

was also found to be superior to the older methods employing zinc and acetic acid (7) or zinc and alcoholic sodium hydroxide (8). The new isobenzofurans that were prepared are listed in Table III.

EXPERIMENTAL

Melting points were determined on a Thomas-Hoover melting point apparatus and are uncorrected. Microanalyses were carried out by Alfred Bernhardt, Mülheim, Germany. Infrared spectra were obtained on a Perkin-Elmer infracord, 0.25% in KBr. Ultraviolet and visible spectra were obtained on a Perkin-Elmer model 202 spectrophotometer, 1 cm cells, 95% ethanol as solvent.

The 2-benzoylbenzophenones (I) were prepared by the method of Vingiello *et al.* (3). The 1,4-diarylphthalazines (II) were prepared by the method of Blicke and Swisher (9). The 1,3-diarylisobenzofurans (III) were prepared by the method of Cava *et al.* (6).

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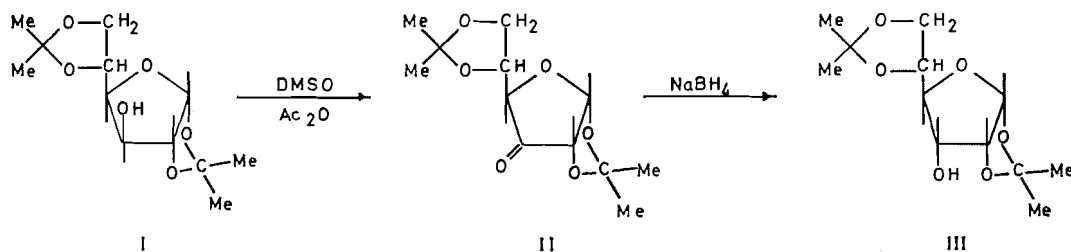
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THE OXIDATION OF 1,2;5,6-DI-O-ISOPROPYLIDENE-D-GLUCOSE BY DIMETHYL SULFOXIDE - ACETIC ANHYDRIDE

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A simple method of selective oxidation with a readily available reagent would be of great value in the field of carbohydrate chemistry. Recently Albright and Goldman reported a general method for the oxidation of alcohols to their corresponding carbonyl derivatives with dimethyl sulfoxide (DMSO) and certain acid anhydrides (1). The procedure, especially useful for the oxidation of sterically hindered hydroxyl groups, was recommended for compounds such as indole alkaloids which are sensitive to nonselective oxidizing agents. The present communication reports the use of DMSO - acetic anhydride for the oxidation of 1,2;5,6-di-O-isopropylidene- α -D-glucofuranose (I). Although it is possible to convert this compound into 1,2;5,6-di-O-isopropylidene- α -D-ribo-hexofuranos-3-ulose (II) in 80% yield with ruthenium tetroxide (2), oxidation with more common reagents is difficult (3, 4). By careful control of the conditions, Theander (4) oxidized I with chromium trioxide - pyridine complex in acetic acid and obtained the 3-keto derivative (II) in 6% yield. Theander also found that sodium borohydride reduced II stereospecifically and practically quantitatively to 1,2;5,6-di-O-isopropylidene- α -D-allofuranose (III), which crystallized with ease. This provided a convenient route to the rare monosaccharide D-allose, as well as evidence for the presence of II.

In the present work, the oxidation of I by DMSO - acetic anhydride was found to be virtually complete after 24 h at room temperature. After removal of the solvents by distillation, the oxidized residue was dissolved in aqueous ethanol and reduced with sodium



borohydride. Extraction of the product with ethyl acetate was followed by chromatography on a column of silicic acid. The D-allose derivative (III) was obtained in 62% yield based on I. The major by-product after oxidation was an unidentified reducing compound with a high R_F^* value. A minor by-product was an ester, probably the 3-O-acetyl derivative of I.

The good yield of II indicates the usefulness of DMSO - acetic anhydride for the oxidation of hydroxyl groups of carbohydrates which are difficult to oxidize by other means. After the completion of this work, similar results were published by Onodera *et al.* (5), who obtained II in 65% yield by oxidation of I with DMSO containing phosphorus pentoxide.

EXPERIMENTAL

Thin-layer chromatography was carried out on layers (250 μ thick) of silica gel G on glass plates in (a) ethyl acetate - light petroleum, b.p. 30-60° (3:1 v/v), or (b) benzene-methanol (95:5 v/v). Compounds on the plates were detected by the following spray reagents: (i) sulfuric acid (30% v/v), followed by heating in an oven at 100-110°; (ii) saturated silver nitrate solution (1 ml) in aqueous acetone (100 ml), followed by a solution of sodium hydroxide (2 g) in aqueous ethanol (100 ml) (6); and (iii) ester spray reagent for thin-layer chromatography based on ferric hydroxamate reaction, according to Tate and Bishop (7). Preparative chromatography was carried out on a column of silicic acid (4 \times 33 cm) with solvent a. Aliquots (15 ml) were collected at 30 min intervals. Evaporations were done under diminished pressure below 40 °C.

1,2;5,6-Di-O-isopropylidene- α -D-glucopyranose (I, 2.60 g) was dissolved in a mixture of DMSO (30 ml) and acetic anhydride (20 ml). Thin-layer chromatography of the solution during the course of the reaction showed that only a faint trace of I remained after 24 h at room temperature. The mixture was distilled at 0.05-0.1 mm, bath temperature 35-40°, to yield a syrupy residue (2.96 g) which consisted mainly of 1,2;5,6-di-O-isopropylidene- α -D-ribohexofuranose-3-ulose (II). It had R_F^* 1.14 in solvent a and R_I 1.33 in solvent b; the reported value is R_I 1.04 in ethyl acetate - light petroleum, b.p. 40-60° (3:1 v/v) (3). The major by-product, also a reducing compound (spray ii), had R_I 1.34 in solvent a. In addition, there was a trace of an ester (spray iii) with R_I 1.25 in solvent a. A solution of the syrupy mixture in aqueous ethanol (100 ml, 70% v/v) was cooled and treated with sodium borohydride (2.6 g) for 30 min. The reaction mixture was poured into water (150 ml) and extracted with ethyl acetate (8 \times 100 ml). Separation of the aqueous and organic layers was promoted by the addition of a small amount of sodium chloride. The combined extracts were dried over anhydrous sodium sulfate and concentrated to a syrup (2.81 g). This was redissolved in ethyl acetate and fractionated by column chromatography. First to be eluted was the reduced by-product (0.70 g), R_I 1.33 in solvent a. A mixture (0.05 g) of the reduced by-product and ester then followed. The starting material (I, 0.03 g) was next obtained and was well separated from the product, 1,2;5,6-di-O-isopropylidene- α -D-allose (III, 1.60 g, 62% yield based on I), R_I 0.85 in solvent a and R_I 1.00 in solvent b. I and III crystallized spontaneously when the eluting solvent was evaporated. After recrystallization of crude III (m.p. 72-75°) from benzene - light petroleum (b.p. 30-60°), it had m.p. 77-78° and $[\alpha]_D^{25} +36^\circ$ (c, 0.5 in water). The reported values are m.p. 76-77° and $[\alpha]_D^{25} +37.7^\circ$ (c, 0.5 in water) (4).

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* R_F and R_I are the rates of movement of the sugars relative to that of the solvent front and of 1,2;5,6-di-O-isopropylidene- α -D-glucopyranose (I), respectively.

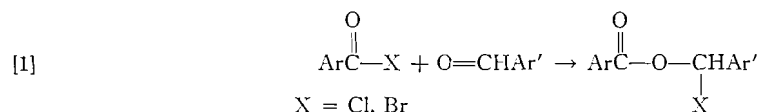
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REACTION OF AROYL HALIDES WITH AROMATIC ALDEHYDES AND ACETOPHENONES

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Adams and Vollweiler (1) reported in 1918 that aromatic acid chlorides and bromides react slowly at room temperature with aromatic aldehydes to form addition compounds, which were shown to be α' -halo esters (eq. [1]). The structures of the products were



established by elemental analyses and by conversion of the halo ester into a diester on reaction with silver benzoate. The addition reaction has attracted little attention since that time, although recently it has been used as a method for obtaining an authentic sample of a diester (2).

In the discussion which follows, we provide infrared spectral evidence for the ester structure, as well as other observations concerning the reaction.

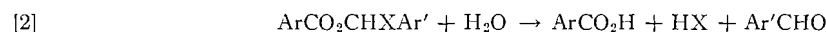
Infrared spectral analysis of the products reveals intense ester carbonyl absorption in the 1755–1735 cm^{-1} region, the position depending on the nature of the Ar group. The presence of the α' -halo group causes a substantial shift to higher frequencies (Table I).

TABLE I
Esters prepared from aroyl halides and aromatic aldehydes

Reactants	Product	$\nu_{\text{C=O}}$ (cm^{-1})*
$\text{C}_6\text{H}_5\text{COBr} + \text{C}_6\text{H}_5\text{CHO}$	$\text{C}_6\text{H}_5\text{CO}_2\text{CHBrC}_6\text{H}_5$	1735
$\text{C}_6\text{H}_5\text{COBr} + p\text{-ClC}_6\text{H}_4\text{CHO}$	$\text{C}_6\text{H}_5\text{CO}_2\text{CHBrC}_6\text{H}_4\text{Cl-}p$	1740
$p\text{-NO}_2\text{C}_6\text{H}_4\text{COCl} + \text{C}_6\text{H}_5\text{CHO}$	$p\text{-NO}_2\text{C}_6\text{H}_4\text{CO}_2\text{CHClC}_6\text{H}_5$	1745
$\text{C}_6\text{F}_5\text{COCl} + \text{C}_6\text{H}_5\text{CHO}$	$\text{C}_6\text{F}_5\text{CO}_2\text{CHClC}_6\text{H}_5$	1755
$\text{C}_6\text{F}_5\text{COCl} + \text{C}_6\text{F}_5\text{CHO}$	No reaction after 3 months, $p\text{-NO}_2\text{C}_6\text{H}_4\text{CO}_2\text{CH}_2\text{C}_6\text{H}_5^\dagger$	1722

*All infrared spectra were measured in CHCl_3 except $\text{C}_6\text{F}_5\text{CO}_2\text{CHClC}_6\text{H}_5$, which was measured in CCl_4 .
†Reference compound, prepared from the acid chloride and benzyl alcohol.

Adams and Vollweiler (1) reported that these compounds reacted with water according to eq. [2]. Ammonia and ethanol similarly gave the corresponding amide and ester.



We found that, immediately after isolation, most of the products exhibited some absorption near 1695 cm^{-1} caused by the presence of carboxylic acid. There was also some