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"Carbomers". II. En Route to $[C,C]_6$Carbo-Benzene.

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Abstract. One strategy for the synthesis of $[C,C]_6$carbo-benzene is tackled. The target substrate 15 and derivatives for the final cyclodimerisation step, have been obtained. New hydroxy-polyynacetals are characterized. Rearrangements to 1,2-disubstituted furans are also reported.

The stability of $[C,C]_6$carbo-benzene **1**[1] can be anticipated from known trends in annulene and dehydroannulene chemistry:[2] the stability of an unsaturated macrocycle is determined by its rigidity and the number of butatriene units it contains.[3] The Hückel rule suggests that this molecule might be aromatic (18=4n+2 electrons, without the central double bonds of each edge). Carbo-benzene **1** is an isomer of Sondheimer's hexadehydro-[18]annulene **3**[4] derived from [18]annulene **2** (Fig. 1).[5] Structural features of carbo-benzenes can be recognized in carbon networks studied by Diederich,[6] and in macrocyclic polyynes.[7] To our knowledge, the stability of the unit **1** has not been discussed. Preliminary attempts at the synthesis of **1** give us the opportunity to report some results in the chemistry of functional polyynes.

One possible route to **1** is based on the synthesis of compound **15**. Cyclodimerization of **15** should give the precursor molecule **4**, which is a carbomer of inositol isomers. **4** might afford either carbo-benzene **1** by reduction, or carbo-1,3,5-trihydroxybenzene **5** by dehydration: this strategy would lead at once to both $[C,C]_6$carbo-cyclohexane ring **4** and to $[C,C]_6$carbo-benzene rings **1** and **5** (Fig. 2).[8]

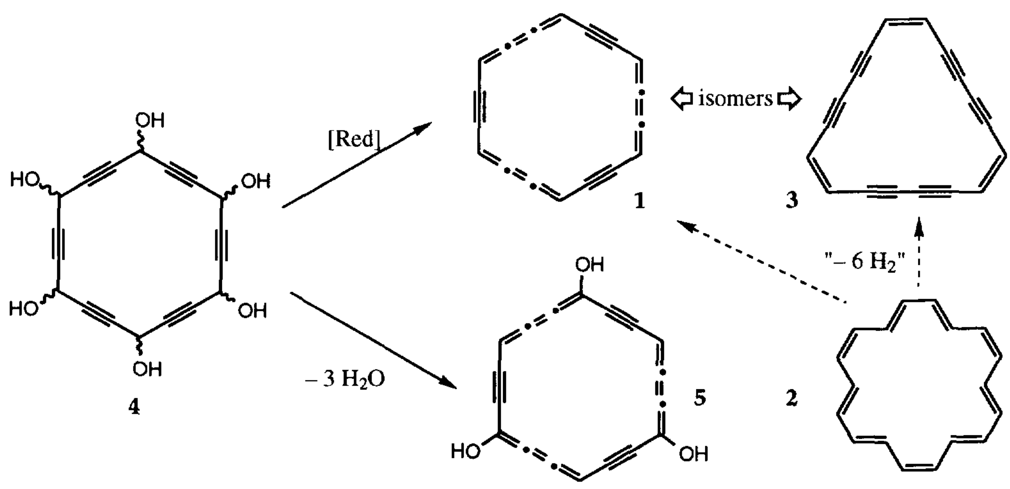

Figure 1. $[C,C]_6$carbo-benzene, $[C,C]_6$carbo-trihydroxybenzene, $[C,C]_6$carbo-inositol isomers and [18]annulenes.

From the reaction of trimethylsilylacetylene **6** and DMF, trimethylsilylpropynal **7** is obtained in 83% yield.[9] Commercial 3,3-diethoxypropyne **8** is deprotonated by CH_3MgBr in THF at –20°C and added to **7**, giving 1-trimethylsilyl-6,6-diethoxyhexa-1,4-diyn-3-ol **9** in 94% yield. Desilylation of **9** by $(n\text{-}Bu)_4NF$ affords **10** in 97% yield. The dianion of **10** is formed in THF at –78°C in the presence of *tert*-butyllithium and added to **7**. Hydrolysis of the intermediate lithium dialkoxide by a buffer solution (pH≈6) prevents decomposition of the products: 1-trimethylsilyl-3,6-dihydroxy-9,9-diethoxy-1,4,7-nonatriyne **13** and the corresponding desilylated product **14** are obtained (**13** can be separated by chromatogaphy on silicagel). Complete desilylation of **13** gives a 1:1 threo:erythro mixture of **14** in 42% overall yield from **10**. Deprotection of the acetal **14** proved to be tedious. The reaction was carried out by heating **14** in acetone with 5% aqueous H_2SO_4 (in the presence of HCl, **14** rearranges at room temperature to the furan **16**). **14** can also be deprotected under neutral conditions in a refluxing mixture of acetonitrile and water in the presence of 10% DDQ (the catalysis does not proceed at room temperature).[10] The major product is an intractable light-brown solid which has not yet been characterized. Nevertheless, the ^1H NMR spectrum of the minor soluble product (≈20%) is consistent with 4,7-dihydroxynona-2,5,8-triyn-1-al **15**, which decomposes rapidly. It is noteworthy that the precursor **10** with one hydroxypropargyl function less is deprotected to aldehyde **12** by both of the above methods in 60% yield.

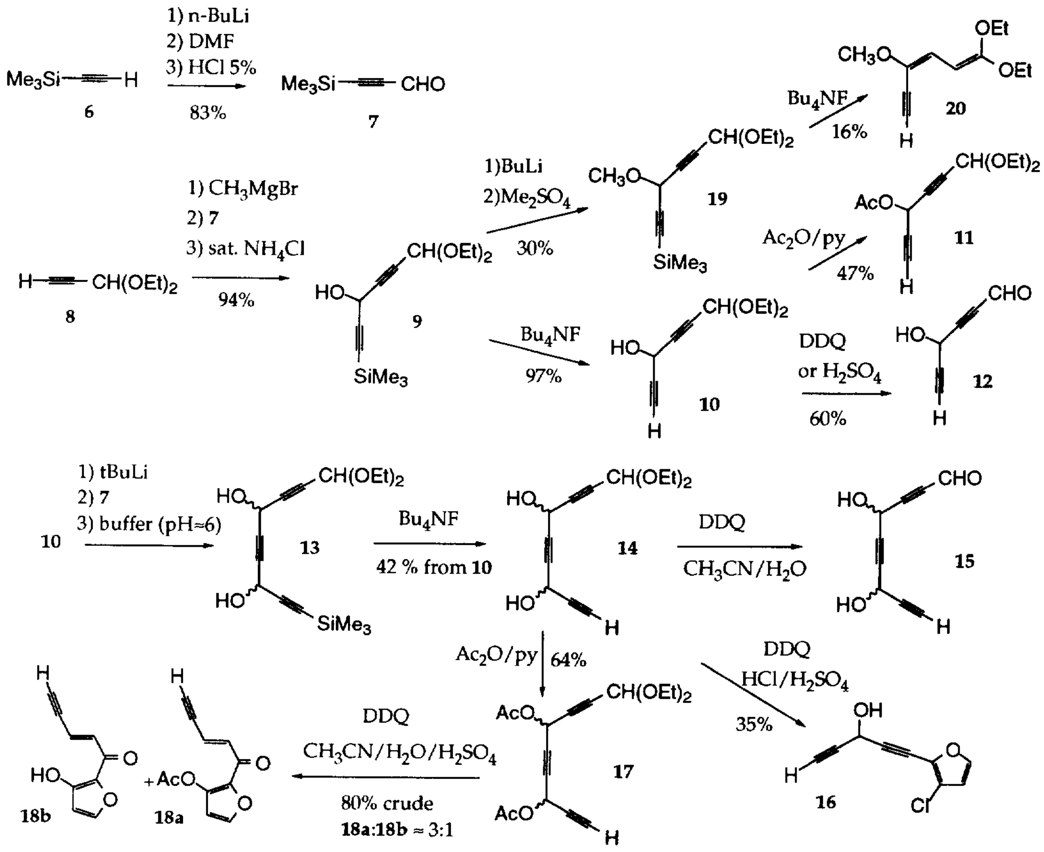

Figure 2. Synthesis of intermediates for $[C,C]_6$carbo-benzene.

During attempts at improving the preparation of **15**,[11] some unexpected reactivities have been observed (Fig. 2). Thus, the diacetate **17** (obtained from **14** in 64% yield) does not react with water in the presence of DDQ in refluxing acetonitrile, but addition of 5% aqueous H_2SO_4 triggers off a complete hydrolysis of **17** to the furans **18a/18b** in a 3/1 ratio (80 % crude yield) via the putative target aldehyde, which was not isolated but which might correspond to an elusive spot on the monitoring TLC plates: this process calls to mind the Meyer-Schuster or Rupe rearrangements.[12] Finally, the ether **19** was prepared from Me_2SO_4 and the lithium alkoxide of **9**. Surprisingly, cleavage of the C–Si bond was accompanied by a rearrangement to the diene **20**.

Concluding remarks. Although many α,ß-acetylenic acetals can be hydrolyzed under classical conditions,[13] the problem raised by the deprotection of acid-sensitive acetal substrates is fueling the search for new, mild deprotecting reagents.[14] Moreover, some functional α,ß-acetylenic aldehydes were intrinsically unstable.[15] To overcome these problems, complexation of a $Co_2(CO)_6$ moiety onto the acetylenic function of the acetal precursor has been carried out prior to acidolysis.[16] This strategy could be applied to the system described here, with conversion of **14** to the $Co_2(CO)_6$–protected aldehyde **15**. The α-carbon of the trimethylsilylalkyne in **13** might also directly substitute one ethoxy group of another molecule of **13** in the presence of $SnCl_4/ZnCl_2$.[17] The intramolecular version of this process would generate the carbo-inositol derivative of **4**. Along the same lines as current fullerene and dendrimer chemistry, applications of carbo-aromatics can be envisaged.[1] These potential applications should promote further efforts for the synthesis of carbo-aromatics .

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8). Compounds **5-20** are oils, which were characterized by UV (254 nm) on silica gel TLC plates, by IR (neat), and by 200 MHz ^{1}H NMR and 50 MHz ^{13}C NMR ($CDCl_3$ solution). Selected spectral data are listed below (the IR frequencies are in cm^{-1}, the NMR chemical shifts are in ppm, all the given coupling constants occur beween H nuclei).

9: IR: ν(C≡CSi)=2179 (w); ν(O–H)=3401 (s). ^{1}H NMR: 0.16 (9H, s); 1.23 (6H, t, ^{3}J= 7.0 Hz); 2.88 (1H,d, broad, ^{3}J=7.3 Hz); 3.54-3.79 (4H, m); 5.14 (1H, dd); 5.31 (1H, d, ^{5}J=1.3 Hz). ^{13}C NMR: –0.56 ($Si(CH_3)_3$); 14.85 (2 CH_3 in $(OEt)_2$); 51.98 (CHOH); 60.87 and 60.94 (2 CH_2 in $(OEt)_2$); 79.29 and 82.38 (C≡C); 89.63 (C≡–Si); 90.94 ($CH(OEt)_2$); 101.08 (≡C–Si).

10: IR: ν(C≡CH)=2122 (w); ν(≡C–H)=3289(s); ν(O–H)=3401 (s). ^{1}H NMR: 1.21 (6H, t, ^{3}J=7.0 Hz); 2.56 (1H, d, ^{4}J= 2.4 Hz); 3.42 (1H, d, broad, ^{3}J=5.5 Hz); 3.53-3.77 (4H, m); 5.16 (1H, m); 5.31 (1H, d, ^{5}J=1.3 Hz). ^{13}C NMR: 14.91 (2 CH_3 in $(OEt)_2$);

51.55 (CHOH); 61.00 and 61.05 (2 CH_2 in $(OEt)_2$); 73.00 (≡C–H); 79.54 and 82.13 (C≡C); 80.25 (C≡–H); 90.95 ($\underline{C}H(OEt)_2$).

12: ^1H NMR: 2.68 (1H,d, ^4J= 2.5 Hz); 2.45 (1H, broad); 5.32 (1H, d); 9.25 (1H, s). ^{13}C NMR: 51.90 (CHOH); 74.80 (≡C–H); 78.62 (≡$\underline{C}$–CHO); 82.35 (C≡–H); 91.22 ($\underline{C}$≡–CHO); 176.75 (CHO).

13: the threo and erythro isomers are not distinguished: IR: ν(C≡CSi)=2179 (w); ν(O–H)=3384 (s). ^1H NMR: 0.20 (9H, s); 1.25 (6H, d, ^3J=7.0 Hz); 2.78 and 2.95 (2H, broad, exchangeable by D_2O); 3.57-3.84 (4H, m); 5.17 (1H, broad); 5.28 (1H, broad); 5.33ppm (1H, d, ^5J=1.3 Hz). ^{13}C NMR: –0.57 ($Si(CH_3)_3$); 14.83 (CH_3 in $(OEt)_2$); 51.64 and 52.09 (2CHOH); 60.87 and 60.99 (CH_2 in $(OEt)_2$); 79.76, 80.72, 81.49 and 81.71 (2C≡C); 90.00 (C≡–Si); 90.90 ($CH(OEt)_2$); 100.71 (≡C–Si).

14: IR: ν(C≡CH)=2122 (w); ν(≡C–H)=3287(s); ν(O–H)=3365 (s). ^1H NMR: 1.22 (6H, t, ^3J=7.1 Hz); 2.58 (0.5 H threo or erythro, d, ^4J=2.4 Hz) and 2.59 (0.5 H erythro or threo, d, ^4J=2.4 Hz); 3.54-3.78 (4H, m); 2.75 and 4.30 (2H, very broad); 5.18 (1H, m, broad); 5. 24 (1H, m, broad), 5.32 (1H, s, broad). ^{13}C NMR: 14.89 (2 CH_3 in $(OEt)_2$); 51.49, 51.51 and 51.56 (2CHOH, threo+erythro); 61.07 and 61.12 (2 CH_2 in $(OEt)_2$); 74.00 (≡C–H); 79.53, 79.58, 80.21, 80.93, 80.97, 81.29, 81.34, 82.04 and 82.16 (2C≡C+C≡–H, threo+erythro); 90.95 ($\underline{C}H(OEt)_2$).

15: ^1H NMR: 2.63 (1H, d, ^4J= 2.2 Hz); 2.80 (2H, very broad); 5.20 (1H, dd); 5.37 (1H, d, ^5J= 1.7 Hz); 9.27 (1H, s).

16: IR: ν(O–H)=3366 (s); ν(≡C–H)=3296 (s); ν(CC≡CC)=2229 (w); ν(C≡CH)=2122 (w); ν(furan ring)=1574 (m), 1490 (m), 1383 (m), 1020 (s), 576(s); ν(CH–OH)=1061 (s); ν(C–Cl)=749 (s). ^1H NMR: 2.61 (1H, broad, exchangeable by D_2O); 2.65 (1H, d, ^4J=2.4 Hz); 5.41 (1H, m, broad); 6.44 (1H, d, ^3J=2.0 Hz); 7.34 (1H, d). ^{13}C NMR: 52.8 (CHOH); 74.0 (≡C–H); 77.6, 79.9 and 94.3 (3 ≡$\underline{C}$–C); 112.8 (=$\underline{C}$H–CCl); 122.5 (C–Cl); 131.5 (O–$\underline{C}$=CCl); 144.0 (CH–O).

17: IR: ν(C≡CH)=2132 (w); ν(≡C–H)=3284(s); ν(C=O)=1748 (s). ^1H NMR: 1.25 (6H, t, ^3J=7.0 Hz); 2.13 (3H, s) and 2.15 (3H, s); 2.575 (0.5 H threo or erythro, d, ^4J=0.8 Hz); 2.585 (0.5 H erythro or threo, d, ^4J=1.7 Hz); 3.55-3.78 (4H, m); 5.31 (1H, d, ^5J=1.4 Hz); 6.10 (1H, m); 6.17 (1H, m). ^{13}C NMR: 15.10 (2 CH_3 in $(OEt)_2$); 20.73 ($\underline{C}H_3CO$); 51.49 and 52.51 (2 $\underline{C}$HOAc); 61.19 and 61.23 (2 CH_2); 74.39 (≡C–H); 76.61, 78.08, 78.73, 78.78, 78.82, 78.87 and 81.22 (2 C≡C+C≡–H, threo+erythro); 91.08 ($\underline{C}H(OEt)_2$); 168.91 (2 C=O).

18a: ν(≡C–H)=3249 (s); ν(C≡C)=2097 (w); ν(C=O, OAc)=1764(s); ν(O=CC_2)=1646 (s); ν(furan ring)=1589 (m), 1561 (w), 1388 (m), 1043 (s), 548 (s); ν(C=C)=1423 (s); ν(C–OCOMe)=1162 (s). ^1H NMR: 2.31 (3H, s); 3.32 (1H, d, ^4J=2 Hz); 6.37 (1H, d, ^3J=6 Hz); 6.40 (1H, dd, ^3J=16 Hz); 7.66 (1H, d). ^{13}C NMR: 20.3 (CH_3); 81.1 (C≡–H); 85.4 (≡C–H); 115.9 and 116.8 (=$\underline{C}$H–C=O and =$\underline{C}$H–O); 128.0 (=$\underline{C}$H–C≡C); 137.2 (O–$\underline{C}$–C=O); 153.2 (=$\underline{C}$–OAc); 153.9 (=CH–O); 167.4 and 172.1 (2 C=O).

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