SYNTHESES ON THE BASIS OF ARYLFURANS

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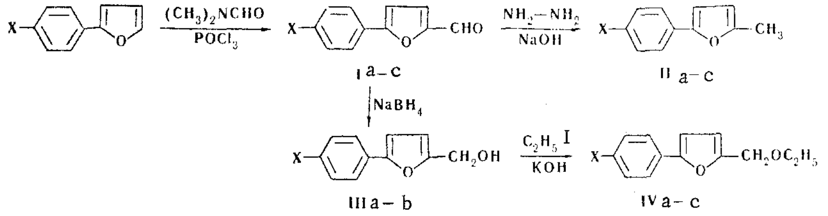
The Meerwein reaction cannot serve as a method for the preparation of 5-arylfurfurals with electron-donor substituents in the benzene ring. A convenient method for the synthesis of such arylfurfurals is formylation of the appropriate arylfurans.

The arylation of furfural by the Meerwein method using various aromatic amines with electron-acceptor substituents in the benzene ring was successfully realized in recent years [1, 2]. The literature data on the behavior of amines with electron-donor substituents in this reaction is contradictory. Akashi and Oda [3-5] assert that the arylation of furfural by benzene- (and also p-toluene- and p-anisidine-) diazonium salts proceeds successfully. However, these results are refuted by the later investigations of Davis and Lougheed [1], who synthesized 5-phenylfurfural by a different route after an unsuccessful attempt to accomplish the phenylation of furfural by the method in [4] and demonstrated that it has absolutely different physical constants than those described by the Japanese authors.

In 1968, Kaltenbronn and Rhee [6] reported the synthesis of 5-arylfuran-2-acetic acids and described the arylation of furfural by benzene-, p-toluene-, and p-anisidinediazonium salts; however, they did not isolate and characterize the arylfurfurals but subjected them to further transformations.

In an attempt to obtain 5-arylfurfurals, we made a thorough investigation of the possibility of the use of aniline, p-toluidine, and p-anisidine in the Meerwein reaction and established that arylation does not occur at room temperature (20-25 deg C); as expected, the diazo group is replaced by halogen via the Sandmeyer reaction under more severe conditions.

In order to obtain the above-cited arylfurfurals, we therefore formylated the appropriate arylfurans via the Vilsmeier reaction and thoroughly characterized the compounds that we obtained. The physical constants of the arylfurfurals (Ia-c) that we synthesized differed from those indicated by Akashi and Oda [3-5].



I–IV a X=H, b X=CH$_3$, c X=OCH$_3$

Aldehydes Ia-c were converted via Kishner reduction to the corresponding 5-aryl-2-methylfurans (IIa-c) and were reduced to the corresponding 2-hydroxymethyl-5-arylfurans (IIIa-c) by means of sodium borohydride. The acetates of IIIa-c and 5-aryl-2-ethoxymethyl furans (IVa-c) were obtained from IIIa-c by the usual route.

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EXPERIMENTAL

5-Phenylfurfural (Ia). This was obtained in 65% yield by the method in [1] and had bp 144-145 deg (3 mm) [bp 122-123 deg (0.25 mm) [1]]. The thiosemicarbazone had mp 196 deg (from benzene). C 58.53; H 4.57; N 17.14; S 13.16%. $C_{12}H_{11}N_{30}S$. Calculated: C 58.76; H 4.52; N 17.14; S 13.07%.

5-(p-Tolyl)furfural (Ib). A 3.7 g (0.023 mole) sample of 2-(p-tolyl)furan [7] was added to a mixture of 5 ml of dimethylformamide and 3 ml of phosphorus oxychloride at room temperature in the course of 30 min at such a rate that the temperature of the reaction mixture did not rise above 40 deg. The mixture was stirred for 2 h at room temperature and then heated on a boiling-water bath for 1 h. The flask contents were dissolved by heating in 50 ml of water, and the resulting solution was neutralized with sodium carbonate and extracted with ether. The combined ether extracts were dried with calcined magnesium sulfate to give 2.7 g (62%) of 5-(p-tolyl)furfural with mp 59.5-60.5 deg (from petroleum ether). Found: C 77.09; H 5.16%. $C_{12}H_{10}O_2$. Calculated: C 77.40; H 5.41%. IR spectrum: ν_{CHO} 1665 cm^{-1}. UV spectrum: λ_{max} 330, 225 nm, log ε 4.47, 4.15 (ethanol). The thiosemicarbazone had mp 190-190.5° (from toluene). Found : C 59.75; H 4.78; N 16.11; S 12.27%. $C_{13}H_{13}N_{30}S$. Calculated: C 60.20; H 5.05; N 16.36; S 12.36%.

5-(p-Anisyl)furfural (Ic). This was similarly obtained in 56% yield and had mp 41-42 deg (from petroleum ether). Found: C 71.41; H 4.72. $C_{12}H_{10}O_3$. Calculated: C 71.29; H 4.95%. UV spectrum: λ_{max} 343, 222 nm, log ε 4.45, 4.10 (ethanol). The thiosemicarbazone had mp 185.5-186.5 deg (from alcohol). Found: C 57.13; H 4.65; N 14.96; S 11.50%. $C_{13}H_{13}N_3O_2S$. Calculated: C 56.73; H 4.73; N 15.27; S 11.64%.

5-Phenyl-2-methylfuran (IIa). A mixture of 1.7 g (0.01 mole) of 5-phenylfurfural and 4 ml of hydrazine hydrate in 20 ml of ethylene glycol was refluxed for 15 min. Powdered potassium hydroxide (4 g) was added to the reaction mixture (cooled to 60 deg), and the mixture was refluxed with stirring for 30 min. The mixture was then cooled, and the resulting precipitate was removed by filtration to give 1.2 g (82%) of IIa with mp 38-39 deg (from hexane). Found: C 83.18; H 6.35%. $C_{11}H_{10}O$. Calculated: C 83.51; H 6.37%. UV spectrum: λ_{max} 287, 223 nm; log ε 4.31, 3.93 (ethanol).

5-(p-Tolyl)-2-methylfuran (IIb). This was obtained as described above in 71% yield and had bp 97-98 deg (2 mm) and n_D^{20} 1.5884. Found: C 83.48; H 7.17%. $C_{12}H_{12}O$. Calculated C 83.68; H 7.02%. UV spectrum: λ_{max} 285, 222 nm, log ε 4.30, 3.92 (ethanol).

5-(p-Anisyl)-2-methylfuran (IIc). This was obtained in the same way as IIa and IIb in 70% yield and had mp 46-47°. Found: C 76.78; H 6.50%. $C_{12}H_{12}O_2$. Calculated: C 76.56; H 6.43%.

5-Phenyl-2-hydroxymethylfuran (IIIa). A solution of 0.4 g of sodium borohydride in 5 ml of water was added dropwise to 1 g (0.006 mole) of 5-phenylfurfural in 20 ml of dioxane. The mixture was refluxed for 1 h, cooled, and 2 ml of 10% sulfuric acid was added. The mixture was then poured into 100 ml of water, and the resulting precipitate was filtered to give 0.9 g (85%) of IIIa with mp 66-66.5 deg (from hexane). Found: C 75.50; H 5.64%. $C_{11}H_{10}O_2$. Calculated: C 75.84; H 5.78%. IR spectrum: ν_{OH} 3120-3240 cm^{-1}. UV spectrum: λ_{max} 285, 221 nm; log ε 4.50, 3.81 (ethanol). The acetate was obtained by the reaction of IIIa with acetic anhydride in the presence of anhydrous sodium acetate and had bp 130 deg (1 mm) and n_D^{20} 1.5728. Found: C 72.06; H 5.52%. $C_{13}H_{12}O_3$. Calculated: C 72.20; H 5.55%.

5-Phenyl-2-ethoxymethylfuran (IVa). This was obtained by the reaction of IIIa with ethyl iodide in the presence of potassium hydroxide and had bp 130 deg (6 mm) and n_D^{20} 1.5720. Found: C 77.39; H 7.19%. $C_{13}H_{14}O_2$. Calculated: C 77.81; H 7.03%.

5-(p-Tolyl)-2-hydroxymethylfuran (IIIb). This was obtained in the same way as IIIa in 82% yield and had mp 65-66 deg (from hexane). Found: C 76.20; H 6.57%. $C_{12}H_{12}O_2$. Calculated: C 76.57; H 6.42%. IR spectrum: ν_{OH} 3410-3450 cm^{-1}; UV spectrum; λ_{max} 285, 209 nm; log ε 4.43, 4.11 (ethanol). The acetate had mp 34-35°. Found: C 73.13; H 6.16%. $C_{14}H_{14}O_3$. Calculated: C 73.02; H 6.12%.

5-(p-Tolyl)-2-ethoxymethylfuran (IVb). This was obtained in the same way as described above for IVa and had bp 119 deg (1 mm) and n_D^{20} 1.5661. Found: C 77.94; H 7.66%. $C_{14}H_{16}O_2$. Calculated: C 77.74; H 7.45%.

5-(p-Anisyl)-2-hydroxymethylfuran (IIIc). This was obtained in the same way as IIIa and IIIb in 84% yield and had mp 98-99 deg (from benzene). Found: C 70.15; H 5.69%. $C_{12}H_{12}O_3$. Calculated: C 70.58; H 5.88%. UV spectrum: λ_{max} 290, 212 nm, log ε 4.42, 4.10 (ethanol). The acetate had mp 64.5-65 deg (from petroleum ether). Found: C 68.64; H 5.61% $C_{14}H_{14}O_4$. Calculated: C 68.27; H 5.73%.

5-(p-Anisyl)-2-ethoxymethylfuran (IVc). This was obtained as described above for IVa and IVb and had mp 44-45 deg (from petroleum ether). Found: C 72.00; H 6.75%. $C_{14}H_{16}O_3$. Calculated: C 72.39; H 6.94.

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