
H	4.23526900	2.97613300	7.20417800	H	-0.27453900	-4.84259699	0.84866200
H	0.14332800	3.28343100	8.47634600	H	0.06711000	-3.63640699	-3.25962100
H	2.55659400	3.11457000	9.02227800	H	-0.13279600	-5.43083699	-1.55666800
H	3.25474800	-1.19531300	1.98273600	H	2.69686300	2.17160200	3.84747701
H	2.70001400	-2.22198600	-0.26800900	H	3.54749600	4.55108801	3.57603100

4.1.2 Temperature effect

The effect of the temperature on the activation barrier during thermolysis of **4a-9** was then studied and is presented in Table S6. The time to reach 99% conversion of **4a-9** was calculated from the first-order integrated rate law: ln[**4a-9**] = ln[**4a-9**]$_0$ – k(T)*$t_{99\%\ conv.}$ where k(T) was extracted from the Eyring equation (2) using the activation barrier computed at the target temperature:

$$k = \frac{\kappa k_B T}{h} e^{\left(\frac{-\Delta G^{\ddagger}}{RT}\right)} \quad (2)$$

k = reaction rate constant , κ = transmission coefficient, h = Planck's constant (J s), k_B = Boltzmann constant (J K^{-1}), T = temperature (K), R = gas constant (cal K^{-1} mol^{-1}), $\Delta G^{\ddagger}$ = activation barrier (cal mol^{-1})

The reaction is considered feasible in flow for industrial perspectives when this time is below 15 min.

Table S6. Effect of the temperature on the activation barrier during thermolysis of **4a-9**

Entry	T (°C)	$\Delta G^{\ddagger}$ (kcal mol^{-1})	$t_{99\%conv.}$ (min)
1	25	28.0	379527620
2	100	27.7	16526
3	150	27.6	145
4	**200**	**24.4**	**3**
5	250	27.3	0.2

4.1.3 Substituent effects

Stationary points for compounds **4a-Y** and their corresponding TS during thermolysis are presented in Table S7. Among the four geometries that can be determined during thermolysis, only the most stable form is represented. Activation barriers are determined at 200 °C.

Table S7. Geometries of the most stable stationary point of sulfoxides **4a-Y** and their corresponding TS during thermolysis

R = 2,3,4,5,6-F (**4a-1**)							
$\Delta G^{\ddagger}$(473 K) = 25.2 kcal mol^{-1}							
Reagent				**TS**			
0 1				0 1			
C	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
C	0.00000000	0.00000000	1.52214000	O	0.00000000	0.00000000	1.57096800
C	1.43329800	0.00000000	2.10807900	C	2.54921500	0.00000000	0.21013200
C	2.15896200	-1.27628100	1.67672400	C	2.57033400	-0.04762300	1.62056700
C	2.16769100	-1.38161400	0.13930800	H	1.29194100	-0.06493900	1.86143400
C	0.76728100	-1.24511700	-0.48637200	C	-0.13612700	1.72634600	-0.49537200
C	1.14367700	0.15443900	3.59105700	C	-0.84373400	2.00695500	-1.66431900
C	-0.21935300	0.88262700	3.72415100	C	-1.02820700	3.30401801	-2.11704500
C	-0.73347000	1.10575200	2.29650800	C	-0.50011500	4.36250401	-1.38960100
S	0.00737400	2.41225400	4.75577600	C	0.21149600	4.11191801	-0.22382900
C	-1.78923600	2.83723700	4.82768300	C	0.39833000	2.80577500	0.20678500
C	-2.50933000	2.39308200	5.93145300	C	3.24116500	-1.37428500	2.00859500
C	-3.83168200	2.75368000	6.13735000	C	2.94272900	-2.32200399	0.82194500
C	-4.45599900	3.58963400	5.21999900	C	2.92360500	-1.33609600	-0.35013400
C	-3.75865800	4.04455700	4.10888100	C	4.01442900	-3.41814000	0.80505600
C	-2.43544100	3.66570000	3.91493000	C	4.02843000	-4.15572799	2.16333899
F	-1.92143200	1.58042500	6.82443300	C	4.06494200	-3.22828700	3.39689799
F	-4.50482700	2.30822900	7.20173200	C	3.04521700	-2.06759600	3.34686400
F	-5.72691600	3.94615700	5.40129400	F	-1.37485300	1.00323100	-2.37797500
F	-4.37038900	4.83582300	3.22258800	F	-1.71476300	3.54187500	-3.23774700
F	-1.82070700	4.11207600	2.81786900	F	-0.67390300	5.61518301	-1.81013300
C	2.24955300	1.26519600	1.73878700	F	0.72892000	5.13034201	0.46988800
O	1.81222600	-0.20351500	4.52897100	F	1.11912500	2.61639700	1.31844400
O	0.70130500	3.43434600	3.89426300	C	1.53155800	-2.96055499	0.87248500
H	-0.44294700	2.09405900	1.93523200	O	3.19328000	-1.56349100	-1.51204100
H	0.46254600	0.91445500	-0.38437800	H	2.02020700	-2.43380000	3.45813400
H	0.17673700	-2.13394300	-0.23098800	H	5.06610801	-2.78760700	3.47796899
H	2.60341900	-2.34133700	-0.15345900	H	4.89331400	-4.82516799	2.19540199
H	3.17974000	-1.29227700	2.06689100	H	3.83487800	-4.12951000	-0.00566800
H	2.82707700	-0.61142600	-0.27303700	H	3.15017700	-4.80429599	2.22939399
H	1.63997600	-2.14315600	2.10142200	H	4.99167201	-2.96104100	0.61821600
H	-0.44887300	-0.95411000	1.83584600	H	4.31748300	-1.15927900	1.94756300
H	1.79371500	2.18530300	2.10921200	H	0.75790600	-2.25353799	1.16537300
H	3.24512600	1.18965400	2.18253100	H	1.27717100	-3.37157099	-0.10771900
H	2.36458200	1.35813500	0.65931500	H	1.49441000	-3.77639400	1.59260400
H	-0.87464100	0.24832800	4.32806700	H	2.61014800	0.88625100	-0.40664800

H	-1.81862000	1.02080200	2.23196000	H	2.82422900	0.85498100	2.17480800
H	-1.02546500	-0.01930100	-0.38260700	H	3.22927200	-1.37803600	4.17659900
H	0.85269900	-1.23237400	-1.57706700	H	3.91602100	-3.82578699	4.30118799

R = 4-pyridine (**4a-2**)							
$\Delta G^{\ddagger}$(473 K) = 26.1 kcal mol^{-1}							
Reagent				**TS**			
0 1				0 1			
S	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
O	0.00000000	0.00000000	1.51630188	O	0.00000000	0.00000000	1.57645300
C	1.82009399	0.00000000	-0.49012137	C	2.54329800	0.00000000	0.22831100
C	2.66538267	1.04721055	0.24943434	C	2.53707000	0.35357200	1.59318900
H	2.15701415	1.43407685	1.13464482	H	1.27900300	0.13280900	1.86013201
C	1.99502260	0.27362774	-1.99279293	C	2.89569500	1.17434300	-0.62672300
C	3.07942133	1.33083150	-2.14207361	C	3.42889000	2.24339800	0.32993000
C	2.91093203	2.11948018	-0.82195603	C	2.68947800	1.88166300	1.64512100
C	2.94621286	2.29116607	-3.32647119	C	3.16274600	3.71241299	0.00373200
C	3.97076178	3.43606775	-3.19781409	C	3.61299400	4.59491399	1.18923600
C	3.92627627	4.14474130	-1.83125772	C	3.06986200	4.13625899	2.55967200
C	3.99348061	3.17192413	-0.63775678	C	3.25547300	2.62862900	2.84128200
C	4.40395691	0.53013635	-2.21797398	C	4.94844700	1.95166900	0.40342500
O	1.37333534	-0.27936695	-2.87051265	O	2.85853300	1.22342900	-1.83998200
C	-0.41416703	1.71042669	-0.49077935	C	-0.31192000	1.70678700	-0.44930600
H	4.98247038	2.70643835	-0.57024576	H	4.30912200	2.38325899	3.00559700
H	2.99057774	4.71212312	-1.75625832	H	1.99544400	4.35275899	2.60183300
H	3.79199522	4.16779845	-3.99128409	H	3.29674700	5.62646999	1.00869500
H	3.08013092	1.76336724	-4.27456806	H	3.68270900	4.01460599	-0.90935300
H	4.97832119	3.04381225	-3.36999355	H	4.70664900	4.61779899	1.22477500
H	1.93284444	2.70640864	-3.33039801	H	2.09207500	3.85107899	-0.17718000
H	1.97025367	2.67082885	-0.93083904	H	1.67894000	2.28252600	1.51772500
H	4.52004361	-0.16660115	-1.38469658	H	5.15006100	0.92310000	0.71239400
H	4.42637257	-0.04959704	-3.14398001	H	5.39722600	2.10122400	-0.58182500
H	5.26890265	1.19265739	-2.21327239	H	5.45183500	2.61375600	1.10636600
H	2.08591774	-1.03454800	-0.26402833	H	2.61007900	-1.00690800	-0.16449100
H	3.59917662	0.59511265	0.59174587	H	2.98773800	-0.30479100	2.33535800
H	3.83768465	3.71849857	0.29791110	H	2.71930900	2.35626800	3.75603300
H	4.73893846	4.87479499	-1.77143965	H	3.53712000	4.73067499	3.35048000
C	-0.46971130	2.68555102	0.49389735	C	-0.75300400	2.63192900	0.49332800
H	-0.26914586	2.43387989	1.52764370	H	-0.90568100	2.34308600	1.52492500
C	-0.72553409	2.02892258	-1.80832133	C	-0.13433400	2.10440500	-1.77155500
H	-0.72086310	1.28529338	-2.59431886	H	0.22149100	1.41964600	-2.53036400
C	-0.79242577	3.98226889	0.09880354	C	-0.98064200	3.93454000	0.06436900
H	-0.83510561	4.78083635	0.83288615	H	-1.32199800	4.68536100	0.77033800
C	-1.03568541	3.35737701	-2.08995963	C	-0.39217200	3.43630600	-2.08807400
H	-1.27420506	3.65514537	-3.10612336	H	-0.24819000	3.78597700	-3.10544200
N	-1.06137381	4.32337943	-1.16539395	N	-0.80234500	4.34430400	-1.19768800

R = *p*-SO_2CF_3 (**4a-3**)
$\Delta G^{\ddagger}$(473 K) = 26.8 kcal mol^{-1}

Reagent				**TS**			
0 1				0 1			
S	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
O	0.00000000	0.00000000	1.51532843	O	0.00000000	0.00000000	1.57477200
C	1.82253299	0.00000000	-0.49393292	C	2.55537300	0.00000000	0.23528000
C	2.66824904	1.05002634	0.24082540	C	2.54001500	0.37038000	1.59544200
H	2.16860235	1.42971865	1.13421599	H	1.28879300	0.14072700	1.86040500
C	1.99176341	0.27288088	-1.99804154	C	2.90188300	1.16585600	-0.63343100
C	3.06087920	1.34466935	-2.15310824	C	3.42151200	2.25218900	0.30970000
C	2.89595195	2.12751340	-0.82918050	C	2.68248200	1.90053600	1.62816300
C	2.90272222	2.30702607	-3.33324016	C	3.13801500	3.71315201	-0.03842100
C	3.90881649	3.46865315	-3.20960777	C	3.57000100	4.61974801	1.13544100
C	3.86585529	4.17141387	-1.84013110	C	3.03315000	4.17157501	2.51193700
C	3.96490514	3.19490435	-0.65183843	C	3.23796300	2.67027200	2.81471100
C	4.39497734	0.56223277	-2.24514268	C	4.94392300	1.97943700	0.39208800
O	1.37428153	-0.29034189	-2.87232385	O	2.86479600	1.19813000	-1.84734200
C	-0.39591594	1.71508272	-0.49020799	C	-0.28997100	1.71045500	-0.44923600
C	-0.39422775	2.68762314	0.50343127	C	-0.71381900	2.62948700	0.51302300
C	-0.63286715	4.01151115	0.15384803	C	-0.89613900	3.95593100	0.15298000
C	-0.88172641	4.31076292	-1.18469955	C	-0.65336100	4.33134100	-1.16925501
C	-0.93695956	3.33186588	-2.17636776	C	-0.25661100	3.41643101	-2.14266800
C	-0.69976395	2.01078644	-1.81817734	C	-0.07678900	2.08910101	-1.77639001
H	4.96188835	2.74493111	-0.59971294	H	4.29428900	2.44039800	2.98307100
H	2.92063065	4.72143946	-1.75272144	H	1.95622900	4.37553101	2.55243900
H	3.70929660	4.20012584	-3.99814034	H	3.23603300	5.64274600	0.93961400
H	3.03762103	1.78455931	-4.28406740	H	3.65707500	4.00949001	-0.95375300
H	4.92113299	3.09435896	-3.39313023	H	4.66285200	4.66258701	1.17141500
H	1.88291440	2.70570427	-3.32824911	H	2.06678400	3.83406401	-0.22621500
H	1.94992967	2.66990747	-0.93012823	H	1.66928200	2.29078100	1.49342400
H	4.52732800	-0.14038913	-1.41919508	H	5.15687900	0.95853001	0.71850200
H	4.41781913	-0.00930606	-3.17616627	H	5.39415600	2.11875600	-0.59391900
H	5.25018852	1.23702525	-2.24099041	H	5.43628600	2.65907400	1.08595300
H	2.08797844	-1.03421665	-0.26636506	H	2.62108400	-1.01180200	-0.14514400
H	3.60790121	0.60099019	0.57096203	H	2.99310200	-0.27630900	2.34666000
H	-0.19261066	2.40035893	1.52797524	H	-0.87551100	2.30399400	1.53233400
H	-0.72624774	1.23195975	-2.56895229	H	0.26729700	1.37068101	-2.50897401
H	-0.60710300	4.79751679	0.89722724	H	-1.20131500	4.69175300	0.88533700
H	-1.14401617	3.59929824	-3.20415128	H	-0.05834700	3.74073001	-3.15558200
H	3.81206075	3.73447835	0.28835511	H	2.70443100	2.40395400	3.73274301
H	4.66448448	4.91695913	-1.78641675	H	3.49266700	4.78271801	3.29426300
S	-1.14824381	6.01265786	-1.64786059	S	-0.83083000	6.04208000	-1.62039401
O	-0.59002879	6.89330848	-0.62629153	O	-0.72638000	6.87989000	-0.42859701
O	-0.85725779	6.18692836	-3.06777241	O	-0.06638200	6.31820000	-2.83314800
C	-3.03320295	6.18969079	-1.49202142	C	-2.65261200	6.14536900	-2.14632400
F	-3.64363751	5.34898989	-2.32974658	F	-2.88715400	5.30261800	-3.15502101
F	-3.41744998	5.91617736	-0.24364778	F	-3.44720600	5.82758500	-1.12144000
F	-3.37099447	7.43996940	-1.79567702	F	-2.91670500	7.38917500	-2.53944401

R = *p*-C(O)CH$_3$ (**4a-4**)							
$\Delta G^{\ddagger}$(473 K) = 27.0 kcal mol^{-1}							
Reagent				**TS**			
0 1				0 1			
S	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
O	0.00000000	0.00000000	1.51753345	O	0.00000000	0.00000000	1.57775800
C	1.82424462	0.00000000	-0.48569418	C	2.54708500	0.00000000	0.23973800
C	2.65941291	1.06451917	0.23996097	C	2.53325200	0.37439600	1.59897900
H	2.15166854	1.44911296	1.12666840	H	1.27255800	0.14399900	1.86359600
C	1.99990244	0.25348864	-1.99140786	C	2.89521900	1.16127700	-0.63239700
C	3.05553693	1.33842010	-2.15512030	C	3.40949300	2.25377900	0.30893000
C	2.87853044	2.13310347	-0.84042074	C	2.66841800	1.90456800	1.62622700
C	2.89131509	2.28645713	-3.34587075	C	3.12028800	3.71208100	-0.04448700
C	3.88969500	3.45577235	-3.23303065	C	3.54784600	4.62411901	1.12695900
C	3.83751191	4.17329889	-1.87123053	C	3.00792500	4.17994401	2.50370100
C	3.93815422	3.21113374	-0.67133423	C	3.21762800	2.68055400	2.81163400
C	4.39824188	0.56933131	-2.23481987	C	4.93242899	1.98748200	0.39533200
O	1.40378737	-0.33577778	-2.86326472	O	2.86969500	1.18896800	-1.84669800
C	-0.41321653	1.70372238	-0.49769512	C	-0.32302100	1.70324900	-0.45290300
C	-0.43665328	2.68632149	0.48333183	C	-0.77256600	2.61849200	0.49777400
C	-0.71806590	3.99883123	0.11679639	C	-1.01377300	3.93084900	0.11375800
C	-0.98395063	4.32234693	-1.21932302	C	-0.81990700	4.33697300	-1.21381800
C	-0.99716946	3.30372893	-2.18235270	C	-0.38426600	3.39582700	-2.15562000
C	-0.72376414	1.99095539	-1.82726170	C	-0.13527100	2.08268700	-1.78438000
H	4.93872390	2.77030081	-0.60917320	H	4.27460499	2.45602500	2.98369600
H	2.88705124	4.71580271	-1.79412665	H	1.92955800	4.37787401	2.53884000
H	3.68813138	4.17726443	-4.03037325	H	3.21399300	5.64676301	0.92657000
H	3.03163147	1.75476112	-4.29083966	H	3.63912900	4.00722801	-0.96046200
H	4.90519559	3.08631881	-3.40904260	H	4.64052400	4.66919501	1.16637000
H	1.86883711	2.67814284	-3.34623616	H	2.04829600	3.82549400	-0.23326000
H	1.92645851	2.66304482	-0.94811375	H	1.65381500	2.28990100	1.48553800
H	4.53249896	-0.12555414	-1.40260089	H	5.14760499	0.96793901	0.72450500
H	4.43113532	-0.00955437	-3.16103124	H	5.38432099	2.12539800	-0.59019800
H	5.24741171	1.25189124	-2.23192820	H	5.42221099	2.66987200	1.08862100
H	2.09438820	-1.02975409	-0.24382303	H	2.61716100	-1.01283100	-0.13692200
H	3.60283624	0.62877329	0.57751577	H	2.98629600	-0.26758000	2.35391400
H	-0.23239811	2.41444459	1.51161426	H	-0.91888100	2.30016000	1.52190300
H	-0.73614666	1.20747895	-2.57434671	H	0.22887800	1.37012000	-2.51394500
H	-0.72360432	4.76634133	0.87985816	H	-1.35830000	4.63698201	0.85804400
H	-1.22441293	3.55993968	-3.20919078	H	-0.22866200	3.71355600	-3.17858700
H	3.77704820	3.76037071	0.26208614	H	2.68290900	2.41531700	3.72938000
H	4.63098760	4.92513807	-1.82321975	H	3.46224300	4.79587500	3.28562800
C	-1.26496525	5.72890898	-1.66048244	C	-1.05522200	5.74680100	-1.65797300
O	-1.45472400	5.97819707	-2.83795622	O	-0.89952700	6.06392300	-2.82483300
C	-1.30207303	6.82042754	-0.61739467	C	-1.48301200	6.76711200	-0.62771900
H	-2.07050420	6.61253458	0.13286114	H	-2.42339700	6.47150400	-0.15357100
H	-0.34366491	6.88975172	-0.09436110	H	-0.73180600	6.85955200	0.16214000
H	-1.51764206	7.77112008	-1.10247020	H	-1.61338500	7.73218400	-1.11493900

R = 2,3,4,5,6-Cl (**4a-5**)							
$\Delta G^{\ddagger}$(473 K) = 27.2 kcal mol^{-1}							
Reagent				**TS**			
0 1				0 1			
S	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
O	0.00000000	0.00000000	1.50386284	O	0.00000000	0.00000000	1.55965200
C	1.78923634	0.00000000	-0.61352401	C	2.59681900	0.00000000	0.25017800
C	2.58988385	-0.97084009	0.27533523	C	2.54754500	0.24794700	1.64035800
H	1.96151850	-1.70046647	0.78878245	H	1.30692199	0.06640000	1.86553100
C	2.52504532	1.35192791	-0.53710436	C	3.03865900	1.22849300	-0.48461600
C	3.73026429	1.17582094	0.37624707	C	3.57506700	2.18699900	0.57977100
C	3.27871203	-0.01155476	1.25437136	C	2.75433400	1.75999100	1.82169500
C	4.10145168	2.36179217	1.27194512	C	3.40088900	3.68890700	0.35707900
C	5.19012936	1.94047335	2.27798209	C	3.81974500	4.45479400	1.63096100
C	4.82223157	0.67427212	3.07323946	C	3.17392600	3.92081300	2.92675000
C	4.38308650	-0.50111787	2.17809041	C	3.27987200	2.38963199	3.10092599
C	4.89476918	0.82880829	-0.58639416	C	5.07316299	1.81322200	0.70230600
O	2.21875470	2.33329422	-1.17109890	O	3.06663300	1.38657300	-1.68761200
C	-0.52610971	1.65733605	-0.64377938	C	-0.13067500	1.71571200	-0.59435200
H	5.23127762	-0.88528119	1.60097617	H	4.31113899	2.08424600	3.30319999
H	3.99595989	0.91124342	3.75446513	H	2.10940700	4.18353700	2.92406900
H	5.37387239	2.76503397	2.97335257	H	3.56177500	5.51146300	1.51388800
H	4.44027682	3.21089230	0.67231966	H	3.98480600	4.03183900	-0.50112900
H	6.13404123	1.77553492	1.74821544	H	4.90896000	4.41971400	1.72964200
H	3.20931168	2.68796485	1.81440577	H	2.35128400	3.89641800	0.13028300
H	2.47672359	0.37695725	1.89545808	H	1.76614900	2.20740500	1.67944400
H	4.64475022	0.01368268	-1.26943973	H	5.21116199	0.75566801	0.94019900
H	5.13777598	1.70549756	-1.19118267	H	5.57777499	2.01350900	-0.24624600
H	5.78921742	0.53462587	-0.03835608	H	5.56976099	2.39525800	1.47739000
H	1.67172462	-0.30296156	-1.65486871	H	2.64893600	-0.97324000	-0.22057700
H	3.30749925	-1.52362860	-0.33527822	H	2.95963700	-0.48128200	2.33864099
H	4.02220065	-1.32741784	2.79868526	H	2.67924900	2.07509200	3.96010199
H	5.66801790	0.37657549	3.70033153	H	3.61659600	4.43104000	3.78728999
C	-0.52668608	2.82842877	0.11442882	C	-0.40908600	2.85191000	0.17403100
C	-1.07305176	1.67091729	-1.92701297	C	0.12233700	1.87353800	-1.96322400
C	-1.11120494	3.99532030	-0.39717003	C	-0.29294000	4.12862900	-0.39401700
C	-1.64318658	2.82926359	-2.45694259	C	0.22135900	3.13851401	-2.54343900
C	-1.67478457	3.99293194	-1.67833321	C	0.04625100	4.27375300	-1.74449901
Cl	0.26006559	2.89588636	1.66056410	Cl	-0.94651000	2.72609200	1.82443199
Cl	-0.99332366	0.22883520	-2.91143295	Cl	0.28491500	0.45174000	-2.95680500
Cl	-2.31069354	2.82908000	-4.05874137	Cl	0.58037500	3.30010101	-4.23037100
Cl	-2.40111962	5.43419359	-2.31175004	Cl	0.24108100	5.85466600	-2.42915901
Cl	-1.12221648	5.45214813	0.54587418	Cl	-0.55791500	5.54181800	0.57970900
R = *p*-C_6H_5 (**4a-6**)							
$\Delta G^{\ddagger}$(473 K) = 27.2 kcal mol^{-1}							
Reagent				**TS**			
0 1				0 1			
S	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000

O	0.00000000	0.00000000	1.51876704	O	0.00000000	0.00000000	1.57952800
C	1.82825902	0.00000000	-0.48218603	C	2.55025000	0.00000000	0.25544300
C	2.65719851	1.07247106	0.23869705	C	2.52782800	0.39390000	1.60930000
H	2.15148776	1.45000821	1.12952849	H	1.26014800	0.15851200	1.86931000
C	2.00112713	0.25066325	-1.98744800	C	2.90598800	1.14592600	-0.62997700
C	3.03838615	1.35332702	-2.15684242	C	3.40625900	2.25661900	0.29807800
C	2.85551041	2.14512412	-0.84174958	C	2.65568500	1.92476400	1.61433300
C	2.85165929	2.29838839	-3.34671204	C	3.11189100	3.70731800	-0.08149700
C	3.82952059	3.48540692	-3.23878520	C	3.52146801	4.64261200	1.07802601
C	3.77215564	4.20220236	-1.87680916	C	2.97374901	4.21629900	2.45743500
C	3.89720218	3.24140701	-0.67801351	C	3.19091500	2.72350300	2.79110600
C	4.39392418	0.60856333	-2.24421029	C	4.92964100	2.00094700	0.40328300
O	1.41714631	-0.35170729	-2.85929646	O	2.89830100	1.15442400	-1.84572800
C	-0.41074800	1.69772440	-0.50156822	C	-0.31649900	1.70477200	-0.45415300
H	4.90623150	2.81912511	-0.62182367	H	4.24796800	2.50848800	2.97541200
H	2.81382650	4.72911837	-1.79247918	H	1.89424801	4.40786500	2.47997500
H	3.61263603	4.20326892	-4.03584265	H	3.17783801	5.65785000	0.85781401
H	2.99617482	1.76909968	-4.29260266	H	3.63903001	3.99052900	-0.99688700
H	4.85034194	3.13328862	-3.41967699	H	4.61341900	4.69919800	1.12587601
H	1.82220434	2.67077482	-3.33942754	H	2.04161701	3.81099800	-0.28203600
H	1.89490332	2.65920247	-0.94380839	H	1.64102300	2.30307400	1.45805400
H	4.54551539	-0.08088044	-1.41052080	H	5.14713800	0.99017300	0.75714800
H	4.43191697	0.02767758	-3.16903123	H	5.38994700	2.11940800	-0.58104300
H	5.23026309	1.30700381	-2.24805291	H	5.40969000	2.70138200	1.08547700
H	2.10154861	-1.02766129	-0.23533904	H	2.62236900	-1.01830800	-0.10557400
H	3.60816545	0.64731566	0.56881242	H	2.97743900	-0.23460500	2.37744500
H	3.73062185	3.78796305	0.25583128	H	2.65046900	2.47005700	3.70893101
H	4.55321848	4.96730116	-1.83355108	H	3.41775500	4.84804200	3.23277600
C	-0.40525174	2.69825781	0.46281146	C	-0.77835000	2.62370900	0.48706100
C	-0.71494505	1.98018988	-1.83121803	C	-0.09559900	2.09259700	-1.77532200
C	-0.63990459	4.01281558	0.07646635	C	-0.98673700	3.94256700	0.10647200
C	-0.94457466	3.29839008	-2.20594580	C	-0.31182700	3.41525300	-2.14330800
C	-0.89110912	4.33772559	-1.26465814	C	-0.74800400	4.36562401	-1.21026700
H	-0.19828478	2.43961108	1.49412835	H	-0.94406000	2.30735500	1.50919400
H	-0.59665348	4.80044714	0.81915276	H	-1.31280500	4.66138000	0.84871200
H	-1.18435098	3.52194075	-3.23835842	H	-0.13710900	3.71089300	-3.17057700
H	-0.75850800	1.18879675	-2.56900873	H	0.26840000	1.38075700	-2.50586799
C	-1.08894102	5.74550872	-1.68134973	C	-0.92777800	5.78413800	-1.59648600
C	-0.54709910	6.21286330	-2.88718580	C	-0.02814700	6.40286600	-2.47663199
C	-1.80907898	6.64258916	-0.88025740	C	-1.98970900	6.54344800	-1.08518100
C	-0.71951111	7.53682096	-3.27973067	C	-0.18655700	7.73826200	-2.83490199
H	0.03234780	5.54030293	-3.50891978	H	0.81303100	5.83977801	-2.86384099
C	-1.98340815	7.96596738	-1.27439093	C	-2.14847700	7.87862901	-1.44478800
H	-2.25544239	6.29547139	0.04421588	H	-2.70777700	6.07833900	-0.41996699
C	-1.43876764	8.41877531	-2.47491498	C	-1.24739300	8.48201500	-2.32074200
H	-0.28535450	7.88192662	-4.21119966	H	0.52463400	8.20069800	-3.50995399
H	-2.55219195	8.64230145	-0.64650876	H	-2.98149100	8.44653501	-1.04618800
H	-1.57416224	9.44970603	-2.78078472	H	-1.37068100	9.52203800	-2.59993000

R = *p*-Br (**4a-7**)							
$\Delta G^{\ddagger}$(473 K) = 27.4 kcal mol^{-1}							
Reagent				**TS**			
0 1				0 1			
S	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
O	0.00000000	0.00000000	1.51774986	O	0.00000000	0.00000000	1.57846800
C	1.82488558	0.00000000	-0.48416188	C	2.54798000	0.00000000	0.24776400
C	2.66160170	1.05682281	0.25049649	C	2.53131300	0.38176500	1.60481200
H	2.15762948	1.43031101	1.14414700	H	1.26616800	0.14879000	1.86672600
C	1.99812975	0.26954578	-1.98666562	C	2.89408400	1.15662500	-0.62957000
C	3.05176730	1.35764009	-2.14179168	C	3.40195900	2.25724300	0.30539300
C	2.87557812	2.13785431	-0.81852456	C	2.66209500	1.91248200	1.62460700
C	2.88096097	2.31787785	-3.32177650	C	3.10699700	3.71247199	-0.05658600
C	3.87404688	3.49083030	-3.19899476	C	3.52980300	4.63349200	1.10958500
C	3.82404006	4.19280157	-1.82892685	C	2.99311600	4.19397999	2.48913800
C	3.93191605	3.21753693	-0.64036812	C	3.20905500	2.69714100	2.80540500
C	4.39674054	0.59422839	-2.23344720	C	4.92610800	1.99830300	0.39459200
O	1.39859509	-0.30825391	-2.86435155	O	2.87082700	1.17773900	-1.84469100
C	-0.41644262	1.70249140	-0.49429593	C	-0.31531600	1.70755200	-0.44984400
C	-0.42100906	2.69042977	0.48278849	C	-0.77216700	2.62010500	0.49975000
C	-0.69456082	4.00728601	0.12366156	C	-0.99636200	3.94175200	0.13145000
C	-0.97109639	4.29864135	-1.20917875	C	-0.76859100	4.32708900	-1.18752200
C	-1.01407547	3.30447159	-2.18331475	C	-0.33499300	3.41802400	-2.14631600
C	-0.74199587	1.98931576	-1.81771073	C	-0.10668100	2.09651600	-1.77252000
H	4.93431372	2.77977699	-0.58617362	H	4.26692300	2.47744500	2.97837800
H	2.87276623	4.73213355	-1.74148999	H	1.91425000	4.38832100	2.52385800
H	3.66617602	4.22053076	-3.98736178	H	3.18830200	5.65232500	0.90352100
H	3.02067961	1.79708587	-4.27296043	H	3.62609200	4.00441200	-0.97358300
H	4.89053616	3.12835041	-3.38355436	H	4.62225601	4.68572200	1.14802400
H	1.85652478	2.70465417	-3.31435383	H	2.03507001	3.82235999	-0.24713200
H	1.92162551	2.66600838	-0.91829193	H	1.64669101	2.29452700	1.48223000
H	4.53955545	-0.10275704	-1.40450856	H	5.14543000	0.98248000	0.73241700
H	4.42651975	0.01930696	-3.16227738	H	5.37798200	2.13008000	-0.59183401
H	5.24287702	1.28054492	-2.23290574	H	5.41244600	2.68864400	1.08240400
H	2.09373202	-1.03215957	-0.25156688	H	2.62030200	-1.01472000	-0.12326200
H	3.60701693	0.61827737	0.57866295	H	2.98199500	-0.25520100	2.36526099
H	-0.20689428	2.42331377	1.51053603	H	-0.93610400	2.29858700	1.52044299
H	-0.76889379	1.20679197	-2.56547720	H	0.26214800	1.39048700	-2.50594300
H	-0.68908802	4.79027357	0.87049137	H	-1.34229000	4.65931100	0.86372400
H	-1.25536061	3.54601016	-3.20995845	H	-0.15564600	3.73071900	-3.16629600
H	3.77130652	3.75612867	0.29916785	H	2.67563400	2.43510600	3.72485300
H	4.61556230	4.94624287	-1.77510265	H	3.44554900	4.81614199	3.26721800
Br	-1.31412467	6.11567805	-1.71689384	Br	-1.04834799	6.15735100	-1.68726701
R = *p*-OCH_3 (**4a-8**)							
$\Delta G^{\ddagger}$(473 K) = 27.4 kcal mol^{-1}							
Reagent				**TS**			
0 1				0 1			
S	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000

O	0.00000000	0.00000000	1.51974483	O	0.00000000	0.00000000	1.58102300
C	1.82867580	0.00000000	-0.47677679	C	2.54792000	0.00000000	0.26155600
C	2.65572188	1.06756114	0.25322854	C	2.52521300	0.39496300	1.61499300
H	2.14632577	1.43902921	1.14461081	H	1.25018600	0.15802100	1.87258600
C	2.00147257	0.26279362	-1.97890729	C	2.89456800	1.14661600	-0.62468200
C	3.04175594	1.36342517	-2.13948312	C	3.39145200	2.26082499	0.30145900
C	2.85650313	2.14702801	-0.81972268	C	2.64577100	1.92608700	1.61962700
C	2.86026485	2.31610792	-3.32376230	C	3.09016800	3.71033899	-0.07753900
C	3.84157763	3.49934065	-3.20596902	C	3.49980600	4.64709000	1.08101300
C	3.78183774	4.20796221	-1.83981052	C	2.95747001	4.21890100	2.46199900
C	3.90014987	3.23991866	-0.64639419	C	3.18104600	2.72698100	2.79494000
C	4.39582376	0.61625460	-2.22790811	C	4.91633200	2.01239699	0.40294500
O	1.41288929	-0.32720313	-2.85651335	O	2.88206500	1.15679900	-1.84087999
C	-0.42981119	1.68911521	-0.49974547	C	-0.33239100	1.70092600	-0.45328000
H	4.90784152	2.81444787	-0.58950327	H	4.23937601	2.51587700	2.97649700
H	2.82386191	4.73573858	-1.75506360	H	1.87731901	4.40627800	2.48724600
H	3.63000146	4.22260623	-3.99958814	H	3.15210100	5.66140900	0.86237800
H	3.00551558	1.79237343	-4.27266748	H	3.61396300	3.99524299	-0.99440500
H	4.86185675	3.14482572	-3.38534302	H	4.59168701	4.70774200	1.12563200
H	1.83166732	2.69144581	-3.31661484	H	2.01872101	3.81051199	-0.27527400
H	1.89561031	2.66197582	-0.92035869	H	1.62900301	2.30045500	1.46597100
H	4.54321091	-0.07949838	-1.39872675	H	5.13883700	1.00278899	0.75685700
H	4.43517935	0.04169522	-3.15667720	H	5.37357200	2.13211499	-0.58269700
H	5.23391691	1.31261221	-2.22441124	H	5.39546500	2.71514999	1.08344100
H	2.10204359	-1.02937192	-0.23723448	H	2.62377700	-1.01814800	-0.09902200
H	3.60618157	0.64154488	0.58379325	H	2.97317900	-0.23111600	2.38581600
H	3.73225602	3.78133982	0.29018937	H	2.64393101	2.47158100	3.71418900
H	4.56433363	4.97122328	-1.78932091	H	3.40125700	4.85240500	3.23609400
C	-0.42409148	2.69944053	0.46096116	C	-0.81121700	2.61637800	0.48800700
C	-0.76882699	1.96381550	-1.81924055	C	-0.12256400	2.09408700	-1.77120600
C	-0.70632092	4.00164550	0.08381056	C	-1.05442600	3.92510800	0.10945400
C	-1.04904910	3.27321603	-2.20507461	C	-0.37592600	3.40948000	-2.15784900
C	-1.00444545	4.29889421	-1.25393808	C	-0.83346400	4.33264000	-1.21435600
H	-0.19809464	2.44990417	1.49047415	H	-0.97615700	2.29819400	1.50969100
H	-0.70304657	4.80700156	0.80825890	H	-1.41860800	4.65232700	0.82500200
H	-1.30023318	3.47705988	-3.23640116	H	-0.19150500	3.69909100	-3.18257199
H	-0.80064097	1.17154190	-2.55702574	H	0.26548700	1.39293600	-2.49977600
O	-1.24778242	5.60482654	-1.52941773	O	-1.08952800	5.64011700	-1.48073199
C	-1.56084927	5.96864930	-2.87304572	C	-0.89321800	6.11283400	-2.81179800
H	-1.70951186	7.04706995	-2.86051148	H	-1.15074600	7.17066900	-2.79090800
H	-0.73795915	5.72352269	-3.55208518	H	0.14972000	6.00087500	-3.12468400
H	-2.47944760	5.47996742	-3.21255895	H	-1.54938800	5.59461500	-3.51841200
R = H (**4a-9**)							
$\Delta G^{\ddagger}$(473 K) = 27.4 kcal mol^{-1}							
Reagent				**TS**			
0 1				0 1			
S	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
O	0.00000000	0.00000000	1.51856000	O	0.00000000	0.00000000	1.57952100

C	1.82284000	0.00000000	-0.48481300	C	2.54359700	0.00000000	0.24779300
C	2.65602800	1.08703800	0.20996500	C	2.52878400	0.37779900	1.60611300
H	2.15241699	1.48889400	1.09129300	H	1.25938100	0.14804700	1.86772800
C	1.98734900	0.21936800	-1.99599400	C	2.89645000	1.15694300	-0.62574900
C	3.03307799	1.30723900	-2.19270400	C	3.40736000	2.25303399	0.31395300
C	2.85858900	2.13225400	-0.89652700	C	2.66246700	1.90773100	1.62993200
C	2.84919599	2.22338900	-3.40474800	C	3.12024600	3.71062399	-0.04403600
C	3.83886599	3.40284200	-3.33165800	C	3.54588000	4.62553399	1.12610801
C	3.79715099	4.15277900	-1.98653001	C	3.00150100	4.18537500	2.50242200
C	3.91210100	3.22163700	-0.76348700	C	3.20890700	2.68667600	2.81471300
C	4.38354199	0.55157500	-2.26200100	C	4.93000600	1.98682399	0.40629500
O	1.38838800	-0.39062200	-2.85199000	O	2.87970200	1.18132400	-1.84094500
C	-0.43463100	1.69493900	-0.50589300	C	-0.33260600	1.70359000	-0.45752300
C	-0.45524300	2.69101900	0.46345700	C	-0.79974300	2.61682800	0.48705100
C	-0.77851000	3.99252900	0.08590100	C	-1.05819800	3.92584700	0.09291600
C	-1.09022100	4.27913900	-1.24276100	C	-0.86220100	4.31506900	-1.23287400
C	-1.09947800	3.26124801	-2.19665200	C	-0.40852100	3.38907099	-2.17001400
C	-0.77906900	1.95625101	-1.83075600	C	-0.13982400	2.07682599	-1.78769600
H	4.91615299	2.78945400	-0.69668300	H	4.26522100	2.46141600	2.99077500
H	2.84637399	4.69468800	-1.91220701	H	1.92343600	4.38446899	2.53288600
H	3.62307500	4.10378300	-4.14360100	H	3.21226300	5.64766299	0.92267000
H	2.98336799	1.66976299	-4.33810701	H	3.64293900	4.00246299	-0.95917799
H	4.85506200	3.03701500	-3.51135400	H	4.63861700	4.67010499	1.16850701
H	1.82290700	2.60514600	-3.40207800	H	2.04896400	3.82541699	-0.23573300
H	1.90080399	2.65109800	-1.00849300	H	1.64830000	2.29284900	1.48483100
H	4.53056799	-0.12087200	-1.41367900	H	5.14353100	0.96877600	0.74108400
H	4.42122299	-0.04910500	-3.17403900	H	5.38524800	2.11965099	-0.57851100
H	5.22450099	1.24411200	-2.27885000	H	5.41820300	2.67229600	1.09775400
H	2.09979900	-1.02195300	-0.21879200	H	2.61591400	-1.01375300	-0.12577600
H	3.60522500	0.66647300	0.55072400	H	2.97783500	-0.26182500	2.36518299
H	-0.22458300	2.43544400	1.49053800	H	-0.94674400	2.29990300	1.51181400
H	-0.78773500	1.16131801	-2.56634400	H	0.23984000	1.36455600	-2.50983800
H	-0.79137300	4.78059100	0.83001400	H	-1.41692300	4.64286499	0.82245200
H	-1.36169300	3.48063401	-3.22506400	H	-0.24765700	3.68771599	-3.19918600
H	-1.34244200	5.29261000	-1.53260400	H	-1.06262500	5.33688500	-1.53307200
H	3.75369600	3.79410500	0.15617900	H	2.67104400	2.42448300	3.73155900
H	4.58902599	4.90764500	-1.96426801	H	3.45406200	4.80309300	3.28410700

R = *m,m*-NO_2 (**4a-10**)

$\Delta G^{\ddagger}$(473 K) = 27.8 kcal mol^{-1}

Reagent				**TS**			
0 1				0 1			
S	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
O	0.00000000	0.00000000	1.51325695	O	0.00000000	0.00000000	1.57256000
C	1.81610933	0.00000000	-0.50355618	C	2.55282500	0.00000000	0.23167700
C	2.68204317	1.02540435	0.24231370	C	2.54651400	0.30318400	1.60815100
H	2.19880975	1.39416607	1.14953599	H	1.29187600	0.09891300	1.86194300
C	1.95718156	0.31119880	-2.00294434	C	2.89184701	1.21347800	-0.57677600
C	3.04058317	1.36729231	-2.15356102	C	3.45421000	2.23096100	0.41582200

C	2.91320431	2.12194067	-0.80869046	C	2.72150600	1.82665400	1.72269200
C	2.87017101	2.35899452	-3.30722269	C	3.21258101	3.71680900	0.15323500
C	3.89540321	3.50322874	-3.18051233	C	3.68914800	4.54060800	1.37016500
C	3.90308517	4.17010333	-1.79203354	C	3.15008800	4.03570900	2.72537600
C	4.00725771	3.16387169	-0.62903952	C	3.30999701	2.51465000	2.94334700
C	4.36191769	0.57102887	-2.28928444	C	4.96938800	1.90958100	0.45910400
O	1.29826761	-0.20669631	-2.87460024	O	2.80836601	1.32630300	-1.78327600
C	-0.40239739	1.72681327	-0.46609403	C	-0.25838500	1.71989400	-0.44324700
H	4.99490656	2.69257002	-0.60862831	H	4.35995401	2.24320300	3.08801000
H	2.97434648	4.74114408	-1.66674937	H	2.08119801	4.27185800	2.79287900
H	3.68513177	4.25789356	-3.94389151	H	3.39303500	5.58503700	1.23579500
H	2.97268991	1.85810624	-4.27304789	H	3.72820000	4.04757300	-0.75219200
H	4.89602798	3.12009607	-3.40413770	H	4.78311301	4.54047600	1.39470900
H	1.85545271	2.77061765	-3.27088655	H	2.14228701	3.88158200	-0.01062900
H	1.97670102	2.68700394	-0.88109547	H	1.71506801	2.24743000	1.62734600
H	4.50802797	-0.14074620	-1.47368334	H	5.15633300	0.86569200	0.72180200
H	4.35491197	0.00944758	-3.22642661	H	5.40891200	2.09376900	-0.52432100
H	5.22401624	1.23674281	-2.30052623	H	5.49185000	2.53248100	1.18329900
H	2.07700246	-1.04146237	-0.30487590	H	2.61798000	-0.99041400	-0.20090600
H	3.61914259	0.55782461	0.55279230	H	2.98348200	-0.38996100	2.32641500
H	3.88690820	3.68396505	0.32661133	H	2.77533800	2.21521300	3.85004000
H	4.71986959	4.89536715	-1.73963761	H	3.63734801	4.58705600	3.53456800
C	-0.41230822	2.66994634	0.55219553	C	-0.63012500	2.64496700	0.52793500
H	-0.19484154	2.37420715	1.57062031	H	-0.76617500	2.34136400	1.55662200
C	-0.72391967	2.06209032	-1.77725659	C	-0.08255600	2.10240200	-1.77166300
H	-0.74348361	1.32673528	-2.56960852	H	0.22187500	1.39857800	-2.53382600
C	-0.70534360	3.98592559	0.21864057	C	-0.80326500	3.96672400	0.14293000
C	-1.00743715	3.39429140	-2.05335712	C	-0.27807100	3.43784700	-2.10013600
C	-1.00014719	4.38135432	-1.07790661	C	-0.63245500	4.39853700	-1.16525300
H	-1.22328831	5.41044482	-1.31652327	H	-0.76368600	5.43383800	-1.44023900
N	-0.68719490	5.01454059	1.28406569	N	-1.15714300	4.96575500	1.17592000
O	-0.99998752	6.15542896	0.97400148	O	-1.37260300	6.11170800	0.80669200
O	-0.35272606	4.65812848	2.40456770	O	-1.20199100	4.58530700	2.33808800
N	-1.31286284	3.78081277	-3.44999194	N	-0.07485200	3.85827600	-3.50497900
O	-1.46172892	4.97153814	-3.68653175	O	-0.12342600	5.05597499	-3.74965900
O	-1.38886670	2.88551918	-4.27873374	O	0.12872200	2.98206200	-4.33256801

R = 2-pyridine (**4a-11**)

$\Delta G^{\ddagger}$(473 K) = 27.9 kcal mol^{-1}

Reagent				**TS**			
0 1				0 1			
S	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
O	0.00000000	0.00000000	1.51050461	O	0.00000000	0.00000000	1.56819000
C	1.81677164	0.00000000	-0.49989000	C	2.53443100	0.00000000	0.21736700
C	2.65423488	1.09126316	0.18632164	C	2.53477300	0.32095900	1.59200900
H	2.13611764	1.52412415	1.04372160	H	1.27405800	0.12261200	1.85708900
C	1.98006181	0.20481313	-2.01329904	C	2.89969000	1.19110900	-0.60660800
C	3.06177027	1.25590971	-2.21921518	C	3.46299000	2.22025100	0.37706900
C	2.89268909	2.10753010	-0.93981510	C	2.71198300	1.84458000	1.68223000
C	2.92014736	2.15467852	-3.44993805	C	3.24677400	3.70474800	0.08768800

C	3.93750038	3.31111859	-3.38231755	C	3.71822700	4.54186200	1.29773700
C	3.89312464	4.08633394	-2.05209620	C	3.15265100	4.06508500	2.65261700
C	3.96930714	3.17433434	-0.81221764	C	3.29626200	2.54671700	2.89676899
C	4.39054921	0.46085508	-2.25806825	C	4.97408000	1.88187100	0.44228600
O	1.35241635	-0.38393877	-2.86398891	O	2.85026400	1.28092000	-1.81806300
C	-0.40168742	1.71605209	-0.56125415	C	-0.27574100	1.71954800	-0.50503300
C	-0.55690720	3.92433528	-0.05170567	C	-0.70292700	3.88495300	0.04198800
C	-0.98418335	4.23683729	-1.34033103	C	-0.71689400	4.27188200	-1.29483500
C	-1.13866544	3.20405018	-2.26179276	C	-0.48983600	3.30177199	-2.26918600
C	-0.85111157	1.90147265	-1.86621197	C	-0.26379600	1.98943600	-1.87391400
H	4.96112036	2.71790117	-0.72653436	H	4.34288800	2.26982400	3.05864499
H	2.95359511	4.65071104	-2.00198494	H	2.08406400	4.30770400	2.69384200
H	3.75243032	4.00148065	-4.21097688	H	3.43700100	5.58807900	1.14279000
H	3.05477000	1.58103611	-4.37104617	H	3.78178400	4.01303500	-0.81502800
H	4.94702973	2.91715643	-3.53794777	H	4.81194500	4.52873600	1.33978000
H	1.90355527	2.56213834	-3.47216919	H	2.18273600	3.88237500	-0.09433800
H	1.94937632	2.64844095	-1.07427001	H	1.70652100	2.26292900	1.56938600
H	4.51359285	-0.19011037	-1.38958212	H	5.14530700	0.84195600	0.73042700
H	4.41486959	-0.16646129	-3.15261673	H	5.42677200	2.03772400	-0.54049300
H	5.25087931	1.12876546	-2.28987216	H	5.49854300	2.51431200	1.15725700
H	2.09818138	-1.01961867	-0.22876464	H	2.59971900	-0.99691200	-0.19993100
H	3.59201241	0.66603028	0.55144282	H	2.97903900	-0.36152000	2.31603999
H	-0.96275571	1.06388729	-2.54253807	H	-0.07033600	1.20740600	-2.59763100
H	-0.44044483	4.69912552	0.69919314	H	-0.86803000	4.61047500	0.83214500
H	-1.48320819	3.40627247	-3.26906640	H	-0.48047700	3.56315499	-3.32064900
H	3.81349625	3.76473730	0.09626415	H	2.74886800	2.26766800	3.80263899
H	4.70110353	4.82392218	-2.03159390	H	3.63092500	4.62705600	3.46068500
H	-1.20185764	5.26360476	-1.60710225	H	-0.89493400	5.30601499	-1.56180100
N	-0.26587600	2.67756728	0.33521781	N	-0.48210500	2.62569500	0.43686100
R = *p*-NO_2 (**4a-12**)							
$\Delta G^{\ddagger}$(473 K) = 28.1 kcal mol^{-1}							
Reagent				**TS**			
0 1				0 1			
C	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
C	0.00000000	0.00000000	1.53011300	O	0.00000000	0.00000000	1.57577800
C	1.45984700	0.00000000	2.04690600	C	2.55335200	0.00000000	0.21218500
C	2.22315600	-1.24403100	1.61664600	C	2.57121700	-0.01870200	1.62321300
C	2.21081800	-1.31560700	0.07735000	H	1.28857500	-0.05732900	1.86230400
C	0.79789800	-1.20938800	-0.52607300	C	-0.00383400	1.72819600	-0.45142400
C	-0.55368700	1.23518900	2.21773900	C	0.08156500	2.04883900	-1.81015900
C	0.26072800	1.44896400	3.51569800	C	0.08021000	3.37975301	-2.19892600
C	1.34753500	0.36722200	3.53511300	C	-0.00663100	4.36512900	-1.21782600
S	-0.88146800	1.43533200	4.99176200	C	-0.09296300	4.05569900	0.13673200
C	0.39162300	1.94961000	6.19388400	C	-0.09447600	2.72249300	0.52267400
C	0.80237100	3.28105100	6.23992300	C	3.25549000	-1.33124300	2.03902300
C	1.74901201	3.66631000	7.17878800	C	2.96476000	-2.30420900	0.87101400
C	2.24697401	2.70489200	8.05543801	C	2.93545900	-1.34246600	-0.32105900
C	1.82594300	1.37984400	8.02841601	C	3.06421500	-2.00082400	3.38989500
C	0.87818400	1.00043300	7.08420200	C	4.09353000	-3.15200600	3.46270500

N	3.25131201	3.11275800	9.05606901	C	4.06813100	-4.10223799	2.24613900
O	3.65950001	2.26226500	9.83803601	C	4.04774700	-3.38960000	0.87465700
C	-0.85028300	-1.16797300	2.09249100	O	3.20057300	-1.59366500	-1.47974000
O	-1.45452600	1.95320400	1.85799700	C	1.56028500	-2.95581300	0.93532200
O	-1.18368400	-0.01920900	5.29612600	N	-0.00148200	5.77755800	-1.62645500
O	3.62426101	4.28055500	9.04911901	O	0.03089700	6.02772000	-2.82693300
H	1.01745900	-0.49041800	4.12647600	O	-0.02795400	6.63066200	-0.74532200
H	1.76962500	-2.14109000	2.04982400	H	2.04228400	-2.37349900	3.50725800
H	2.82516900	-0.49303200	-0.30969200	H	5.09074100	-2.70156100	3.53807200
H	0.87299000	-1.14449800	-1.61575201	H	4.94020800	-4.76150099	2.29140700
H	-1.02186800	-0.01853300	-0.38760700	H	3.87597000	-4.11735400	0.07685300
H	0.24317400	-2.12949400	-0.31566600	H	3.19681000	-4.75893999	2.32294200
H	0.46153800	0.92740400	-0.35779500	H	5.02052800	-2.92629000	0.68004100
H	1.94784600	0.85302400	1.55197900	H	4.32978700	-1.10792600	1.97429100
H	-0.92465900	-1.15055900	3.18156900	H	0.77812099	-2.24738000	1.20026900
H	-1.86442700	-1.09641500	1.69208600	H	1.31647100	-3.39900400	-0.03350300
H	-0.43676300	-2.13235100	1.79898900	H	1.52845800	-3.74967499	1.67983200
H	0.65805400	2.46643900	3.49319200	H	2.59758100	0.87727300	-0.41863600
H	2.28538400	0.73214100	3.95404400	H	2.81816500	0.89675800	2.16046699
H	0.38954701	4.01582200	5.55794900	H	0.15644600	1.26860600	-2.55936400
H	0.51118900	-0.01713200	7.03112500	H	-0.16951000	2.44705400	1.56635200
H	2.09437601	4.68830600	7.24235900	H	0.14758700	3.65746100	-3.24115300
H	2.23165000	0.66780799	8.73316901	H	-0.16209300	4.84816500	0.86863800
H	3.25448900	-1.20412100	1.98132000	H	3.24216200	-1.29476500	4.20709900
H	2.68456900	-2.24186900	-0.26075800	H	3.94758100	-3.73424600	4.37738800

R = benzothioazole (**4a-13**)

$\Delta G^{\ddagger}$(473 K) = 28.5 kcal mol^{-1}

Reagent				**TS**			
0 1				0 1			
C	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
C	0.00000000	0.00000000	1.39930600	O	0.00000000	0.00000000	1.57672400
C	1.22525500	0.00000000	2.10722500	C	2.55892800	0.00000000	0.20874200
C	2.44879701	-0.00791600	1.43686900	C	2.57306100	-0.00938500	1.62081400
C	2.42882201	-0.01342100	0.04788100	H	1.29999599	-0.05525300	1.86339500
C	1.21731800	-0.00814600	-0.66344300	C	0.01630100	1.73360400	-0.38487600
S	0.92067100	0.02056600	3.83782100	N	0.04121400	2.16747200	-1.59605800
C	-0.79803199	0.02132200	3.44660600	C	0.06535400	3.55448200	-1.62024900
N	-1.12986499	0.01561700	2.20604700	C	0.06342400	4.16787100	-0.34536900
S	-2.00399499	0.08849700	4.80480800	S	0.01565300	2.93927300	0.91185000
C	-2.67118999	-1.61950500	4.47800600	C	3.26171500	-1.31625500	2.04778700
C	-1.67209599	-2.75898999	4.71229300	C	2.97639700	-2.29854700	0.88676400
C	-2.58350299	-3.87083100	5.25336700	C	2.95415500	-1.34542400	-0.31212600
C	-3.56604299	-3.14369600	6.20396700	C	4.05926200	-3.38374200	0.90293800
C	-3.88323299	-1.89486299	5.39908300	C	4.07556200	-4.08527200	2.28020800
C	-4.73781799	-4.07059099	6.53152600	C	4.09682800	-3.12490100	3.48890700
C	-4.21570299	-5.38318099	7.14728100	C	3.06669600	-1.97557300	3.40307100
C	-3.13367099	-6.06431399	6.28897200	C	0.08676200	5.55463001	-0.20592400
C	-1.98492399	-5.11718999	5.88968000	C	0.11415600	6.32449501	-1.36326400
C	-2.88942899	-2.60959300	7.49227800	C	0.11654500	5.72622701	-2.63335601

O	-4.87746999	-1.21193899	5.43647100	C	0.09231400	4.34643601	-2.77318601
O	-1.16804499	0.02263100	6.06752200	C	1.57154800	-2.94930600	0.94865000
H	-0.92613599	-2.46586499	5.45514900	O	3.24074900	-1.60178300	-1.46364600
H	-1.38095399	-4.85057199	6.76285700	H	2.04481499	-2.34881400	3.51924400
H	-3.59862299	-6.44557299	5.37115400	H	5.09350000	-2.67302500	3.56335300
H	-5.05277899	-6.07298499	7.29048400	H	4.94757000	-4.74407700	2.33365400
H	-5.44034099	-3.58219500	7.21189200	H	3.89028400	-4.11804600	0.11054700
H	-3.81457299	-5.18115999	8.14557300	H	3.20398000	-4.74141600	2.35967900
H	-5.28677299	-4.29135199	5.60903300	H	5.03252800	-2.92181500	0.70747600
H	-3.19343799	-4.21454700	4.40491900	H	4.33554899	-1.09053000	1.98435900
H	-2.11308599	-1.87002399	7.28608700	H	0.78816000	-2.23942700	1.20653800
H	-3.64381399	-2.12849300	8.11929100	H	1.33167700	-3.39808800	-0.01859400
H	-2.43554499	-3.41910799	8.06321300	H	1.53565400	-3.73859300	1.69792400
H	-3.02947999	-1.55378600	3.44710700	H	2.59653000	0.87125900	-0.43132700
H	-1.15130599	-3.04181299	3.79717900	H	2.81658600	0.91109500	2.15094100
H	-1.31437599	-5.62014000	5.18547200	H	3.24010200	-1.26286500	4.21547900
H	-2.73703899	-6.93455699	6.82036100	H	3.94866000	-3.69961500	4.40804499
H	3.38631100	-0.00702900	1.97858600	H	0.08239500	6.02071901	0.77156699
H	3.36652300	-0.01842900	-0.49504300	H	0.13262900	7.40474001	-1.28110000
H	1.23708200	-0.00805800	-1.74672900	H	0.13740600	6.35321101	-3.51667400
H	-0.94126700	0.00657600	-0.53558800	H	0.09375600	3.87178601	-3.74652901

R = *p*-CF_3 (**4a-14**)

$\Delta G^{\ddagger}$(473 K) = 28.6 kcal mol^{-1}

Reagent				**TS**			
0 1				0 1			
S	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
O	0.00000000	0.00000000	1.51679563	O	0.00000000	0.00000000	1.57710000
C	1.82340342	0.00000000	-0.48816830	C	2.54665900	0.00000000	0.23806200
C	2.66243379	1.05556980	0.24568342	C	2.53492800	0.36391200	1.60006200
H	2.15983957	1.43056595	1.13936176	H	1.27399500	0.13776400	1.86337300
C	1.99365381	0.27001410	-1.99153058	C	2.89376200	1.16874700	-0.62484500
C	3.05060934	1.35425971	-2.14753916	C	3.41511500	2.25065000	0.32396300
C	2.87784465	2.13555917	-0.82412155	C	2.67629600	1.89333000	1.64054000
C	2.88286901	2.31414239	-3.32809733	C	3.13255000	3.71356400	-0.01539600
C	3.88131581	3.48250848	-3.20632075	C	3.56958800	4.61268499	1.16245200
C	3.83280967	4.18664343	-1.83751058	C	3.03150900	4.15918599	2.53675100
C	3.93734887	3.21259738	-0.64764063	C	3.23304700	2.65591500	2.83115600
C	4.39348394	0.58701579	-2.23871159	C	4.93720100	1.97617400	0.40356300
O	1.38848510	-0.30477792	-2.86718555	O	2.86004300	1.20854700	-1.83890800
C	-0.41311728	1.70750407	-0.49375059	C	-0.31733800	1.70668800	-0.45133100
H	4.93815325	2.77137285	-0.59324192	H	4.28900100	2.42320700	2.99861700
H	2.88378890	4.73004992	-1.75113613	H	1.95482000	4.36439399	2.57718000
H	3.67859390	4.21157447	-3.99649820	H	3.23990000	5.63842900	0.97263300
H	3.01983980	1.79185561	-4.27881750	H	3.64955600	4.01403800	-0.93075800
H	4.89613676	3.11410744	-3.38811843	H	4.66271800	4.65082700	1.19821200
H	1.86006381	2.70530821	-3.32052480	H	2.06030400	3.83532100	-0.19787400
H	1.92533021	2.66647430	-0.92287955	H	1.66295500	2.28489100	1.50734700
H	4.53171351	-0.11327328	-1.41181228	H	5.14871600	0.95256099	0.72219700
H	4.42407185	0.01527410	-3.16939455	H	5.38699200	2.12172000	-0.58183400

H	5.24111230	1.27149852	-2.23364346	H	5.43165700	2.64972699	1.10200300
H	2.09117169	-1.03284518	-0.25718094	H	2.61607700	-1.00972100	-0.14694400
H	3.60681156	0.61529569	0.57406675	H	2.98507600	-0.28609400	2.34979099
H	3.77873699	3.75263437	0.29134307	H	2.69884300	2.38574600	3.74771099
H	4.62692071	4.93731546	-1.78432747	H	3.49215700	4.76533399	3.32249200
C	-0.43007012	2.68704773	0.49246260	C	-0.76510500	2.62086400	0.50269100
C	-0.72711457	1.99799500	-1.81858094	C	-0.12499100	2.08763500	-1.77855600
C	-0.70677883	4.00094316	0.13465436	C	-1.00186600	3.93470200	0.12565900
C	-1.00356541	3.31425607	-2.17341635	C	-0.36752200	3.40532400	-2.15205400
C	-0.97543827	4.31195333	-1.19948416	C	-0.79672300	4.32722600	-1.19948700
H	-0.22202089	2.41114721	1.51880076	H	-0.91253500	2.30077300	1.52594300
H	-0.70690717	4.78004840	0.88684038	H	-1.34213600	4.65389400	0.86026000
H	-1.23308201	3.55995847	-3.20188239	H	-0.20146900	3.71273200	-3.17611400
H	-0.74104410	1.21911838	-2.56987907	H	0.23929400	1.37807400	-2.51033500
C	-1.29368931	5.73367478	-1.56533622	C	-1.08710500	5.74488100	-1.59334500
F	-1.14215208	5.97687733	-2.88568859	F	-0.46950300	6.10570300	-2.73941600
F	-0.50331482	6.61635000	-0.90817158	F	-0.70075400	6.62915300	-0.64092600
F	-2.57410925	6.06563763	-1.25518281	F	-2.41666100	5.95880000	-1.78864500

R = 3-pyridine (**4a-15**)

$\Delta G^{\ddagger}$(473 K) = 28.6 kcal mol^{-1}

Reagent				**TS**			
0 1				0 1			
S	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
O	0.00000000	0.00000000	1.51683175	O	0.00000000	0.00000000	1.57729900
C	1.82161130	0.00000000	-0.48836369	C	2.54274000	0.00000000	0.23743400
C	2.66535896	1.04037679	0.26213420	C	2.53509500	0.34119900	1.60553300
H	2.15955508	1.41049680	1.15615669	H	1.27022000	0.12556900	1.86532000
C	-0.42370334	1.69801665	-0.50039608	C	-0.30342500	1.70533500	-0.45838400
C	-0.78296132	1.98997348	-1.81301462	C	-0.11649300	2.09726600	-1.78221500
C	-1.09160370	3.31009259	-2.11921808	C	-0.37230300	3.42321499	-2.11154700
C	-1.03927801	4.26294298	-1.10302209	C	-0.79545200	4.29384700	-1.11092500
N	-0.73048463	3.97383639	0.16585931	N	-0.98234000	3.91668700	0.16017200
C	-0.43804703	2.70365585	0.46217513	C	-0.74808500	2.64194900	0.47701100
C	2.89955912	2.13012704	-0.79412123	C	2.69026900	1.86834600	1.67395800
C	3.06700521	1.36101657	-2.12569450	C	3.42925900	2.24167600	0.36195800
C	1.98948945	0.29557615	-1.98635248	C	2.89415500	1.18245300	-0.60476000
C	3.97691426	3.18633847	-0.60074754	C	3.25935999	2.60154200	2.87731000
C	3.89934760	4.17421481	-1.78127996	C	3.07824699	4.11259400	2.61127000
C	3.94157848	3.48466456	-3.15778575	C	3.62158100	4.58350500	1.24511599
C	2.92311711	2.33572757	-3.29680607	C	3.16589000	3.71466600	0.05157700
O	1.36344335	-0.24361906	-2.87038464	O	2.85399700	1.24670100	-1.81797001
C	4.39714150	0.57160178	-2.21621275	C	4.94846699	1.94675800	0.43133400
H	4.96865392	2.72523843	-0.54397867	H	4.31216899	2.35050800	3.03898300
H	2.96086965	4.73529853	-1.69360585	H	2.00497899	4.33258400	2.65632100
H	3.75532833	4.22612842	-3.94062179	H	3.30789200	5.61790899	1.07649300
H	3.05553289	1.82092194	-4.25230461	H	3.68365800	4.02480500	-0.86029700
H	4.95049931	3.10078138	-3.34008950	H	4.71545699	4.60257600	1.27850999
H	1.90726147	2.74526695	-3.29053298	H	2.09469200	3.85744000	-0.12263100
H	1.95501176	2.67735034	-0.89058461	H	1.68051900	2.27363600	1.55361500

H	4.52158273	-0.13577601	-1.39314055	H	5.14817999	0.91462400	0.72923300
H	4.42211095	0.00525248	-3.15048069	H	5.39685600	2.10593800	-0.55264901
H	5.25649257	1.24110970	-2.20327509	H	5.45361300	2.60031100	1.14092100
H	2.08789571	-1.03711049	-0.27436828	H	2.61324600	-1.00284500	-0.16474900
H	3.60333879	0.58848848	0.59285588	H	2.97909500	-0.32515300	2.34436500
H	-1.37053499	3.59768016	-3.12532947	H	-0.23108800	3.77849499	-3.12467200
H	3.82148567	3.72004510	0.34214684	H	2.72195799	2.32197200	3.78904600
H	4.70808516	4.90810381	-1.71504937	H	3.54892199	4.69706300	3.40749100
H	-1.26511666	5.30332637	-1.31491806	H	-0.99281700	5.33701800	-1.33565600
H	-0.20866815	2.46684062	1.49486231	H	-0.90592300	2.34710700	1.50806000
H	-0.80932459	1.21816408	-2.57210941	H	0.23934300	1.39755500	-2.52818700

R = *p*-CN (**4a-16**)

$\Delta G^{\ddagger}$(473 K) = 28.7 kcal mol^{-1}

Reagent				**TS**			
0 1				0 1			
C	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
C	0.00000000	0.00000000	1.38873703	O	0.00000000	0.00000000	1.57691900
C	1.18402172	0.00000000	2.12335830	C	2.55163500	0.00000000	0.21580900
C	2.39748362	0.02836861	1.45136807	C	2.56961800	-0.01650900	1.62677200
C	2.41247127	0.04557113	0.04788005	H	1.28243200	-0.05461600	1.86413700
C	1.21316243	0.02923988	-0.67706347	C	-0.00666500	1.73004000	-0.45072000
S	-1.60467907	-0.09177919	2.25142030	C	0.09441400	2.05290200	-1.80688600
O	-2.65670472	-0.21158860	1.16476755	C	0.09429600	3.38435901	-2.19292000
C	3.66128417	0.06657721	-0.64658352	C	-0.00964200	4.39186301	-1.22146900
N	4.67047410	0.08645388	-1.20813027	C	-0.11451600	4.05575401	0.13605900
C	-1.60787683	1.69000543	2.80889680	C	-0.11371800	2.72289200	0.52194000
C	-2.79514881	1.93985444	3.76936344	C	3.25369600	-1.32793800	2.04532300
C	-3.65040066	3.03707597	3.16041305	C	2.96483800	-2.30254300	0.87823800
C	-2.59436329	3.81145510	2.33426322	C	2.93588500	-1.34192000	-0.31510700
C	-1.73577048	2.71850863	1.67776157	C	4.04881300	-3.38689300	0.88426700
C	-4.33959095	3.99622299	4.13324855	C	4.06836800	-4.09811300	2.25654900
C	-4.96869466	5.17067064	3.35944578	C	4.09108100	-3.14662900	3.47227900
C	-3.97578718	5.87849712	2.41972080	C	3.06112200	-1.99620100	3.39673299
C	-3.22296009	4.90884751	1.48717800	C	-0.00490200	5.76395101	-1.61631100
C	-4.68292826	2.28596221	2.28148446	C	1.56101300	-2.95536300	0.94188100
O	-2.96083468	1.34957627	4.80906860	O	3.20254500	-1.59557400	-1.47318300
H	-2.25068170	2.27746800	0.82063875	N	0.00057500	6.87479501	-1.93425200
H	-3.90439734	4.47607421	0.74782040	H	2.03929400	-2.36945400	3.51320699
H	-3.23547673	6.41584411	3.02558033	H	5.08786000	-2.69537200	3.54869400
H	-5.37414361	5.89567802	4.07151423	H	4.94114101	-4.75636800	2.30370100
H	-5.10094594	3.47388846	4.71853334	H	3.87874200	-4.11577000	0.08708700
H	-5.82218166	4.80681833	2.77902516	H	3.19767101	-4.75572100	2.33287700
H	-3.59800778	4.37969678	4.84323936	H	5.02140900	-2.92288500	0.69028000
H	-1.95100672	4.31396608	3.07150416	H	4.32815400	-1.10475700	1.98181000
H	-4.22207164	1.52653717	1.64714802	H	0.77797500	-2.24685100	1.20395800
H	-5.40401456	1.78121770	2.92891116	H	1.31908700	-3.40045200	-0.02657400
H	-5.22644899	2.97607484	1.63666420	H	1.52853500	-3.74795400	1.68776500
H	-0.68609331	1.79004946	3.38701362	H	2.59469400	0.87654100	-0.41603300
H	-0.76499423	3.08374798	1.34232256	H	2.81472700	0.89972200	2.16341400

H	1.16722290	-0.02862795	3.20708443	H	0.18121500	1.27347200	-2.55594300
H	-0.94376779	-0.02922187	-0.53092372	H	-0.19918900	2.44571000	1.56459201
H	3.33030832	0.02901083	2.00043368	H	0.17634700	3.65005601	-3.23910801
H	1.23755930	0.03383174	-1.75937798	H	-0.19790700	4.83881801	0.87911100
H	-2.45216090	5.44957236	0.92854467	H	3.23748800	-1.28915800	4.21347199
H	-4.50283587	6.63496539	1.83061173	H	3.94424500	-3.72817900	4.38729800
R = *p*-CH_3 (**4a-17**)							
$\Delta G^{\ddagger}$(473 K) = 28.8 kcal mol^{-1}							
Reagent				**TS**			
0 1				0 1			
C	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
C	0.00000000	0.00000000	1.52991600	O	0.00000000	0.00000000	1.58103200
C	1.46013300	0.00000000	2.04614600	C	2.54620800	0.00000000	0.22808100
C	2.22397200	-1.24319000	1.61394700	C	2.56383300	-0.00199200	1.63925500
C	2.21093400	-1.31483500	0.07474400	H	1.26033300	-0.04132300	1.87127800
C	0.79730600	-1.20922200	-0.52725700	C	-0.01966800	1.73035200	-0.45570100
C	-0.54848800	1.23852400	2.21879400	C	0.08425600	2.05292500	-1.80871100
C	0.25431600	1.44131400	3.52147600	C	0.07476800	3.39027500	-2.19363200
C	1.34729200	0.36515400	3.53420000	C	-0.03850600	4.41568000	-1.24894900
S	-0.88237300	1.40694000	5.00473100	C	-0.14008400	4.06284000	0.10224200
C	0.38052999	1.91264300	6.21272999	C	-0.13366700	2.73193500	0.50588100
C	0.75303599	3.24970300	6.30367499	C	3.25055600	-1.30528300	2.07402000
C	1.70738199	3.62479300	7.24570999	C	2.97125100	-2.29187399	0.91489701
C	2.28278899	2.68213200	8.10508699	C	2.94247900	-1.34068200	-0.28756600
C	1.87181499	1.34751100	8.00128699	C	3.05360800	-1.96298199	3.43022800
C	0.92087800	0.95657400	7.06384000	C	4.08816100	-3.10795299	3.52210000
C	3.31738599	3.08642200	9.12261599	C	4.07870000	-4.06956599	2.31370300
C	-0.84995900	-1.16739100	2.09232500	C	4.06125900	-3.36980699	0.93524401
O	-1.43788100	1.96604900	1.84614400	O	3.21864500	-1.60851400	-1.44143500
O	-1.17956500	-0.05793700	5.28258800	C	1.57134701	-2.95193599	0.97814901
H	1.02242000	-0.49470400	4.12545500	C	-0.07073600	5.86112400	-1.66974900
H	1.77132100	-2.14081500	2.04704300	H	2.03285300	-2.33996699	3.54424000
H	2.82410700	-0.49146600	-0.31272300	H	5.08232100	-2.65126199	3.60133400
H	0.87110600	-1.14510300	-1.61722600	H	4.95566000	-4.72163299	2.37143300
H	-1.02191100	-0.01801700	-0.38785900	H	3.89967600	-4.10683299	0.14363101
H	0.24315100	-2.12942200	-0.31537300	H	3.21189101	-4.73235899	2.39061200
H	0.46155200	0.92744000	-0.35796400	H	5.03222200	-2.90188099	0.74193201
H	1.94721500	0.85385800	1.55137000	H	4.32526200	-1.08079500	2.01463300
H	-0.92618700	-1.14672800	3.18127800	H	0.78288601	-2.24297999	1.22191101
H	-1.86367100	-1.09677400	1.69010400	H	1.33989001	-3.41187399	0.01394701
H	-0.43644800	-2.13271000	1.80111100	H	1.53648601	-3.73421499	1.73501301
H	0.64652299	2.46067600	3.51763600	H	2.58112700	0.87104800	-0.41145900
H	2.28308600	0.73405200	3.95383200	H	2.79995300	0.92016700	2.16923700
H	0.30628999	3.99588900	5.65467099	H	0.18198100	1.27304500	-2.55692800
H	0.58869100	-0.07177200	6.98638500	H	-0.21729000	2.46442700	1.55167700
H	2.00239799	4.66581300	7.31937899	H	0.16043800	3.63970700	-3.24562401
H	2.29836799	0.60507400	8.66791199	H	-0.22850600	4.84291100	0.85153800
H	3.25560900	-1.20308500	1.97820900	H	3.22176300	-1.24822799	4.24217100
H	2.68516700	-2.24068100	-0.26439100	H	3.93844000	-3.68329399	4.44077500

H	3.02222699	2.77866800	10.12995699	H	-1.08566300	6.26653200	-1.59781600
H	4.28206299	2.61443000	8.91040099	H	0.56941100	6.47635299	-1.03178600
H	3.46788199	4.16753600	9.13061099	H	0.26134700	5.98268700	-2.70266800
R = *p*-F (**4a-18**)							
$\Delta G^{\ddagger}$(473 K) = 28.8 kcal mol^{-1}							
Reagent				**TS**			
0 1				0 1			
S	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
O	0.00000000	0.00000000	1.51831895	O	0.00000000	0.00000000	1.57913400
C	1.82404250	0.00000000	-0.48110001	C	2.54521200	0.00000000	0.24916500
C	2.65936757	1.06017973	0.25055441	C	2.53094600	0.36792500	1.60994500
H	2.15171708	1.43984447	1.13948848	H	1.26086000	0.14163700	1.86833400
C	1.99883967	0.26381510	-1.98411032	C	2.89438600	1.16489200	-0.61570100
C	3.05898608	1.34491347	-2.14166299	C	3.41090900	2.25172600	0.33106000
C	2.87941184	2.13442447	-0.82411871	C	2.66944300	1.89736900	1.64673400
C	2.89967590	2.29727793	-3.32933979	C	3.12692600	3.71324000	-0.01320700
C	3.89885214	3.46526869	-3.20993691	C	3.56065000	4.61632700	1.16300600
C	3.84504765	4.17741268	-1.84532045	C	3.02035700	4.16616900	2.53764400
C	3.94016741	3.21034462	-0.64903490	C	3.22285200	2.66394800	2.83638300
C	4.40111235	0.57487951	-2.22041024	C	4.93327999	1.98059700	0.41557300
O	1.39441490	-0.31102391	-2.86051659	O	2.86778100	1.20141300	-1.83047000
C	-0.42627222	1.69911739	-0.49397141	C	-0.32452600	1.70614600	-0.45207700
C	-0.44508904	2.68530053	0.48610777	C	-0.79249500	2.61598700	0.49544800
C	-0.74909056	3.99652066	0.13164242	C	-1.04295300	3.93119400	0.11978600
C	-1.03584574	4.26857731	-1.19678400	C	-0.82763800	4.29532900	-1.20078700
C	-1.05774449	3.29137418	-2.18041835	C	-0.37868400	3.40426499	-2.16080300
C	-0.75648723	1.98192193	-1.81824961	C	-0.12202200	2.09062899	-1.77795700
H	4.93960730	2.76700106	-0.58650337	H	4.27877300	2.43298900	3.00681900
H	2.89665623	4.72318096	-1.76745885	H	1.94328300	4.36990600	2.57496300
H	3.69996232	4.19028676	-4.00493728	H	3.23037500	5.64137500	0.96977400
H	3.04126442	1.76867999	-4.27594512	H	3.64569900	4.01171100	-0.92831800
H	4.91424364	3.09553620	-3.38582687	H	4.65367700	4.65596300	1.20098000
H	1.87733841	2.68981498	-3.33033035	H	2.05486600	3.83322700	-0.19852400
H	1.92658170	2.66434152	-0.93030660	H	1.65596799	2.28742900	1.50956200
H	4.53618627	-0.11766947	-1.38651434	H	5.14533999	0.95858600	0.73887800
H	4.43401699	-0.00576113	-3.14559782	H	5.38533799	2.12267300	-0.56935600
H	5.25033864	1.25740043	-2.21885003	H	5.42540099	2.65761300	1.11241700
H	2.09433244	-1.03099678	-0.24470353	H	2.61761500	-1.01074100	-0.13238900
H	3.60283742	0.62296419	0.58579720	H	2.97640799	-0.27914100	2.36475799
H	-0.22456265	2.41757807	1.51212135	H	-0.94817400	2.29523400	1.51746200
H	-0.76790179	1.19905255	-2.56579254	H	0.25789300	1.38499299	-2.50579300
H	-0.76817329	4.79353863	0.86416745	H	-1.40203700	4.66362400	0.83167200
H	-1.30967838	3.55350767	-3.20008585	H	-0.21734100	3.73566299	-3.17857700
H	3.77821112	3.75678707	0.28572437	H	2.68709600	2.39580200	3.75269000
H	4.64090253	4.92636103	-1.79217638	H	3.47872600	4.77515600	3.32265000
F	-1.32372478	5.54718014	-1.54928549	F	-1.06809100	5.58188299	-1.56634900
R = *p*-Cl (**4a-19**)							
$\Delta G^{\ddagger}$(473 K) = 28.9 kcal mol^{-1}							

Reagent				**TS**			
0 1				0 1			
S	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
O	0.00000000	0.00000000	1.51784812	O	0.00000000	0.00000000	1.57850800
C	1.82479382	0.00000000	-0.48391063	C	2.54840800	0.00000000	0.24900500
C	2.66129164	1.05690693	0.25083793	C	2.53115900	0.38003800	1.60654000
H	2.15724449	1.42992443	1.14465465	H	1.26534200	0.14810400	1.86729400
C	1.99784298	0.26978685	-1.98629937	C	2.89697600	1.15722100	-0.62635600
C	3.05092012	1.35839073	-2.14139794	C	3.40547999	2.25596700	0.31059700
C	2.87439410	2.13829553	-0.81797851	C	2.66365600	1.91053200	1.62851500
C	2.87944364	2.31862388	-3.32128111	C	3.11323199	3.71216999	-0.04966800
C	3.87184383	3.49214066	-3.19847968	C	3.53662099	4.63071599	1.11830600
C	3.82142780	4.19393501	-1.82833745	C	2.99749899	4.19030599	2.49662500
C	3.93025580	3.21848207	-0.64000384	C	3.21047699	2.69267199	2.81104000
C	4.39633914	0.59578398	-2.23322806	C	4.92913600	1.99459399	0.40116400
O	1.39837193	-0.30800095	-2.86407762	O	2.87543300	1.18000600	-1.84150799
C	-0.41892184	1.70157542	-0.49434467	C	-0.31310300	1.70732700	-0.45194200
C	-0.42848077	2.68916422	0.48327773	C	-0.77086600	2.62230600	0.49498800
C	-0.70921458	4.00407134	0.12465550	C	-0.99309700	3.94297100	0.12324000
C	-0.98706845	4.29421059	-1.20769351	C	-0.76155700	4.32449600	-1.19565100
C	-1.02308717	3.30114587	-2.18262700	C	-0.32804700	3.41342400	-2.15187300
C	-0.74451225	1.98768122	-1.81807761	C	-0.10169700	2.09308600	-1.77526200
H	4.93284629	2.78109555	-0.58644267	H	4.26776799	2.47093700	2.98501899
H	2.86972201	4.73239226	-1.74062264	H	1.91893300	4.38646199	2.53030400
H	3.66365837	4.22177815	-3.98683378	H	3.19773500	5.65066899	0.91349500
H	3.01934924	1.79799406	-4.27253092	H	3.63381399	4.00446799	-0.96572900
H	4.88855245	3.13024741	-3.38298297	H	4.62914899	4.68045999	1.15806600
H	1.85475964	2.70473852	-3.31364520	H	2.04160299	3.82395599	-0.24094700
H	1.91998802	2.66574156	-0.91733406	H	1.64886899	2.29410000	1.48555500
H	4.53959453	-0.10134890	-1.40448533	H	5.14652300	0.97793299	0.73770000
H	4.42643271	0.02113387	-3.16222562	H	5.38236400	2.12712200	-0.58454800
H	5.24209329	1.28258177	-2.23246972	H	5.41577400	2.68314399	1.09055300
H	2.09376157	-1.03216290	-0.25145091	H	2.62054600	-1.01428500	-0.12320300
H	3.60697252	0.61872281	0.57869756	H	2.98055499	-0.25833600	2.36656699
H	-0.21369375	2.42222268	1.51084902	H	-0.93709100	2.30271700	1.51585799
H	-0.76683831	1.20531423	-2.56603486	H	0.26751700	1.38482100	-2.50620700
H	-0.71072894	4.79076216	0.86784223	H	-1.33997300	4.66694300	0.84914199
H	-1.26507386	3.54785547	-3.20804175	H	-0.14834200	3.72946700	-3.17098400
H	3.76989286	3.75676672	0.29974734	H	2.67549199	2.43024699	3.72946500
H	4.61244212	4.94792405	-1.77451733	H	3.45011299	4.81060999	3.27608200
Cl	-1.31485346	5.95853157	-1.67146720	Cl	-1.01513000	6.00263100	-1.65964700
R = *p*-CO_2CH_3 (**4a-20**)							
$\Delta G^{\ddagger}$(473 K) = 29.3 kcal mol^{-1}							
Reagent				**TS**			
0 1				0 1			
S	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
O	0.00000000	0.00000000	1.51738262	O	0.00000000	0.00000000	1.57749600
C	1.82451615	0.00000000	-0.48601206	C	2.54881600	0.00000000	0.24226200

C	2.65909265	1.06355548	0.24127412	C	2.53316200	0.37303200	1.60195500
H	2.15430950	1.44216558	1.13218312	H	1.27238999	0.14420900	1.86461400
C	1.99796181	0.25805061	-1.99103784	C	2.90237600	1.16089200	-0.62763400
C	3.04781779	1.34877615	-2.15334683	C	3.41723000	2.25116200	0.31589200
C	2.86934615	2.13756051	-0.83536986	C	2.67176300	1.90285500	1.63099900
C	2.87507914	2.29991068	-3.34031251	C	3.13330700	3.71058400	-0.03697100
C	3.86642088	3.47498198	-3.22545460	C	3.56029500	4.62054300	1.13628800
C	3.81219009	4.18768618	-1.86127402	C	3.01525500	4.17662700	2.51107100
C	3.92213320	3.22210653	-0.66496267	C	3.21994000	2.67642600	2.81846200
C	4.39537663	0.58913682	-2.23864643	C	4.93917500	1.98044100	0.40649400
O	1.40322999	-0.33121791	-2.86409693	O	2.88054100	1.18953500	-1.84215400
C	-0.41514263	1.70356338	-0.49870997	C	-0.31384500	1.70435800	-0.45668300
C	-0.43772389	2.68826531	0.48186298	C	-0.75811400	2.62650100	0.49131900
C	-0.71895270	3.99995024	0.11635098	C	-0.98307400	3.94095500	0.10727800
C	-0.98889614	4.31226442	-1.22049286	C	-0.77596200	4.33425000	-1.22121400
C	-1.00531239	3.29910045	-2.18550191	C	-0.35079800	3.39291300	-2.16361700
C	-0.72696675	1.98668442	-1.82766963	C	-0.11851000	2.07682499	-1.78773400
H	4.92582719	2.78775049	-0.60698611	H	4.27578099	2.44846200	2.99342700
H	2.85880804	4.72415378	-1.77945129	H	1.93761300	4.37806700	2.54288700
H	3.65956857	4.19756312	-4.02051793	H	3.22844700	5.64379500	0.93605700
H	3.01619668	1.77233823	-4.28752140	H	3.65546100	4.00483200	-0.95143100
H	4.88385080	3.11191597	-3.40374807	H	4.65306700	4.66293400	1.17854700
H	1.85017713	2.68505852	-3.33629064	H	2.06222700	3.82765300	-0.22781900
H	1.91369993	2.66156755	-0.93821749	H	1.65857900	2.29093999	1.48820300
H	4.53698536	-0.10512022	-1.40721143	H	5.15069100	0.96033300	0.73633800
H	4.43002145	0.01162822	-3.16563571	H	5.39434100	2.11711500	-0.57774100
H	5.23916893	1.27843628	-2.23730226	H	5.42873400	2.66160400	1.10114600
H	2.09405961	-1.03031704	-0.24599670	H	2.61800700	-1.01259900	-0.13516100
H	3.60545966	0.62944661	0.57246829	H	2.98407400	-0.27055100	2.35685500
H	-0.23204960	2.41744074	1.51010709	H	-0.91064000	2.31114600	1.51548200
H	-0.73836241	1.20249682	-2.57375433	H	0.24090000	1.35956299	-2.51476601
H	-0.72700977	4.78175278	0.86355906	H	-1.31914700	4.66557400	0.83652300
H	-1.23641948	3.55223629	-3.21214531	H	-0.18646900	3.70641700	-3.18632300
H	3.75919312	3.76712072	0.27047387	H	2.68167100	2.41205500	3.73438900
H	4.60114721	4.94424990	-1.81238220	H	3.46919800	4.79062800	3.29476400
C	-1.27623498	5.70557826	-1.66517086	C	-0.97562000	5.73718599	-1.67320300
O	-1.51385905	6.01988424	-2.81085272	O	-0.82091700	6.11761999	-2.81340800
O	-1.23704296	6.58611153	-0.65061737	O	-1.34244500	6.55422200	-0.66807200
C	-1.50338248	7.96075857	-0.99271729	C	-1.53506000	7.93838799	-1.01724900
H	-1.42908373	8.51087411	-0.05708149	H	-1.84419600	8.42971599	-0.09695000
H	-0.76590187	8.32517783	-1.70910781	H	-0.60407800	8.37233899	-1.38516000
H	-2.50392757	8.06117343	-1.41539712	H	-2.30961500	8.03693999	-1.77879900

R = *p*-N(CH_3)$_2$ (**4a-21**)

$\Delta G^{\ddagger}$(473 K) = 29.6 kcal mol^{-1}

Reagent				**TS**			
0 1				0 1			
S	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000
O	0.00000000	0.00000000	1.52128899	O	0.00000000	0.00000000	1.58283800
C	1.83278577	0.00000000	-0.47091214	C	2.55453700	0.00000000	0.27721100

C	2.64801078	1.08378667	0.24798977	C	2.52034300	0.41266400	1.62543000
H	2.13389813	1.45663670	1.13624834	H	1.24105000	0.16864500	1.87762800
C	-0.43498202	1.67879788	-0.50265196	C	-0.34184900	1.69326000	-0.45717700
C	-0.43593587	2.69884714	0.44321725	C	-0.85059600	2.60750299	0.46414900
C	-0.71555539	4.00220945	0.06243241	C	-1.10691300	3.91523699	0.08353000
C	-0.99810495	4.32386242	-1.28738952	C	-0.86309500	4.35529999	-1.23965500
C	-1.04820507	3.25650393	-2.21672423	C	-0.38023300	3.40037799	-2.16293900
C	-0.77243966	1.95528800	-1.82631618	C	-0.11672200	2.09538900	-1.77391800
N	-1.22135387	5.62387867	-1.68202773	N	-1.07869299	5.66743299	-1.60824800
C	-1.35472301	6.66871217	-0.67923150	C	-1.80010599	6.55330799	-0.70908601
C	2.83096411	2.15647241	-0.83485258	C	2.62660700	1.94463400	1.60887400
C	3.02714589	1.36393983	-2.14746810	C	3.38010200	2.26762300	0.29256900
C	2.00631323	0.24580590	-1.97478068	C	2.90195700	1.13422000	-0.62146600
C	3.85417383	3.27001928	-0.67305624	C	3.14300900	2.76893799	2.77656000
C	3.71514805	4.22491878	-1.87494752	C	2.90474700	4.25304200	2.42008199
C	3.78729471	3.50429866	-3.23430703	C	3.45447700	4.66682500	1.03758300
C	2.82695953	2.30271543	-3.33991057	C	3.06603500	3.70801600	-0.11013100
O	1.43493443	-0.36837105	-2.84751983	O	2.90581000	1.12647200	-1.83815200
C	4.39344129	0.63886695	-2.23185313	C	4.90633700	2.03729100	0.41045900
C	-1.72652418	5.89363492	-3.01910677	C	-1.01142699	6.03664899	-3.01277300
H	4.87040656	2.86573751	-0.61337964	H	4.20236800	2.57353799	2.96981399
H	2.74627128	4.73300460	-1.79455557	H	1.82208600	4.42701400	2.43233899
H	3.56233704	4.21619125	-4.03454330	H	3.09698300	5.67362600	0.79989000
H	2.98075274	1.77317442	-4.28428434	H	3.59419400	3.98579900	-1.02668201
H	4.81405039	3.16672446	-3.41039255	H	4.54511899	4.74151200	1.09151500
H	1.79198959	2.66009257	-3.33474152	H	1.99560400	3.79230400	-0.31867800
H	1.86127449	2.65310081	-0.93840766	H	1.60766500	2.30628400	1.44012400
H	4.55285367	-0.04867728	-1.39795610	H	5.13593800	1.03629099	0.78386300
H	4.44145042	0.05811876	-3.15641093	H	5.37029400	2.14441400	-0.57356300
H	5.22069846	1.34821938	-2.23407745	H	5.37347500	2.75663100	1.08214000
H	2.11084130	-1.02476032	-0.21732685	H	2.63343800	-1.02272900	-0.06940700
H	3.60494223	0.67381636	0.58113928	H	2.96766400	-0.19848300	2.40856099
H	3.67671986	3.81639833	0.25904408	H	2.60157400	2.52084899	3.69540199
H	4.48238144	5.00422211	-1.83281188	H	3.33383800	4.90327500	3.18878800
H	-0.22128441	2.45955993	1.47783288	H	-1.03536200	2.29285699	1.48396900
H	-0.71777737	4.77310854	0.81932098	H	-1.50133400	4.59833399	0.82205800
H	-1.30683313	3.44089596	-3.24920198	H	-0.18647500	3.67769600	-3.18875900
H	-0.81076414	1.16049792	-2.56163817	H	0.28788800	1.39951400	-2.49898200
H	-2.71749911	5.45071248	-3.18887206	H	-1.78153899	5.53603599	-3.61677100
H	-1.80466704	6.97064384	-3.15676021	H	-1.15122499	7.11277099	-3.10223900
H	-1.04334078	5.51141026	-3.78223450	H	-0.03241199	5.79555199	-3.43415900
H	-0.46563313	6.71740176	-0.04531495	H	-1.28115199	6.65031499	0.24834800
H	-1.45425400	7.62980245	-1.18117966	H	-1.85217599	7.54496499	-1.15567801
H	-2.23215773	6.52203885	-0.03419681	H	-2.82529100	6.20905699	-0.51279800

R = *o,p*-NO_2 (**4a-22**)

$\Delta G^{\ddagger}$(473 K) = 30.1 kcal mol^{-1}

Reagent				**TS**			
0 1				0 1			
C	0.00000000	0.00000000	0.00000000	S	0.00000000	0.00000000	0.00000000

C	0.00000000	0.00000000	1.52231154	O	0.00000000	0.00000000	1.57274700
C	1.43230128	0.00000000	2.10870750	C	2.57053900	0.00000000	0.19251300
C	2.15731232	-1.27711350	1.67837574	C	2.58050400	-0.03008900	1.60546700
C	2.16798000	-1.38144523	0.14095727	H	1.32441900	-0.07314200	1.85326300
C	0.76819103	-1.24486150	-0.48592279	C	0.01632400	1.76069500	-0.37574800
C	1.14732500	0.15990204	3.59327187	C	0.05809100	2.28846100	-1.67727800
C	-0.23163653	0.85571849	3.72835478	C	0.06731800	3.65503400	-1.92011000
C	-0.73821838	1.09834004	2.30283454	C	0.03230400	4.50751200	-0.83127300
S	-0.02330091	2.38439174	4.78164434	C	-0.01557900	4.02817400	0.47631700
C	-1.79346127	2.92186469	4.67820360	C	-0.02604500	2.66078000	0.69482000
C	-2.85097044	2.46083543	5.47094165	C	3.26606000	-1.34741600	2.01129500
C	-4.12946020	2.99045897	5.36385219	C	2.97882100	-2.31048100	0.83420200
C	-4.33576893	3.99851688	4.43682245	C	2.97230400	-1.33864100	-0.34825200
C	-3.30758962	4.49672711	3.64409211	C	4.05404500	-3.40328900	0.83787901
C	-2.03428152	3.96072610	3.78447822	C	4.06247200	-4.12430300	2.20477600
N	-2.64303647	1.39519108	6.46225939	C	4.09015900	-3.18112800	3.42626001
O	-3.54851705	1.13627107	7.23860853	C	3.06551900	-2.02590100	3.35610100
N	-5.69404027	4.56430546	4.29810995	N	0.09709900	1.39295899	-2.83564900
O	-5.84738444	5.46921041	3.48895859	O	0.07009300	0.18645200	-2.59581000
C	2.24979878	1.26411725	1.73759197	N	0.04240500	5.96200100	-1.06872800
O	1.83284823	-0.17128979	4.52781303	O	0.06556200	6.34991200	-2.22944600
O	0.70437825	3.37893372	3.90241016	C	1.56818501	-2.95059300	0.88062600
O	-1.55148619	0.83060916	6.44710125	O	3.28813600	-1.56537600	-1.49679000
O	-6.58015249	4.09222569	4.99688952	O	0.15311700	1.87733999	-3.95509901
H	-0.44535088	2.09054301	1.95112681	O	0.02833700	6.69530900	-0.08774200
H	0.46231343	0.91428147	-0.38552828	H	2.04170200	-2.39625101	3.46414400
H	0.17743578	-2.13359042	-0.23114319	H	5.08916600	-2.73542100	3.50637801
H	2.60396137	-2.34087212	-0.15221197	H	4.92895600	-4.79081300	2.24963300
H	3.17738478	-1.29379801	2.07014239	H	3.88134800	-4.12466700	0.03469700
H	2.82774544	-0.61076679	-0.26993494	H	3.18557101	-4.77435300	2.27426900
H	1.63701374	-2.14361065	2.10207054	H	5.03085100	-2.94545300	0.65087601
H	-0.44727722	-0.95556771	1.83340022	H	4.34027600	-1.12321600	1.95240000
H	1.80115334	2.18231402	2.12113558	H	0.79212901	-2.24350300	1.16568200
H	3.24908337	1.18230432	2.17165030	H	1.31905601	-3.36541200	-0.09918300
H	2.35493223	1.36267926	0.65750725	H	1.53002601	-3.76346900	1.60403201
H	-0.87537011	0.19689874	4.31078185	H	2.62745700	0.88215200	-0.43038000
H	-1.82279401	1.01294154	2.23022177	H	2.84056600	0.88096400	2.14504100
H	-1.19957770	4.34292987	3.20893605	H	-0.07465500	2.26443100	1.69974600
H	-1.02541111	-0.02073098	-0.38297716	H	3.24078300	-1.32616100	4.17932300
H	0.85431025	-1.23173300	-1.57654742	H	3.93891300	-3.76693500	4.33772900
H	-4.93258656	2.62543292	5.98694151	H	0.10119300	4.03156700	-2.93184400
H	-3.50420124	5.29248730	2.93932319	H	-0.04912000	4.72273400	1.30408500

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