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# SYNTHESIS OF STERICALLY HINDERED AROMATIC DIALDEHYDES

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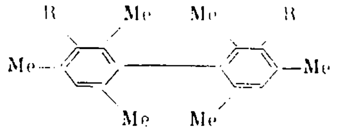
A study was carried out on the formylation of a series of aromatic compounds containing two mesitylene or durene residues [dimesityl (I), dimesitylmethane (II), 1,2-dimesitylethane (III), 1,6-dimesitylhexane (IV), dimesityl sulfide (V), 1,1-dimesitylethylene (VI), 1,1-dimesityl-1-butene (VII), and didurylmethane (VIII)] by the action of dichloromethyl methyl ether (DCM) in the presence of $AlCl_3$ and $TiCl_4$. The corresponding dialdehydes are the major products. The formylation products when the reaction is carried out in the presence of $AlCl_3$ in the case of (I) and (V) contain significant amounts of monoaldehydes, while partial cleavage of the substrates with the formation of products containing only one benzene ring is observed in the case of (II) and (VIII) in addition to formylation.

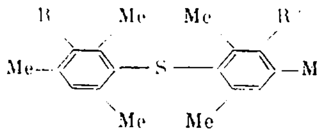
In a previous work [1], we proposed a modified procedure for Rieche formylation by the action of dichloromethyl methyl ether (DCM), which permits the smooth conversion of mesitylene to the corresponding aldehyde in high yield. This procedure also permitted discovery of a previously unknown reaction course, leading not to aldehydes but rather to the corresponding dichloromethyl derivatives. This reaction course is especially evident upon carrying out the reaction in the presence of aluminum chloride. Cleavage of the substrate is also observed in the case of the formylation of dimesitylmethane with the formation of products with only one benzene ring [1].

In the present work, we studied the effect of the nature of the condensing agent ($AlCl_3$ or $TiCl_4$) on the reaction course and optimized the synthesis of dialdehyde from a series of available compounds containing two mesitylene or durene residues. Such dialdehydes hold interest for further transformations, in particular, to new stable bisnitrile oxides.

The starting compounds were dimesityl (I), dimesitylmethane (II), 1,2-dimesitylethane (III), 1,6-dimesitylhexane (IV), dimesityl sulfide (V), 1,1-dimesitylethylene (VI), 1,1-dimesityl-1-butene (VII), and didurylmethane (VIII).

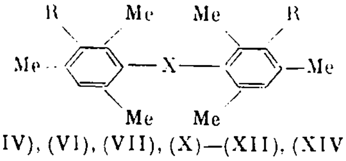


(I), (IX), (XXII)

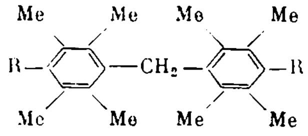


(V), (XIII), (XXIII)

R = R' = H (I), (V), CHO (IX), (XIII); R = H, R' = CHO (XXII), (XXIII).



(II)—(IV), (VI), (VII), (X)—(XII), (XIV), (XV)



(VIII), (XVI)

R = H; X = $CH_2$, (II), $(CH_2)_2$, (III), $(CH_2)_6$ (IV), $\overset{|}{-C}=CH_2$ (VI), $\overset{|}{-C}=CHCH_2CH_3$ (VII).

R = H (VIII), CHO (XVI).

R = CHO; X = $CH_2$ (X), $(CH_2)_2$ (XI), $(CH_2)_6$ (XII), $\overset{|}{-C}=CH_2$ (XIV), $\overset{|}{-C}=CHCH_2CH_3$ (XV).

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TABLE 1. Indices of Sterically Hindered Dialdehydes (IX)-(XVI)

| Compound | Mp, °C (solvent) | Found/calculated, % |  | Chemical formula | M+ | νCO, cm$^{-1}$ | Yield, % in the presence of |  |
|---|---|---|---|---|---|---|---|---|
|  |  | C | H |  |  |  | $AlCl_3$ | $TiCl_4$ |
| (IX) | 96-103 [a] | 81,88 / 81,59 | 7,80 / 7,53 | $C_{20}H_{22}O_2$ | 294 | 1675 | 18 | 67 |
| (X) | 149-156 (EtOH-$CHCl_3$) | 81,76 / 81,78 | 7,74 / 7,84 | $C_{21}H_{24}O_2$ | 308 | 1675 | 60 | 86 |
| (XI) | 166-168 [b] (EtOH-$CHCl_3$) | – | – | $C_{22}H_{26}O_2$ | 322 | 1675 | 85 | 91 |
| (XII) | 142-147 (EtOH) | 82,72 / 82,49 | 9,01 / 9,05 | $C_{26}H_{34}O_2$ | 378 | 1691 | 79 | 84 |
| (XIII) | 141-144 [c] (MeOH) | 73,25 / 73,57 | 6,60 / 6,80 | $C_{20}H_{22}O_2S$ | 326 | 1691 | 44 | 69 |
| (XIV) | 96,5-97,5 [d] (EtOH) | 82,33 / 82,45 | 7,48 / 7,56 | $C_{22}H_{24}O_2$ | 320 | 1691 | 34 | – |
| (XV) | 98-103 [d] (MeOH) | 82,61 / 82,72 | 8,10 / 8,10 | $C_{24}H_{28}O_2$ | 348 | 1691 | 37 | 56 |
| (XVI) | 195 (dec.) (EtOH-$CHCl_3$) | 81,89 / 82,14 | 8,59 / 8,33 | $C_{23}H_{28}O_2$ | 336 | 1690 | 39 | 78 |

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[a] The product was purified by chromatography on a silica gel column with chloroform as the eluent. Dimesityl-3-carbaldehyde (XXII), mp 79-82°C, characterized by its PMR spectrum, was isolated in addition to (IX). A pure sample of (XXII) could not be isolated.

[b] Dialdehyde (XI) could not be isolated as a pure sample. This product was characterized as its dioxime, mp 223-225°C (from ethanol). Found: C, 74.81; H, 7.76; N, 8.00%. Calculated for $C_{22}H_{28}N_2O_2$: C, 74.79; H, 8.01; N, 7.95%.

[c] The reaction products were separated on a silica gel column with hexane—chloroform as the eluent. Dimesityl sulfide-3-carbaldehyde (XXIII), mp 94-98°C, characterized by its PMR spectrum, was obtained in addition to (XIII). An analytically pure sample of sulfide (XXIII) could not be isolated.

[d] The product was purified prior to recrystallization by chromatography on silica gel with 1:1 hexane—chloroform as the eluent.

The major products in the reactions of (I), (V), and (VIII) with DCM in the presence of $AlCl_3$ are the corresponding dialdehydes: 2,4,6,2′,4′,6′-hexamethyldiphenyl-3,3′-dicarbaldehyde (IX), dimesitylmethane-3,3′-dicarbaldehyde (X), 1,2-di-(3-formyl-2,4,6-trimethylphenyl)ethane (XI), 1,6-di-(3-formyl-2,4,6-trimethylphenyl)hexane (XII), di(2,4,6-trimethylphenyl)sulfide-3,3′-dicarbaldehyde (XIII), 1,1-di(3-formyl-2,4,6-trimethylphenyl)-ethylene (XIV), 1,1-di(3-formyl-2,4,6-trimethylphenyl)-1-butene (XV), and didurylmethane-4,4′-dicarbaldehyde (XVI), whose physical indices and yields are given in Table 1. The specificity of the behavior of dimesitylmethane (II) in its reaction with DCM and $AlCl_3$, related to cleavage of the substrate during the reaction examined in our previous work [1]. Cleavage of the substrate under the formylation is also found in the case of didurylmethane (VIII). This leads to the formation of 2,3,5,6-tetramethylbenzaldehyde along with other products of the reaction of (VIII) with DCM in the presence of $AlCl_3$.

The data in Table 1 show that the yields of dialdehydes from dimesityl (I) and dimesityl sulfide (V) upon carrying out the reaction with DCM in the presence of $AlCl_3$ are significantly lower than in the case of $TiCl_4$. Such a reduction in yield is apparently a result not of cleavage of the substrate molecule as in the case of (II) and (VIII), but rather the strong deactivation of the molecule after the introduction of the first formyl

TABLE 2. PMR spectra of Dialdehydes (IX)-(XVI) and Monoaldehydes (XXII) and (XXIII)

| Compound | δ, ppm[a] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2-Me | 3-Me | 4-Me | 5-Me | 6-Me | $H^5$ | $CH_2$ | CHO |
| (IX) | 2,16 | – | 2,62 | – | 1.87 | 7,08 | – | 10,63 |
| (X) | 2,32 | – | 2,53 | – | 2.20 | 6,91 | 4.15 | 10,57 |
| (XI) | 2,58 | – | 2,52 | – | 2.30 | 6,92 | 2.88 | 10,60 |
| (XII) | 2,54 | – | 2.50 | – | 2,32 | 6,90 | 2,67 br.s (4H)<br>1,49 br.s (8H) | 10,61 |
| (XIII) | 2,54 | – | 2.55 | – | 2.22 | 6,95 | – | 10,50 |
| (XIV) | 2,57 | – | 2,57 | – | 2.15 | 6,93 | 5,66 | 10,60 |
| (XV)[b] | 2,55 | - | 2,55 | - | 2,49 | 6,90 | 2,05 m | 10,61 |
| (XVI) | 2,03 | 2,33 | – | 2,33 | 2,03 | – | 4,23 | 10,62 |
| (XXII)[c] | 2,33 | – | 2,62 | – | 2,19 | 7,04 | – | 10,64 |
| (XXIII)[d] | 2,51 | – | 2,55 | – | 2,27 | 6,92 | – | 10,51 |

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[a] Unless otherwise indicated, these signals are singlets.

[b] The spectrum also has signals at 5.79 t (CH, J = 7.6 Hz) and 1.06 t ($CH_3$, J = 7.6 Hz).

[c] The spectrum also has signals at 1.89 ($H^{2'}$), 1.90 ($H^{4'}$), 1.84 ($H^{6'}$), and 6.96 ($H^{3'}$ and $H^{5'}$).

[d] The spectrum also has signals at 2.12 ($H^{2'}$), 2.25 ($H^{4'}$), 2.18 ($H^{6'}$), and 6.84 ($H^{3'}$ and $H^{5'}$).

group due to complexation with aluminum chloride. This effect is transferred to the unsubstituted ring if the benzene rings are directly linked as in (I) or through a sulfide bridge as in (V) as indicated by the formation of monoaldehydes (XXII) and (XXIII) in both cases. These monoaldehydes were not found in the other cases.

## EXPERIMENTAL

The chromatographic analyses were carried out on an M-3700 chromatograph with a flame ionization detector and linear temperature programming from 110 to 250°C at a rate of 10 deg/min using a 2 × 100 mm column packed with 5% SE-30 on Chromosorb P. The nitrogen gas carrier flow rate was 20 ml/min with heptadecane as the internal standard.

The PMR spectra were taken in deuterochloroform on a Bruker WM-250 spectrometer at 250 MHz. The mass spectra were taken on a Varian MAT CH-6 mass spectrometer with direct sample inlet into the ion source. The ionizing voltage was 70 eV and the emission current was 100 μA.

Starting reagents: dimesityl (I) [2,3], dimesitylmethane (II) [4], 1,2-dimesitylethane (III) [5], dimesityl sulfide (V) [6,7], 1,1-dimesitylethylene (VI) [8], 1,1-dimesityl-1-butene (VII) [9], and didurylmethane (VIII) [10] were obtained by reported procedures. The synthesis of 1,6-dimesitylhexane is described below.

a. 1,6-Dimesitylhexane-1,6-dione (XXIV). A sample of 9.0 g (49 mmoles) of the diacid chloride derivative of adipic acid in 30 ml $CH_2Cl_2$ and 13.0 g (109 mmoles) mesitylene in 30 ml $CH_2Cl_2$ were added consecutively with stirring for 20 min to 15.72 g (118 mmoles) $AlCl_3$ in 70 ml $CH_2Cl_2$ at 0°C. Stirring was continued for an additional 30 min with concurrent warming to about 20°C. After treatment of the reaction mixture with water, the organic layer was washed with water, 5% aq. KOH, and water again. The solvent was evaporated. Recrystallization from hexane gave 12.28 g (71%) 1,6-dimesitylhexane-1,6-dione, mp 108-109.5°C. Found: C, 82.51, 82.54; H, 9.16, 8.99%. Calculated for $C_{24}H_{30}O_2$: C, 82.24; H. 8.62%.

b. 1,6-Dimesitylhexane (IV). A solution of 116.27 g (570 mmoles) $AlCl_3$ etherate in 200 ml ether was added dropwise to a suspension of 21.6 g (570 mmoles) lithium aluminum hydride in 300 ml ether dried over $LiAlH_4$ at 20°C and distilled in an argon stream. The mixture was heated to reflux and a solution of 20.0 g (57 mmoles) diketone (XXIV) in 300 ml ether was added dropwise over 1 h. The reaction mixture was stirred at reflux for an additional 1 h and decomposed by the addition of 300 ml of a solution obtained by mixing one part concentrated sulfuric acid and four parts water at 5-10°C, and then an additional 500 ml portion of this dilute sulfuric acid solution. The organic layer was separated and the aqueous layer was extracted with two 100 ml ether portions. The combined extract was washed with 10% aq. $Na_2CO_3$ and two 200 ml portions of water. The solvent was evaporated and the residue was recrystallized from hexane to give 14.85 g (81%) (IV), mp 119-122°C. Additional recrystallization gave an analytical sample with mp 122-123°C. Found: C, 89.68; H, 10.56%. Calculated for $C_{24}H_{34}$: C, 89.37; H, 10.62%.

Formylation of (I)-(VIII). A mixture of 4 mmoles substrate (I)-(VIII) and 16 mmoles DCM in 10 ml $CH_2Cl_2$ was added over 2 min to a suspension or solution of 32 mmoles condensing agent in 10 ml $CH_2Cl_2$. After stirring for 15 min, the mixture was poured onto ice and extracted with three 25 ml chloroform portions. The extract was washed with three 50 ml water portions. The solution was evaporated. The products were separated by crystallization or column chromatography. The physical indices of the products are given in Tables 1 and 2.

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