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An Efficient Synthesis of Highly Functionalized and Electron-Deficient 1,3-Dienes from Cyclobutene Derivatives

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Cyclobutene derivatives undergo electrocyclic ring-opening reactions in boiling toluene to produce highly electron-deficient 1,3-dienes. These cyclobutenes prepare from the reaction of 2-thenoyltrifluoroacetone in presence of triphenyl phosphine at room temperature, *via* intramolecular Wittig reaction.

Key Words: 2-Thenoyltrifluoroacetone, Cyclobutene derivatives, Electrocyclic ring opening, Electron-deficient 1,3-dienes.

INTRODUCTION

Dienes and polyenes have been a subject of great interest due to their important role in biology, materials science and organic synthesis. The efficient synthesis of functionalized dienes with defined double bond geometries is an important goal in organic synthesis, as they are frequently used as intermediates in the synthesis of natural products. Such dienes are usually desired as precursors to Diels-Alder cyclizations or as substrates for other stereocentre generating reactions like dihydroxylations and epoxidations[1,2].

As part of our current studies on the development of the synthesis of functionalized vinyl systems[3-5], we now report a facile synthesis of highly functionalized and electron-deficient 1,3-dienes *via* electrocyclic ring-opening reaction of cyclobutene derivatives in boiling toluene. Thus, reaction of triphenyl phosphine and dialkyl acetylene dicarboxylates (**1**) in the presence of a strong CH-acid such as 2-thenoyltrifluoroacetone (**2**) leads to the corresponding cyclobutene derivatives (**3a-c**[6]), which are converted to tetra-substituted buta-1,3-dienes (**4a-c**) in quantitative yields (Fig. 1).

EXPERIMENTAL

Dialkyl acetylenedicarboxylate, triphenyl phosphine and 2-thenoyltrifluoroacetone were obtained from Fluka (Buchs, Switzerland) and used without further purification. Elemental analyses for C and H were performed using a Heraeus CHN-O-Rapid analyzer. ^{1}H, ^{13}C NMR spectra were measured ($CDCl_3$ solution) with a Bruker DRX-500 Avance spectrometer at 500.1, 125.8 MHz, respectively. IR spectra were recorded on a Shimadzu IR-460 spectrometer.

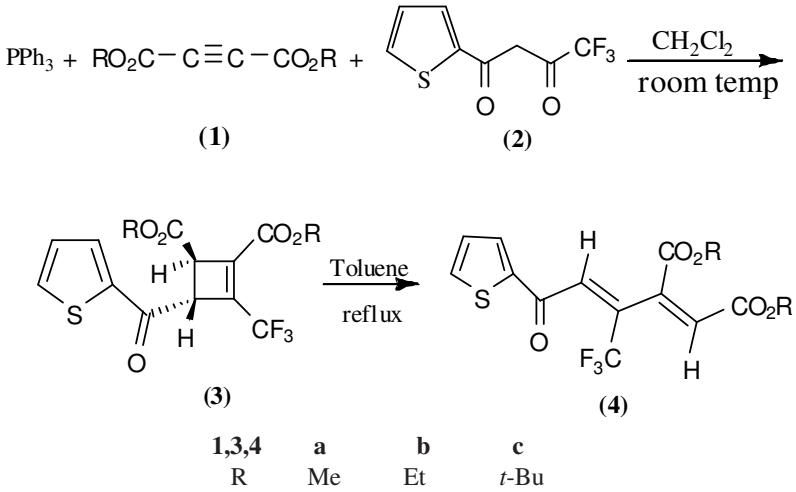


Fig. 1

General procedure: To a magnetically stirred solution of 2-thenoyltrifluoroacetone (0.44 g, 2 mmol) and triphenyl phosphine (0.52 g, 2 mmol) in 10 mL CH_2Cl_2 was added dropwise at -10 °C over 10 min dialkyl acetylenedicarboxylates (2 mmol). The reaction mixture was then allowed to warm up to room temperature and stand for 48 h. The solvent was removed under reduced pressure and the residue was separated by silica gel column flash chromatography (Merck 230-400 mesh) using *n*-hexane-ethyl acetate as eluent. Then, the cyclobutene derivatives **4a-c** were refluxed in toluene and functionalized tetra-substituted buta-1,3-dienes (**5a-c**) were prepared after purification by flash column chromatograph.

Dimethyl(Z)-2-[(Z)-3-oxo-3-(2-thienyl)-1-(trifluoromethyl)-1-propenyl]-2-butendioate (4a): Yellow oil, yield 48 %. ^{1}H NMR (500.1 MHz, $CDCl_3$): δ = 3.71 and 3.83 (6 H, 2 s, 2 OCH_3), 7.09 (1 H, s, CH), 7.18 (1 H, dd, $^3J_{HH}$ = 4.8 and 4.0 Hz, CH of thiophene), 7.46 (1H, s, CH), 7.75 (1 H, dd, $^3J_{HH}$ = 4.8 Hz and $^4J_{HH}$ = 1.0 Hz, CH of thiophene), 7.84 (1H, dd, $^3J_{HH}$ = 4.0 Hz and $^4J_{HH}$ = 1.0 Hz, CH of thiophene). ^{13}C NMR (125.7 MHz, $CDCl_3$): δ = 52.50 and 53.60 (2OCH_3), 123.15 ($^1J_{CF}$ = 270.4 Hz, CF_3), 128.06 ($^3J_{CF}$ = 4.3 Hz, CH-C-CF_3), 129.10 (CH of thiophene), 131.30 (CH-CO_2CH_3), 133.80 and 136.50 (2 CH of thiophene), 138.00 (C-CO_2CH_3), 138.30 ($^2J_{CF}$ = 37.7 Hz, C-CF_3), 144.70 (C of thiophene), 164.10 and 164.80 (2 C=O, ester), 180.60 (C=O, ketone). ^{19}F NMR (470.59 MHz, $CDCl_3$): δ_F = -250.28. IR (KBr, ν_{max}, cm^{-1}): 1715-1735 (C=O). MS, (m/z, %): 348 (9) (M^+), 69 (34), 44 (96), 31 (15). Anal. calcd. for $C_{14}H_{11}O_5SF_3$ (348): C, 48.28; H, 3.16 %: Found: C, 48.2; H, 3.1 %.

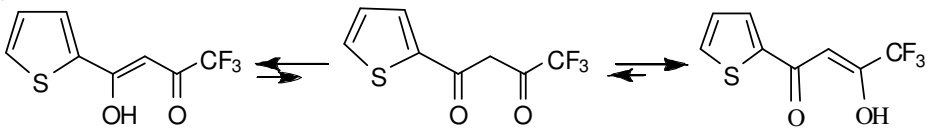
Diethyl(Z)-2-[(Z)-3-oxo-3-(2-thienyl)-1-(trifluoromethyl)-1-propenyl]-2-butendioate (4b): Yellow oil, yield 51 %. ^{1}H NMR (500.1 MHz, $CDCl_3$): δ = 1.22 and 1.28 (6 H, t, $^3J_{HH}$ = 7.2, 7.1 Hz, 2 CH_3), 4.14 and 4.32 (4 H, q, $^3J_{HH}$ = 7.2, 7.1 Hz, 2OCH_2), 7.10 (1H, s, CH), 7.10 (1 H, dd, $^3J_{HH}$ = 4.8 and 4.0 Hz, CH of thiophene),

7.46 (1 H, s, CH), 7.75 (1H, dd, $^3J_{HH}$ = 4.8 Hz and $^4J_{HH}$ = 1.0 Hz, CH of thiophene), 7.80 (1H, dd, $^3J_{HH}$ = 4.0 Hz and $^4J_{HH}$ = 1.0 Hz, CH of thiophene). ^{13}C NMR (125.7 MHz, $CDCl_3$): δ = 13.46 and 13.56 ($2OCH_2CH_3$), 60.99 and 61.32 ($2OCH_2$), 123.15 ($^1J_{CF}$ = 270.4 Hz, CF_3), 128.43 ($^3J_{CF}$ = 4.4 Hz, CH-C-CF_3), 130.96 (CH of thiophene), 133.15 (CH-CO_2CH_3), 135.07 and 135.76 (2 CH of thiophene), 138.24 (C-CO_2CH_3), 139.75 ($^2J_{CF}$ = 37.8 Hz, C-CF_3), 143.98 (C of thiophene), 162.84 and 163.74 (2 C=O, ester), 179.94 (C=O, ketone). ^{19}F NMR (470.59 MHz, $CDCl_3$): δ_F = -250.32. IR (KBr, ν_{max}, cm^{-1}): 1715-1730 (C=O). MS, (m/z, %): 376 (6) (M^+), 69 (25), 45 (18), 44 (91). Anal. calcd. for $C_{16}H_{15}O_5SF_3$ (376): C, 51.06; H, 3.99 %: Found: C, 51.1; H, 3.9 %.

Di(*t*-butyl)(Z)-2-[(Z)-3-oxo-3-(2-thienyl)-1-(trifluoromethyl)-1-propenyl]-2-butendioate (4c): Yellow oil, yield 61 %. ^{1}H NMR (500.1 MHz, $CDCl_3$): δ = 1.40 and 1.55 (18 H, 2 s, 2 CMe_3), 6.94 (1H, s, CH), 7.21 (1H, dd, $^3J_{HH}$ = 4.7, 4.0 Hz, CH of thiophene), 7.41 (1H, d, $^3J_{HH}$ = 4.7 Hz, CH of thiophene), 7.70 (1H, d, $^3J_{HH}$ = 4.0 Hz, CH of thiophene), 7.79 (1H, s, CH). ^{13}C NMR (125.7 MHz, $CDCl_3$): δ = 27.87 and 27.97 ($2CMe_3$), 47.77 and 48.93 (2CH), 82.71 and 83.17 ($2OCMe_3$), 118.21 (q, $^1J_{CF}$ = 271.8 Hz, CF_3), 127.5 (q, $^2J_{CF}$ = 40.1 Hz, C=C-CF_3), 128.40, 132.50 and 135.30 (3CH of thiophene), 136.50 (q, $^3J_{CF}$ = 5.4 Hz, C=C-CF_3), 144.35 (C of thiophene), 162.11 and 163.37 (2C=O, ester), 180.11 (C=O, ketone). ^{19}F NMR (470.59 MHz, $CDCl_3$): δ_F = -250.35. IR (KBr, ν_{max}, cm^{-1}): 1718-1735 (C=O). MS, (m/z, %): 432 (7) (M^+), 73 (17), 69 (38), 44 (90). Anal. calcd. for $C_{20}H_{23}O_5SF_3$ (432): C, 55.56; H, 5.32 %: Found: C, 55.5; H, 5.3 %.

RESULTS AND DISCUSSION

2-Thenoyltrifluoroacetone (**2**) is a multifunctional system, which is apparently enolized in the liquid phase. This asymetric β-diketone has two enolic tautomer, as indicated by ^{1}H and ^{13}C NMR spectroscopy (Fig. 2).



(2)

Fig. 2

On the basis of the chemistry of trivalent phosphorus nucleophiles[7], it is reasonable to assume that cyclobutene derivatives **3a-c** result from initial addition of triphenyl phosphine to the acetylenic ester and subsequent protonation of the reactive 1:1 adduct by **2**, followed by attack of the carbon atom of the anion of **2** to vinyltriphenyl phosphonium cation **5** to generate ylide **6**, which is chemoselectively converted into strained carbocyclic ring systemes **3a-c** *via* intramolecular Wittig reaction. Compounds **3a-c** undergo an electrocyclic ring-opening reaction in boiling toluene to produce electron deficient 1,3-dienes **4a-c** in fairly good yields (Fig. 3).

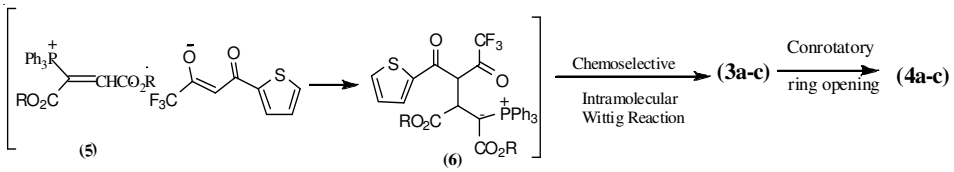


Fig. 3

^{1}H NMR spectra of the butadiene derivatives **4a-c** displayed signals at about δ = 7.09 and 7.46 ppm for two olefinic protons. The ^{13}C NMR of **4a-c** displayed four signals in the olefinic region. The ^{19}F NMR of **4a-c** also displayed one singlet peak at about δ = -250.28 for the CF_3 group. Although, we have not proved the stereochemistry of dienes **4a-c**, the geometry shown in Fig. 1 is the most reasonable on steric ground and on the basis of conrotatory cyclobutene opening. The structural assignments made on the basis of NMR spectra for compounds **4a-c** were supported by measurments of their IR spectra. Of special interest are the strong carbonyl absorption bonds at 1725-1715 cm^{-1} for these compounds. Although the presence of the ^{19}F nucleus complicated both ^{1}H and ^{13}C NMR spectra of **4a-c**, it helps in assignment of the signals by the long-range coupling with ^{1}H and ^{13}C nuclei.

Conclusion

In present studies, it is found that the reaction of 2-thenoyltrifluoroacetone with dialkyl acetylene dicarboxylates in the presence of triphenyl phosphine leads to a facile synthesis of highly fnctionalized cyclobutenes, which are converted to electron-deficient 1,3-dienes on the basis of conrotatory opening.

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REFERENCES

1. G. Metha and H.S.P. Rao, in ed.: Z. Rappoport, The Chemistry of Dienes and Polyenes, John Willy & Sons: Chichester, UK, Vol. 1 (1997).
2. S. Patai, The Chemistry of Alkenes, Wiley, New York (1964).
3. R. Baharfar, M. Tajbakhsh, A. Hamedaninejad and S. Hosseini, *J. Chin. Chem. Lett.*, **19**, 175 (2008).
4. R. Baharfar, A. Ostadzadeh and A. Abbasi, *J. Chem. Res. (S)*, 37 (2004).
5. R. Baharfar, S.M. Baghbanian, R. Hosseinnia and H. Bijanzadeh, *Lett. Org. Chem.*, **4**, 567 (2007).
6. M.H. Mosslemin, I. Yavari, M.A. Abbasinejad and M.R. Nateghi, *Synthesis*, 1029 (2004).
7. D.E.C. Cobridge, Phosphorus, An Outline of Chemistry, Biochemistry and Uses, Elsevier, Amsterdam, edn. 6 (1995).

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