Investigation into Ionic and Photoredox Reactions of Sulfoxonium Ylides

Supporting Information

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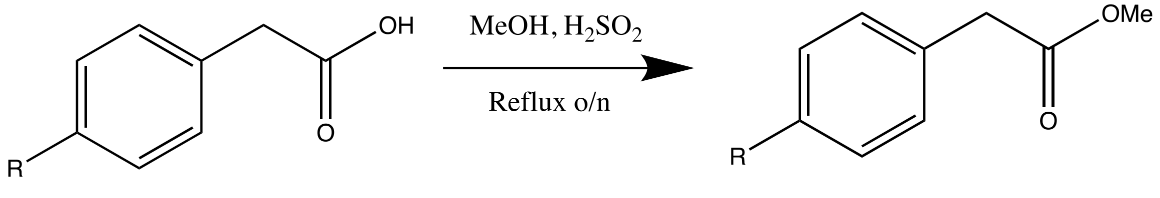
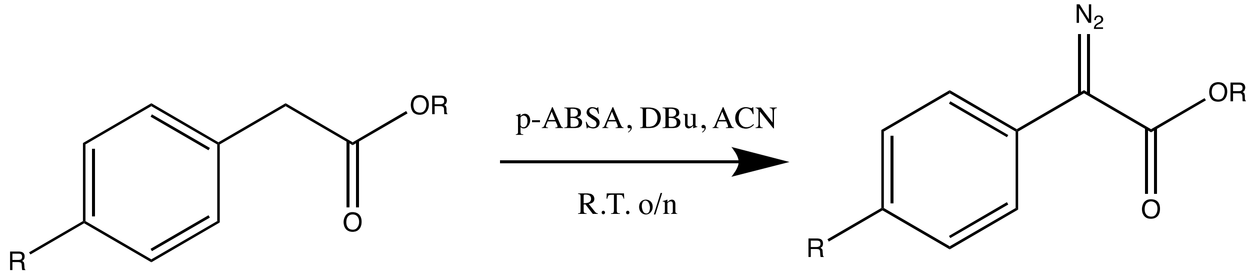
General procedures for the synthesis of sulfoxonium ylides 1[1-5]

Step 1. Fischer Esterification (If necessary)



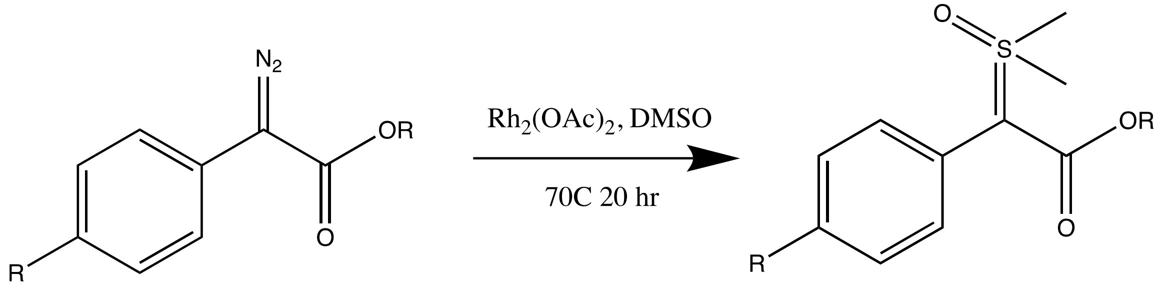
Phenyl carboxylic acid (2.5 g, 18.4 mmol), methanol (15 mL), and sulfuric acid (4 drops) was added to a round bottom flask and refluxed overnight. The reaction was then worked up with DCM and DI water, then washed with brine.

Step 2. Formation of a diazo compound



Phenyl acetate (1 eq), acetonitrile (30 mL, and 4-acetamindobenzenesulfonyl azide (1.2 eq) were combined and brought to 0°C. 1,8-diazabicyclo(5.4.0)undec-7-ene was added to the mixture dropwise. The reaction was allowed to room temperature and stirred overnight. Once the reaction was complete, it was worked up with DI water and ethyl acetate, washed with saturated ammonium chloride and brine, and columned in silica gel using 10:90 EtOAc:Hexanes.

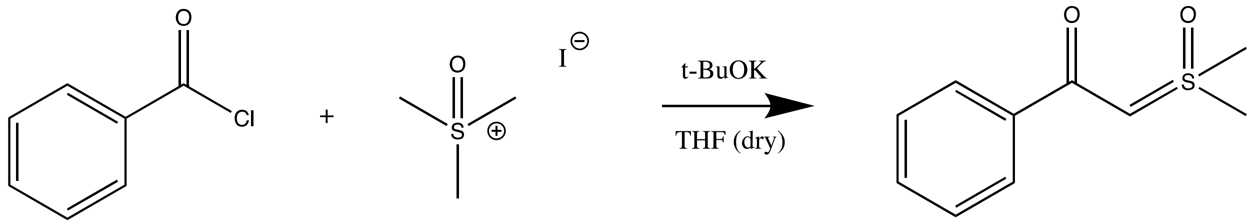
Step 3. Sulfoxonium ylide synthesis



Rhodium acetate dimer (0.015 eq) and DMSO (20 mL) were added to a 3-neck round bottom flask and brought to reflux at 70°C. Diazo compound (1 eq) was added in DMSO (8-10 mL) over 18 hours via a syringe pump. The reaction was then reacted for an additional 2 hours, then brought to room temperature. It was then diluted with ethyl acetate, rinsed with DI water to remove the DMSO, and extracted with DCM and washed with DI water again. It was then concentrated, washed with 10:90 EtOAc:Hexanes, and filtered via a Buchner funnel.

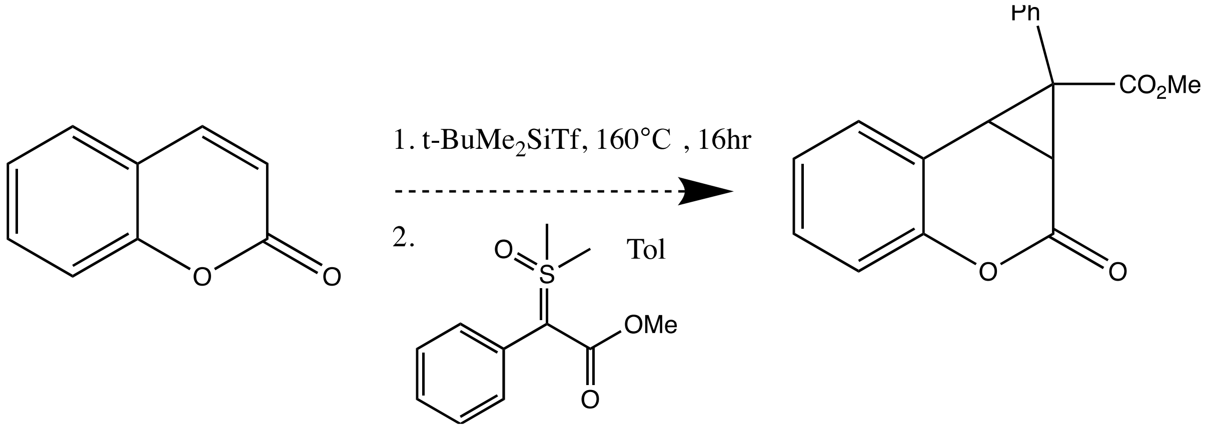
(Exact amounts for steps 2 and 3 depend on the yield of steps 1 and 2.)

General procedure for synthesis of sulfoxonium ylid 2



Potassium tert-butoxide (1.5 g, 13.4 mmol, 4 eq) was dissolved in 20 mL of tetrahydrofuran. Trimethylsulfoxonium iodide (2.2 g, 10.0 mmol, 3 eq) was added at room temperature, and the reaction mixture was then refluxed at 65°C for 2 hours. Once the reflux was complete, the reaction was brought to 0°C, and the acyl chloride was added dropwise in 4 mL of tetrahydrofuran. The reaction was allowed back to room temperature and stirred for an additional 3 hours. The reaction mixture was then concentrated, and DI water and DCM were added. The organic layer was collected, and the aqueous layer was washed with DCM. The organic layer was dried with sodium sulfate, concentrated, in columned in silica gel with 95:5 DCM:MeOH. Product is a white powder, 96% yield.

General procedures from *Ionic Conditions – Experiments with Coumarin*



Coumarin was added to a flame-dried glass vial with a stir bar, and the vial was fitted with a screw cap with a Teflon coated septum for injections. Tert-butyldimethylsilyl trifluoromethanesulfonate was then added dropwise to the vial. Once the addition was complete, the vial was stirred and heated at 160°C for 16-24 hours. The sulfoxonium ylide was then added in toluene, and the reaction was stirred at room temperature for several days. The reaction mixture was worked up with DCM and H_2O, and was analyzed by prep-TLC, ^{1}HNMR, and GC-MS. Amounts of material used and other parameters can be seen in the table below.

Table 1. Coumarin ionic conditions reaction conditions.

Reaction	Vial size	mmol coumarin	mmol TBSOFT	mmol ylide	Time
1	2-dram	2.2 (2 eq)	2.2 (2 eq)	1.3 (1 eq)	6 days
2	2-dram	2.2 (1 eq)	2.2 (1 eq)	2.2 (1 eq)	7 days
3	1-dram	1.1 (1 eq)	1.1 (1 eq)	1.1 (1 eq)	9 days
4	1-dram	1.1 (1 eq)	1.1 (1 eq)	1.1 (1 eq)	7 days

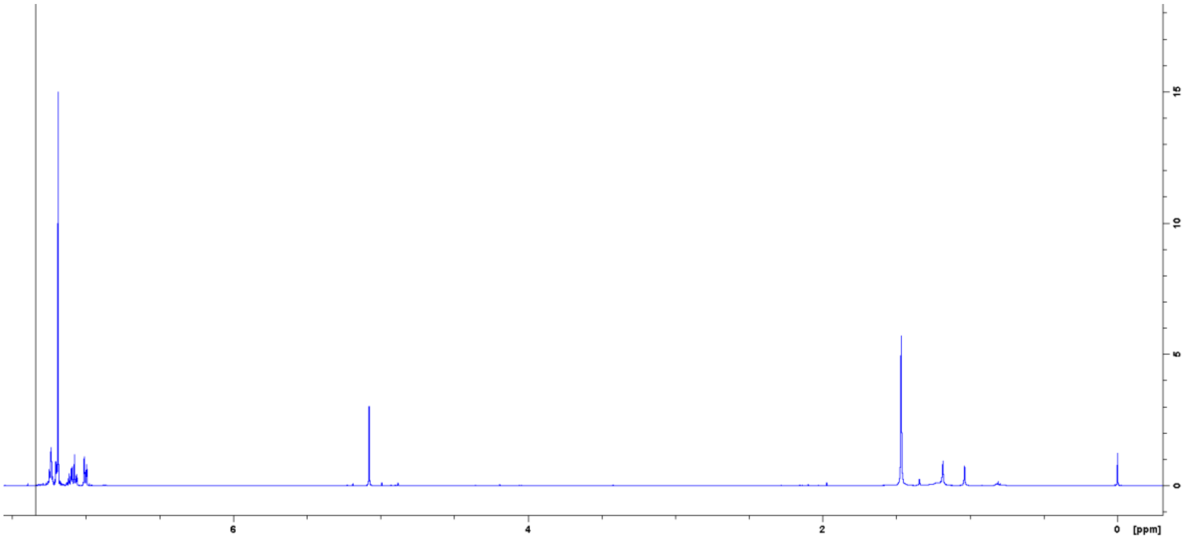
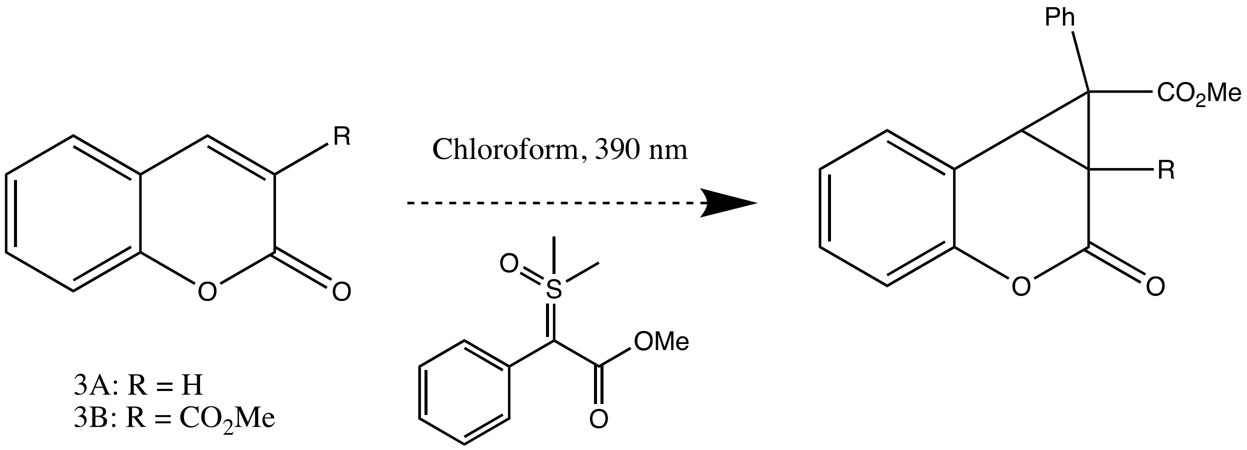


Figure 1. Example ^{1}HNMR of product

General procedures from *Coumarin Photochemistry*



3A: R = H
3B: R = CO_2Me

Coumarin (29.2 mg, 0.2 mmol, 1 eq), sulfoxonium ylide (50.0 mg, 0.22 mmol, 1.1 eq), and dry chloroform (4 mL) were added to a flame dried glass vial. The vial was placed under 390 nm lights and stirred for 24 hours. A fan was also directed at the vial to counteract the heating effect of the lights. The reaction mixture was analyzed by prep-TLC and ^{1}HNMR.

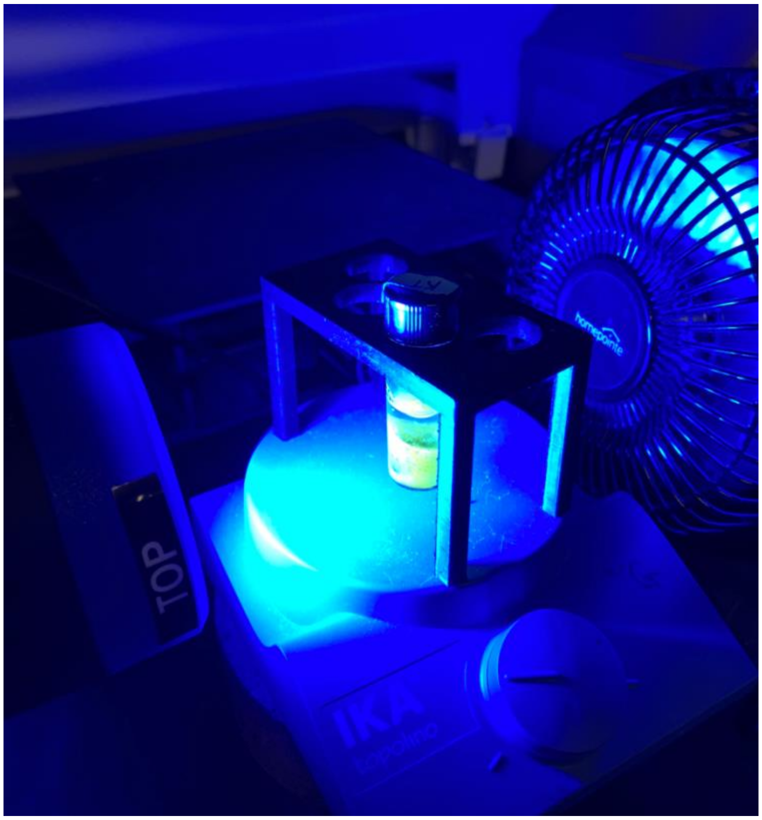


Figure 2. Photochemical reaction set up

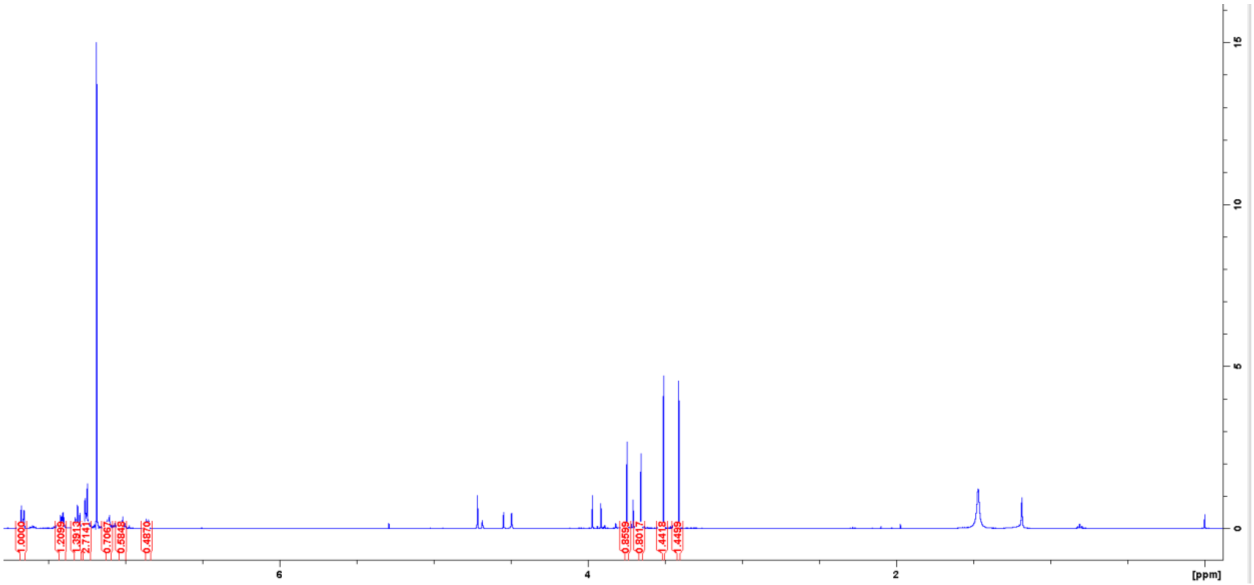
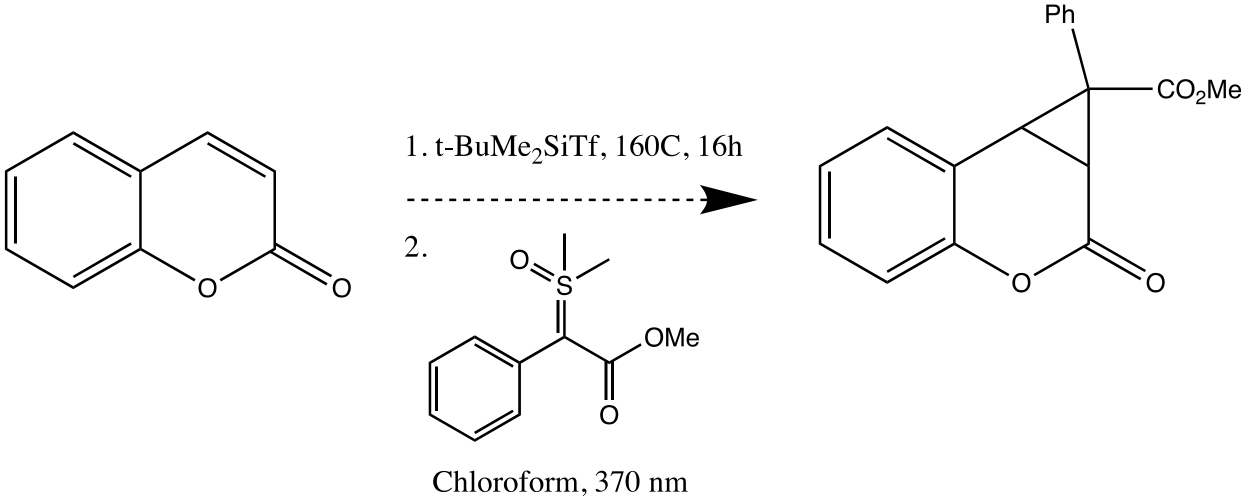
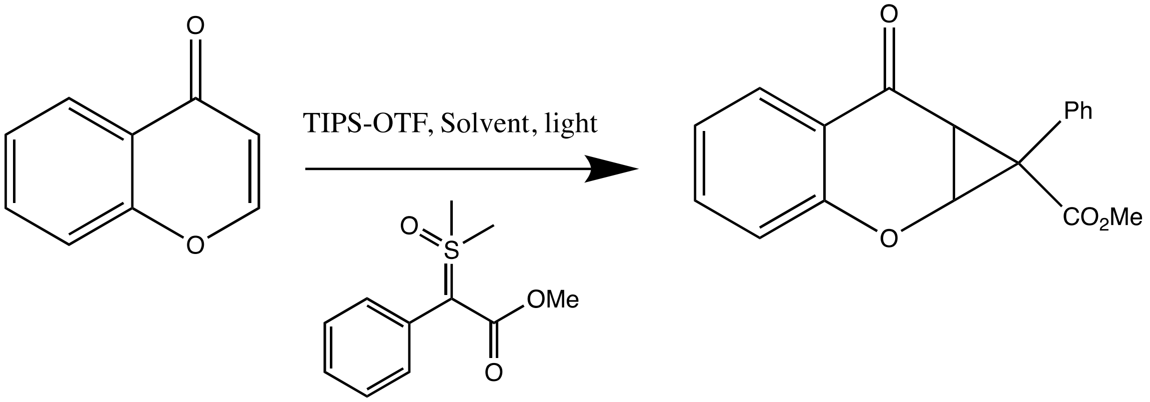


Figure 3. ^{1}HNMR of product when R=CO_2Me



Coumarin (0.16 g, 1.1 mmol, 2 eq) was added to a flame-dried glass vial with a stir bar, and the vial was fitted with a screw cap with a Teflon coated septum for injections. Tert-butyldimethylsilyl trifluoromethanesulfonate (0.24 mL, 1.1 mmol, 2 eq) was then added dropwise to the vial. Once the addition was complete, the vial was stirred and heated at 160°C for 16-24 hours. The reaction was then allowed to come to room temperature, and 1 mL of toluene was added. This was stirred until the reaction was homogeneous. The sulfoxonium ylide (0.13 g, 0.55 mmol, 1 eq) was then added with an addition 1 mL of toluene. The reaction was then placed under 370 nm lights and stirred for 24 hours. The reaction mixture was analyzed by prep-TLC and ^{1}HNMR.

General procedures from *Sulfoxonium Ylide Photochemistry*



4H-1-Benzopyran-4-one (14.6 mg, 0.1 mmol, 1 eq), TIPS-OTF (30 µL), sulfoxonium ylide (31.6 mg, 0.14 mmol, 1.4 eq), and solvent (0.8 mL) were added to a flame-dried glass vial and stirred under 390 nm lights for two hours. The reaction was check periodically by TLC in 20:80 EtOAc:Hexanes.

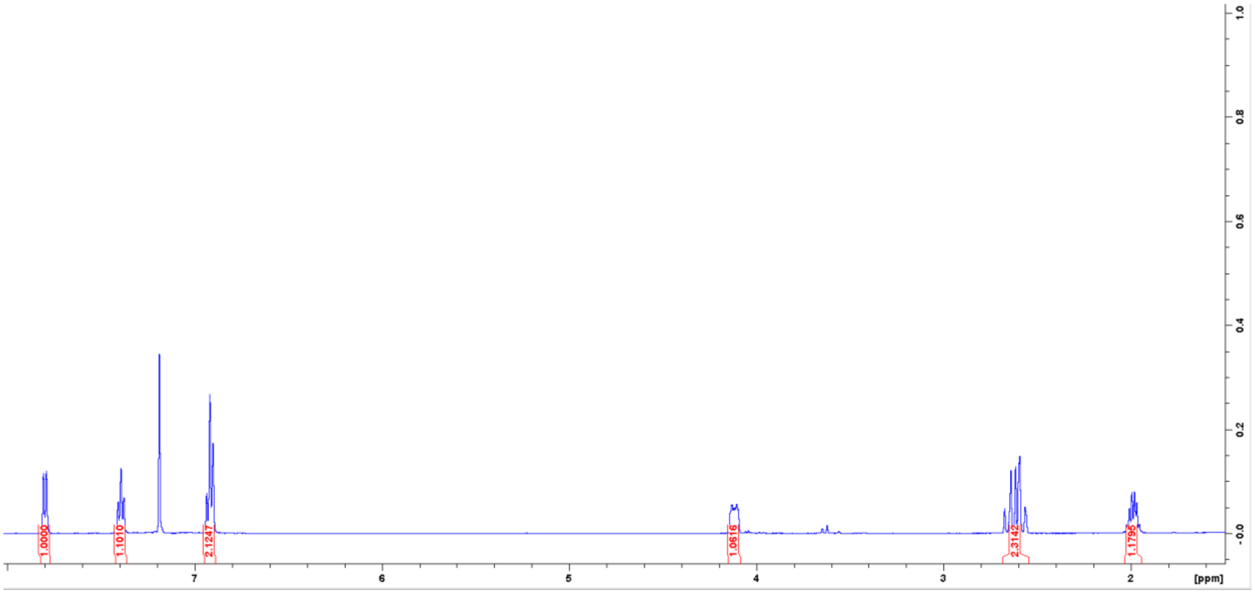
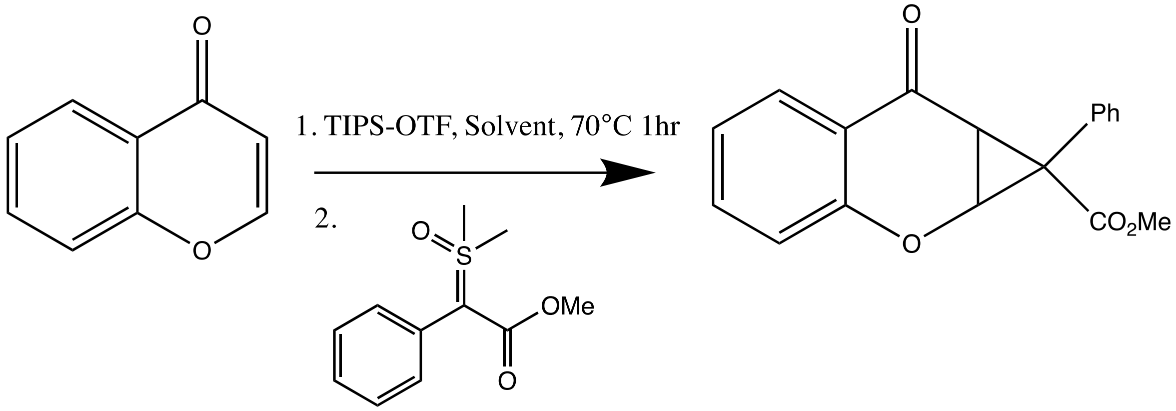
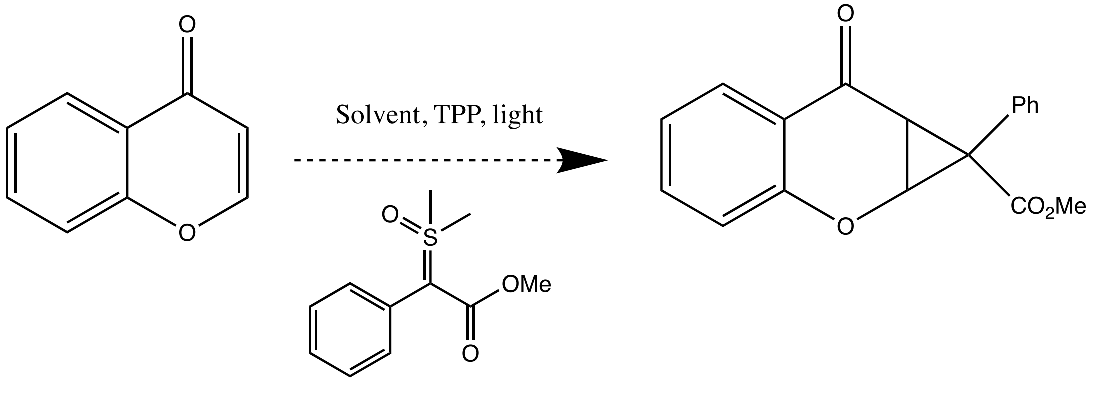


Figure 4. Example ^{1}HNMR when light is used in the reaction



4H-1-Benzopyran-4-one (14.6 mg, 0.1 mmol, 1 eq), TIPS-OTF (30 µL), and solvent (0.8 mL) were added to a flame-dried glass vial and stirred at 70°C for 1 hour. Sulfoxonium ylide (22.7 mg, 0.1 mmol, 1 eq) was added, the reaction was allowed to come to room temperature and stirred for 24 hours. The reaction was check periodically by TLC in 20:80 EtOAc:Hexanes.



4H-1-Benzopyran-4-one (14.6 mg, 0.1 mmol, 1 eq), and DCM (0.8 mL) were added to a flame-dried glass vial and stirred to combine. Once combined, sulfoxonium ylide (22.7 mg, 0.1 mmol, 1 eq) and 2,4,6-triphenylpyryrium (TPP) (8.0-11.9 mg, 0.02-0.03 mmol, 20-30 mol%) were added to the reaction, and the reaction was placed under lights (390, 440, or 467 nm). The reaction was analyzed by TLC in 20:80 EtOAc:Hexanes.

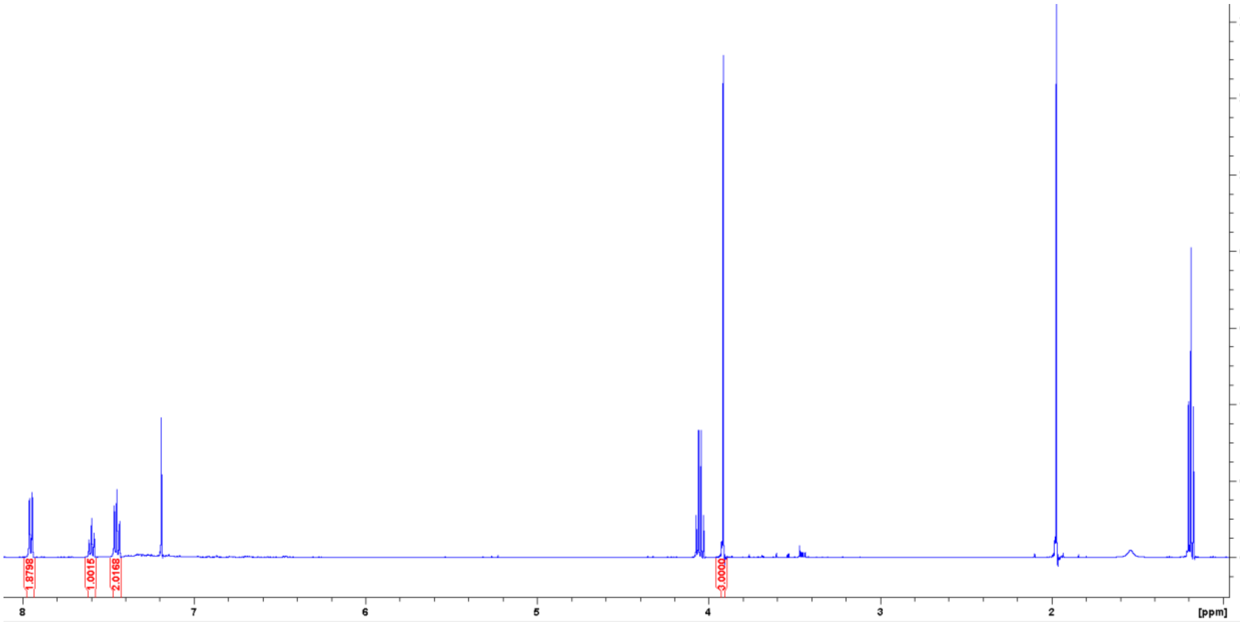
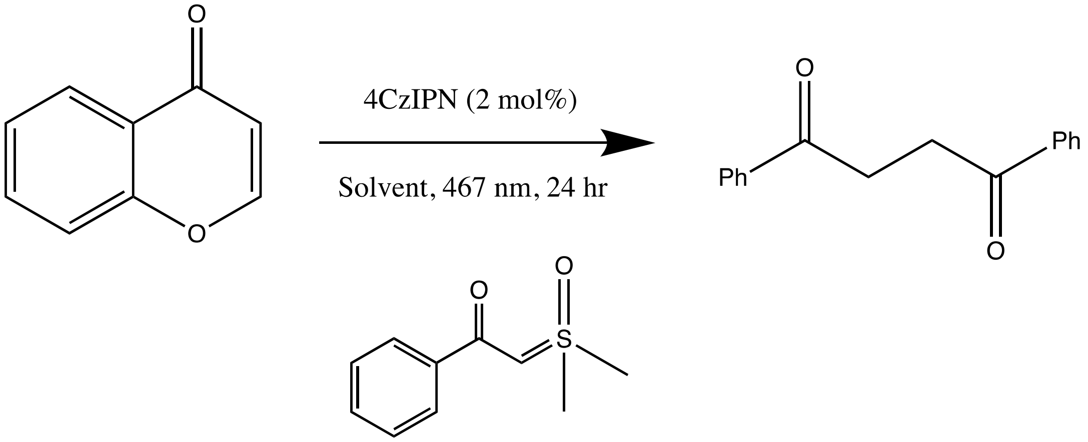


Figure 5. Example ^{1}HNMR of product with TPP



4H-1-Benzopyran-4-one (14.6 mg, 0.1 mmol, 1 eq) and DCM (2.0 mL) were added to a flame-dried glass vial and stirred to combine. Sulfoxonium ylide (22.7 mg, 0.1 mmol, 1 eq) and 4CzIPN (1.5 mg, 0.002 mmol, 2 mol%) was then added to the reaction, and it was placed under 467 nm lights and stirred for 24 hours. The reaction was analyzed by TLC in 1:2 EtOAc:Hexanes.

Alternatively, the solvent system 1:2 DCM:H_2O (2.0 mL) was also used. In this case, the reaction was stirred vigorously in order to ensure mixing between the DCM and H_2O.

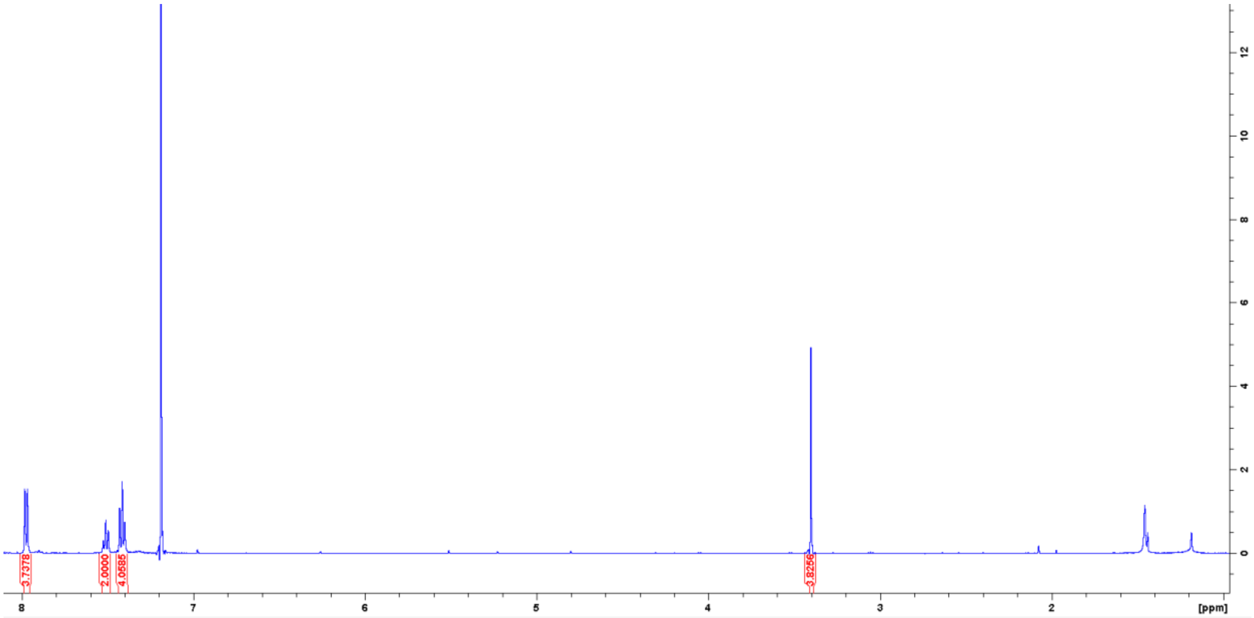


Figure 6. ^{1}HNMR of 1,4-diphenylbutane-1,4-dione, the byproduct formed by the combination of two sulfoxonium ylide radicals

References

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