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A VERSATILE PREPARATION OF 2,6-DI-t-BUTYLBROMOBENZENE. APPLICATION TO STERIC PROTECTION FOR ORGANOPHOSPHORUS COMPOUNDS IN LOW COORDINATION STATES

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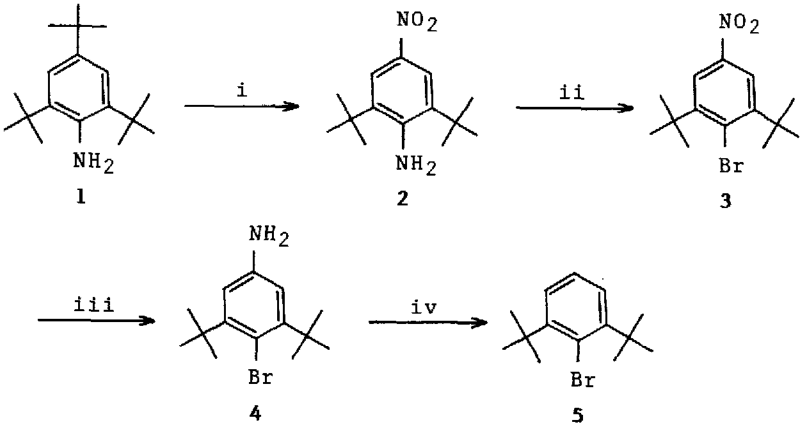
Abstract: 2,6-Di-t-butylbromobenzene (**5**) was prepared from 2,4,6-tri-t-butylbromobenzene by ipso nitration followed by reduction of the nitro group and deamination. The diphosphene (**8**) and 1,3-diphosphaallene (**10**) were prepared.

2,4,6-Tri-t-butylphenyl group (hereafter abbreviated to Ar) is extremely effective to accomplish kinetic stabilization of unstable compounds especially bearing multiple bonds involving heavier main group elements.

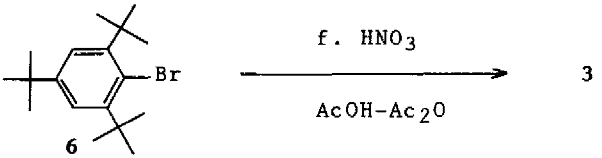
We have been successful in isolation of diphosphenes,1) phosphaethylenes,2) 1-phosphaallenes,3) and 1,3-diphosphaallenes4) by utilizing the 2,4,6-tri-t-butylphenyl group as a bulky protective group. On the other hand, it is reasonable to expect that only the o-t-butyl groups are essential to play a part in kinetic stabilization. We were very much interested in 2,6-di-t-butylphenyl as an alternative and simplified protecting group. We now report the preparation of diphosphene and 1,3-diphosphaallene which are sterically stabilized by 2,6-di-t-butylphenyl group.



Scheme. Reagents: i) f. HNO_3-AcOH-Ac_2O. ii) NOBr. iii) H_2-Raney Ni. iv) H_2SO_4, HNO_2, and then H_3PO_2.

From a synthetic point of view, it would take several further steps to prepare such a bulky bromobenzene without p-t-butyl group. Actually, Rundel5) reported the preparation of 2,6-di-t-butylbromobenzene (**5**) starting from 2,4,6-tri-t-butylaniline (1) as shown in Scheme. However, each reaction we followed except for reduction (iii) was not efficient so that it required an elaborate separation process because of the formation of a lot of by-products in every step. Furthermore, 2,6-di-t-butyl-4-nitrobromobenzene **3**, originally described in the literature as green crystals was colorless in the pure state. **3**: Mp 91-92.5 °C (lit.,5) 91.5-92 °C). ^{1}H NMR (CDCl$_3$) δ 8.13 (2H, s, arom.), 1.60 (18H, s, t-Bu). MS m/z 315 (M+2, 44%), 313 (M$^+$, 43), 298 (M-Me, 100). The green "impurity" turned out to be 2,6-di-t-butyl-4-nitro-nitrosobenzene: Oil. ^{1}H NMR (CDCl$_3$) δ 8.15 (2H, s, arom.), 1.11 (18H, s, Bu). MS m/z 264 (M$^+$, 0.6%), 234 (M-NO, 0.2), 218 (M-NO$_2$, 2.2), 207 (M-Bu, 0.1), 192 (M-Bu-Me, 2), 57 (Bu, 100).

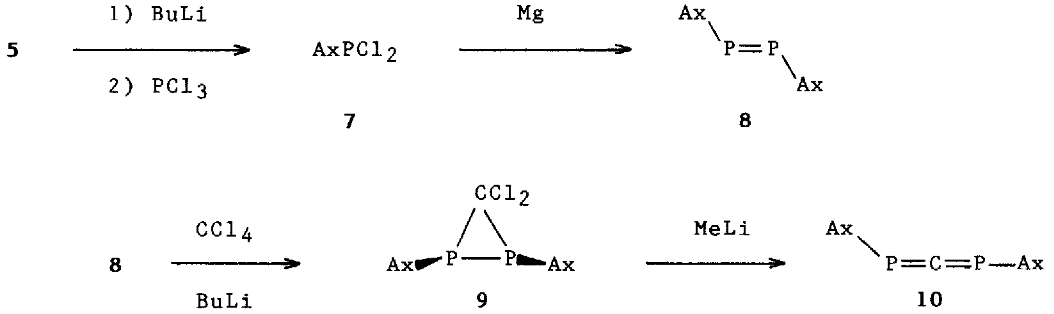
Alternatively, several attempts were made to apply ipso-nitration reaction6) directly at the 4 position of 2,4,6-tri-t-butylbromobenzene **6**7) in order to obtain the p-nitrobromobenzene **3**, as follows.8)



The bromobenzene **6** (1.00 g, 3.08 mmol) was suspended in a mixture of acetic acid (3 ml) and acetic anhydride (12 ml) and added dropwise was a freshly prepared solution of fuming nitric acid (d = 1.52 g/ml; 12.5 g, 0.20 mol) in 2 ml of acetic acid while hot within 1 min. The initial reaction temperature was maintained at 40 - 60 °C and the mixture was stirred at room temperature overnight. The solid, mainly consisting of 2,4,6-tri-t-butyl-1,3-dinitrobenzene (32% yield),9) was removed by filtration, washed with methanol (15 ml) and the filtrate was treated with hexane (60 ml). The hexane layer was washed with aqueous 5%-NaOH solution (100 ml), washed with water (20 ml), and dried (MgSO$_4$). Then **3** was purified through silica gel column chromatography using hexane as an eluent (10% yield based on **6**) and was used for the further reactions.10) The p-bromonitrobenzene **3** was reduced11) to the corresponding aniline **4** and then deaminated to give 2,6-di-t-butylbromobenzene **5** according to the literature method.5,12)

The bromobenzene **5** thus obtained (hereafter abbreviated to AxBr: A stands for aryl and x does for xylyl) (562 mg, 2.09 mmol) was lithiated in tetrahydrofuran (THF, 5 ml) with a hexane solution of butyllithium (2.30 mmol) at -78 °C for 15 min, PCl$_3$ added (345 mg, 2.51 mmol) and the mixture was gradually warmed up to refluxing temperature. The volatiles were removed by rotary-evaporation and the residue was diluted with pentane, washed with ice-water, and dried (MgSO$_4$). The pentane was evaporated in vacuo to give 2,6-di-tbutylphenylphosphonous dichloride (**7**, 558 mg, 92% yield). **7**: Oil. ^{31}P NMR (pentane) δ_P 148.9. ^1H NMR ($CDCl_3$) δ 7.37 (3H, m, arom.), 1.59 (18H, s, Bu^t). Found: m/z 290.0757. Calcd for $C_{14}H_{21}Cl_2P$: M, 290.0757.

The dichloride **7** was dissolved in THF (5 ml) and was allowed to react with magnesium metal (46.6 mg, 1.96 mg-atom) at room temperature under argon for 30 min to give an orange solution. The solvent was removed in vacuo and the residue was chromatographed over silica gel using hexane as an eluent to give 159.9 mg (0.363 mmol) of the corresponding diphosphene **8** in 35% yield based on **7**. **8**: Yellow prisms. Mp 211 - 213 °C (decomp). ^{31}P NMR ($CDCl_3$) δ_P 488.7. ^1H NMR ($CDCl_3$) δ 7.36 (2H, d, ^3J = 7.80 Hz, m-arom.), 7.20 (1H, t, ^3J = 7.80 Hz, p-arom.), 1.45 (18H, s, Bu^t). ^{13}C {^1H}NMR ($CDCl_3$) δ 155.0 (t, $^2J_{PC} = {}^3J_{PC}$ = 5.1 Hz, o-arom.), 141.7 (t, $^1J_{PC} = {}^2J_{PC}$ = 30.0 Hz, i-arom.), 127.0 (p-arom.), 124.8 (m-arom.), 38.3 ($\underline{C}Me_3$), 34.3 (t, $^4J_{PC} = {}^5J_{PC}$ = 5.1 Hz, Me). UV (CH_2Cl_2) λ_{max} (ε) 290 (10670), 340 (7160), 450 nm (1020). Found: m/z 440.2766. Calcd for $C_{28}H_{42}P_2$: M, 440.2761.



(Ax = 2,6-$Bu^t_2C_6H_3$)

The diphosphene **8** was allowed to react with dichlorocarbene generated from carbon tetrachloride with butyllithium to give diphosphirane **9** in 8% yield with 50.0 mg of recovered **8** (41%). **9**: Mp 169 - 170 °C. ^{31}P NMR ($CDCl_3$) δ_P -67.1. ^1H NMR ($CDCl_3$) δ 7.26 (2H, dd, ^3J = 7.5 Hz, J_{PH} = 1.3 Hz, m-arom.), 7.22 (2H, dd, ^3J = 7.6 Hz, J_{PH} = 0.8 Hz, m'-arom.), 7.05 (2H, dd, p-arom.), 1.631 (18H, s, o-Bu^t), 1.626 (18 H, s, o'-Bu^t). MS m/z 526 (M+4), 524 (M+2), 522 (M^+). ^{13}C {^1H} NMR ($CDCl_3$) δ 84.1 (t, $^1J_{PC}$ = 63.4 Hz, P-$\underline{C}$-P).

Then **9** was allowed to react with methyllithium[13,14] to give the corresponding 1,3-diphosphaallene **10** in 40% yield. **10**: Mp 126 - 129 °C (decomp). ^{31}P NMR ($CDCl_3$) δ_P 142.4. ^{13}C {^1H} NMR ($CDCl_3$) δ 275.6 (t, $^1J_{PC}$ = 58.0 Hz, P=$\underline{C}$=P). ^1H NMR ($CDCl_3$) at 25 °C showed broad signals due to the restricted rotation around the phosphorus and the bulky phenyl groups as observed in 1,3-bis(2,4,6-tri-t-butylphenyl)-1,3-diphosphaallene.[13] The signals of o-t-butyl groups coalesced at 15 °C and became singlet at δ 1.36 at 52 °C but appeared at -37.5 °C as two singlets at δ 1.11 and 1.59.

In conclusion, p-t-butyl group in 2,4,6-tri-t-butylphenyl is not essential to show its capability of effective steric protection. However, the Ax group can also serve as a new protective group for stabilizing unusual compounds involving heavier main group elements.

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References

1) M. Yoshifuji, I. Shima, N. Inamoto, K. Hirotsu, and T. Higuchi, J. Am. Chem. Soc., **103**, 4587 (1981); **104**, 6167 (1982).
2) M. Yoshifuji, K. Toyota, and N. Inamoto, Tetrahedron Lett., **26**, 1727 (1985).
3) M. Yoshifuji, K. Toyota, K. Shibayama, and N. Inamoto, Tetrahedron Lett., **25**, 1809 (1984).
4) M. Yoshifuji, K. Toyota, and N. Inamoto, J. Chem. Soc., Chem. Commun., **1984**, 689.
5) W. Rundel, Chem. Ber., **101**, 2956 (1968).
6) J. Burgers, W. Van Hartingsveldt, J. Van Keulen, P. E. Verkade, H. Visser, and B. M. Wepster, Recl. Trav. Chim. Pays-Bas, **75**, 1327 (1956).
7) M. Yoshifuji, I. Shima, and N. Inamoto, Tetrahedron Lett., **20**, 3963 (1979).
8) This reaction sequence has been successfully applied to the corresponding fluoride: P. C. Myhre, J. W. Edmonds, and J. D. Kruger, J. Am. Chem. Soc., **88**, 2459 (1966).
9) P. C. Myhre, M. Beug, and L. L. James, J. Am. Chem. Soc., **90**, 2105 (1968).
10) 2,4-Di-t-butyl-6-nitrobromobenzene was obtained in 10% yield as another byproduct: Mp 78 - 79 °C. ^{1}H NMR ($CDCl_3$) δ 7.50 (2H, s, arom.), 1.38 (9H, s, Bu^t), 1.32 (9H, s, Bu^t). MS m/z 313 (M^+). The nitro group was reduced to give the corresponding known aniline; A. J. de Koning, Recl. Trav. Chim. Pays-Bas, **96**, 149 (1977).
11) When lithium aluminum hydride was used in stead of hydrogen gas catalyzed by Raney nickel, 4,4'-dibromo-3,5;3',5'-tetra-t-butylazobenzene was obtained in 40% yield.
12) Bis(4-bromo-3,5-di-t-butylphenyl) ether was obtained as a by-product during the deamination process with hypophosphorous acid, which was characterized by MS (m/z 550, M^+) and ^{1}H NMR ($CDCl_3$): δ 7.05 (2H, arom.), 1.52 (18H, Bu^t).
13) M. Yoshifuji, S. Sasaki, T. Niitsu, and N. Inamoto, Tetrahedron Lett., **30**, 187 (1989).
14) M. Gouygou, C. Tachon, R. El Ouatib, O. Ramarijaona, G. E.-Moghadam, and M. Koenig, Tetrahedron Lett., **30**, 177 (1989).

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