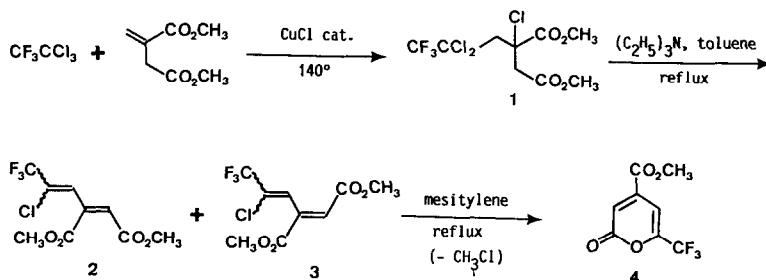


A NEW ELECTROPHILIC 2-PYRONE BEARING A CF₃-GROUP, ITS PREPARATION
 AND ITS [4+2] CYCLOADDITION REACTIONS.¹

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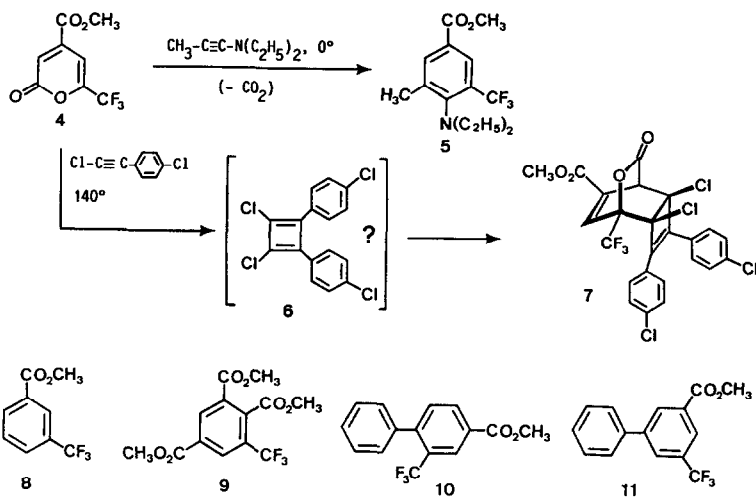
Abstract: An efficient method for the synthesis of 4-methoxycarbonyl-6-trifluoromethyl-2H-pyran-2-one (**4**) starting from the 1:1-adduct of the CuCl-catalysed addition of 1,1,1-trichloro-2,2,2-trifluoroethane to dimethyl itaconate is presented. The new electrophilic 2-pyrone **4** affords [4+2] cycloadducts with a number of olefins and acetylenes. Their formation follows the reactivity patterns of a typical Diels-Alder reaction with inverse electron demand. The overall sequence represents a new methodology for the transfer of the CF₃-group from a simple Freon into more complex organic compounds.

Organic polyhalides are known to add to olefins in the presence of various catalysts such as peroxides, light and transition metal salts or complexes. Cu(I)-salts as catalysts show definite advantages especially on an industrial scale³ due to the simplicity of the reaction systems as well as to the exclusive formation of 1:1 adducts, often in high yields. Recently, we took advantage of the smooth CuCl-catalysed reaction between acrylic acid derivatives and CF₃CCl₃⁵ to prepare several CF₃-group containing biologically active compounds, e.g. pyrethroids^{4b} and pyridines.^{1,5} The purpose of the present work is to describe another utility of this simple Cu(I)-catalytic approach to the selective introduction of CF₃-group into preparatively useful molecules.



The CuCl (5 mol % in 200 ml CH₃CN)-catalysed reaction of 1.5 mol CF₃CCl₃ with 1 mol of dimethyl itaconate at 140° affords after 8 h the 1:1-adduct **1** in 57 % yield, bp. 80-85° at 0.3 mm. Double dehydrochlorination of **1** with triethylamine in refluxing

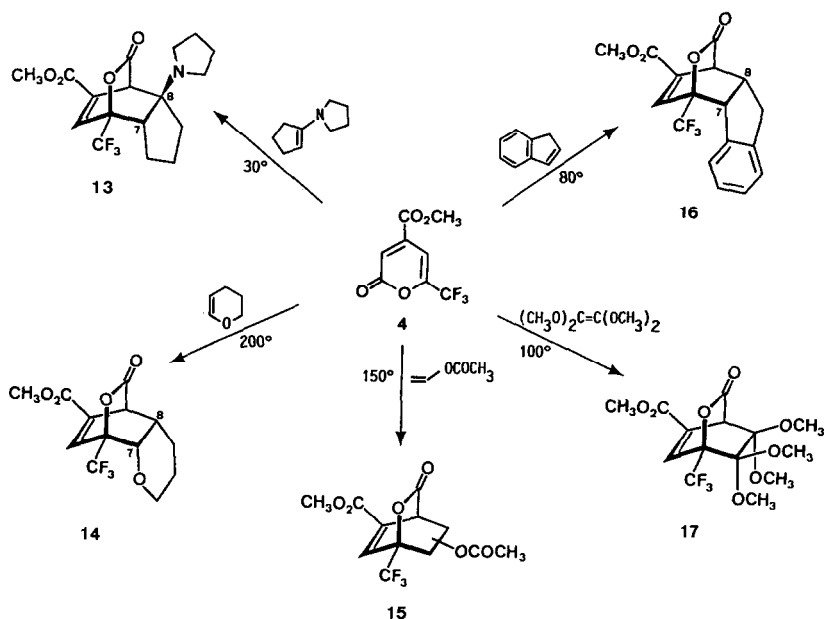
toluene gives a 83:17 mixture of butadienes 2 and 3 in 80 % yield, bp. 59-61° at 0.2 mm. On heating of these isomers in refluxing mesitylene in the presence of small amounts of hydroquinone and CuCl, ring closure to a new 2-pyrone derivative 4 occurs. Normal work-up gives a 62 % yield of 4-methoxycarbonyl-6-trifluoromethyl-2H-pyran-2-one (4), mp. 38-40°.



A noteworthy feature of 4 is its ability to undergo Diels-Alder reactions with acetylenes. The cycloadducts decarboxylate spontaneously to form benzene rings bearing the trifluoromethyl group. The substitution pattern is determined by the regioselectivity of the [4+2] cycloaddition step. Thus, the reaction of 4 with 1-(N,N-diethylamino)-1-propyne takes place at 0° to produce 5 as a single isomer (68 %). Less electron rich acetylenes require reaction temperatures of 140° to 200°. Treatment of 4 with acetylene at 200° leads to 8 (91 %). With dimethyl acetylenedicarboxylate 9 is formed (67 %). Phenylacetylene affords a 3:2 mixture of biphenyls 10 and 11 (39 % overall yield). However, with 1-chloro-2-(4'-chlorophenyl)acetylene at 140° the expected derivative of biphenyl is not formed. Instead, the tricyclic cyclobutene derivative 7 can be isolated as the sole product in 70 % yield.

The structure of 7 was established by X-ray structure analysis.⁶ This surprising result indicates that 1-chloro-2-(4'-chlorophenyl)acetylene may first undergo an head-to-head [2+2] cycloaddition reaction leading to the highly reactive 1,2-dichloro-3,4-di-(4'-chlorophenyl)cyclobutadiene, which then is immediately captured by the diene 4 across its least sterically hindered, 1,2-dichlorosubstituted double bond.⁷

We have also studied the reactivity of 4 towards olefins. In most cases, the [4+2] cycloadducts do not eliminate CO_2 under the experimental conditions of their formation, e.g., the reaction of 4 with N-pyrrolidino-1-cyclopentene at 30° gives rise to the tricyclic lactone 13 (92 %). When 13 is treated with HCl/dioxane, the indane derivative 12 is obtained in 51 % yield. The reaction with 1-trimethylsilyloxy-1-cyclopentene and 4 at 180° leads directly to 12 (90 %). With 3,4-dihydro-2H-pyran at 200° 14 is formed as



the sole regio isomer (81 %). The reversal of the regioselectivity of **13** versus **14** is remarkable. All four possible regio- and stereoisomers can be identified in the NMR spectra of **15**, the product of reaction of **4** with vinylacetate at 150° (71 % yield). Above 180°, **15** loses the elements of acetic acid and CO₂ to give **8** quantitatively. **16**, formed from **4** and indene at 80° (87 %) contains the methylene group attached exclusively endo to C(8). *Endo*-adducts of this type result also with 2,5-dihydrofuran (130°;71 %), cyclopentene (120°;92 %), cyclooctene (150°;87 %) and acenaphthylene (100°;89 %). Whereas the very nucleophilic tetramethoxyethylene adds (at 100°) to **4** to afford **17** (71 %), the first Diels-Alder adduct of tetramethoxyethylene with a cyclic diene known so far, the different attempts to add 'classic' dienophiles such as tetracyanoethylene and maleic anhydride to **4** failed.⁸

On the basis of our results, we can conclude that [4+2] cycloaddition reactions of **4** exhibit the typical features of Diels-Alder reactions with inverse electron demand.⁹ The merit of the described sequence of facile reactions is obvious: no exotic reagents are needed for the regioselective introduction of the trifluoromethyl group of inexpensive origin (Freon) into useful aromatic compounds. As far as the Cu(I)-catalysed addition of organic polyhalides to olefins is concerned, the addition described herein represents a useful synthetic application of this versatile organometallic reaction.¹⁰

References and Notes

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