Synthesis of 5-Deoxy-1,2-*O*-isopropylidene-3-*O*-methyl-α-D-xylofuranose-4-ene and Its Benzylmercaptan Adduct

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The present report will describe the synthesis of a new unsaturated sugar, 5-deoxy-1,2-*O*-isopropylidene-3-*O*-methyl-α-D-xylofuranose-4-ene [4] from 1,2-*O*-isopropilydene-5-*O*-*p*-toluenesulfonyl-α-D-xylofuranose [1], and the photocatalyzed addition of benzylmercaptan to the unsaturated sugar [4], which gives 5-benzylthio-5-deoxy-1,2-*O*-isopropylidene-3-*O*-methyl-α-D-xylofuranose [5]

1,2-*O*-Isopropylidene-5-*O*-*p*-toluenesulfonyl-α-D-xylofuranose [1]1) was treated with methyl iodide and silver oxide in dimethylformamide (DMF)2) to give, in a 72% yield, a white crystalline product analyzed as 1,2-*O*-isopropylidene-3-methyl-5-*O*-*p*-toluenesulfonyl-α-D-xylofuranose [2]. This [2] was heated with tetraethylammonium bromide in DMF to give, in a 73% yield, a colorless, oily product analyzed as 5-bromo-5-deoxy-1,2-*O*-isopropylidene-3-*O*-methyl-α-D-xylofuranose [3]. This [3] was then treated with silver fluoride3) in pyridine to give, in a 60% yield, a colorless, oily product identified as 5-deoxy-1,2-*O*-isopropylidene-3-*O*-methyl-α-D-xylofuranose-4-ene [4] by infrared and NMR spectrum and by elementary analysis.

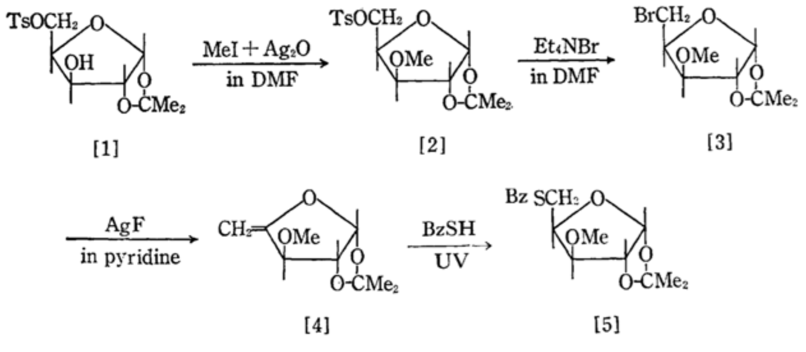
The infrared absorption spectrum of [4] shows absorption bands at about 800 cm^{-1} (s) (out-of-plane deformation vibration of the $>C{=}CH_2$ group), at about 1650 cm^{-1} (s) (C=C stretching vibration of $>C{=}CH_2$), and at about 3100 cm^{-1} (m) (C–H stretching vibration of the $>C{=}CH_2$ group). The NMR spectrum of [4] permits a straightforward analysis, as shown in Fig. 1.

The unsaturated sugar [4] was treated with benzylmercaptan, under ultraviolet light4) to give, in a 85% yield, a white crystalline adduct analyzed as 5-benzylthio-5-deoxy-1,2-*O*-isopropylidene-3-*O*-methyl-α-D-xylofuranose [5]. The structure of this product was established by elementary analysis, by a study of its NMR spectrum (shown in Fig. 2), and by comparison with an authentic sample prepared by the treatment of [3] with sodium benzylmercaptanate in ethanol.

Experimental

General Methods. The infrared spectra were determined on a liquid film with a Perkin-Elmer 337 grating infrared spectrophotometer. The NMR spectra were measured at 60 Mc with a Hitachi Perkin-Elmer R-20 spectrometer. The ultraviolet illumination was from a Halos PIH-100 (100W) (a high-pressure mercury lamp).

Preparation of 1,2-*O*-Isopropylidene-3-*O*-methyl-5-*O*-*p*-toluenesulfonyl-α-D-xylofuranose [2]. [1] (12 g) was dissolved in 120 m*l* of dry DMF, 20 g of silver oxide and 15 m*l* methyl iodide were added, and then the whole was shaken at room temperature in the dark for 20 hr. The solution was filtered, and, after the addition of water, the filtrate was extracted four times with chloroform. The combined extracts were filtered again to remove white precipitates, washed thoroughly with water, and dried over sodium sulfate, and the chloroform was distilled *in vacuo*. The resulting crystalline residue was recrystallyzed from ethyl acetate-petroleum



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2) R. Kuhn, H. Trischmann and I. Löw, *Angew. Chem.*, **67**, 32 (1955).

3) B. Helferich and E. Himmen, *Ber.*, **61**, 1825 (1928).

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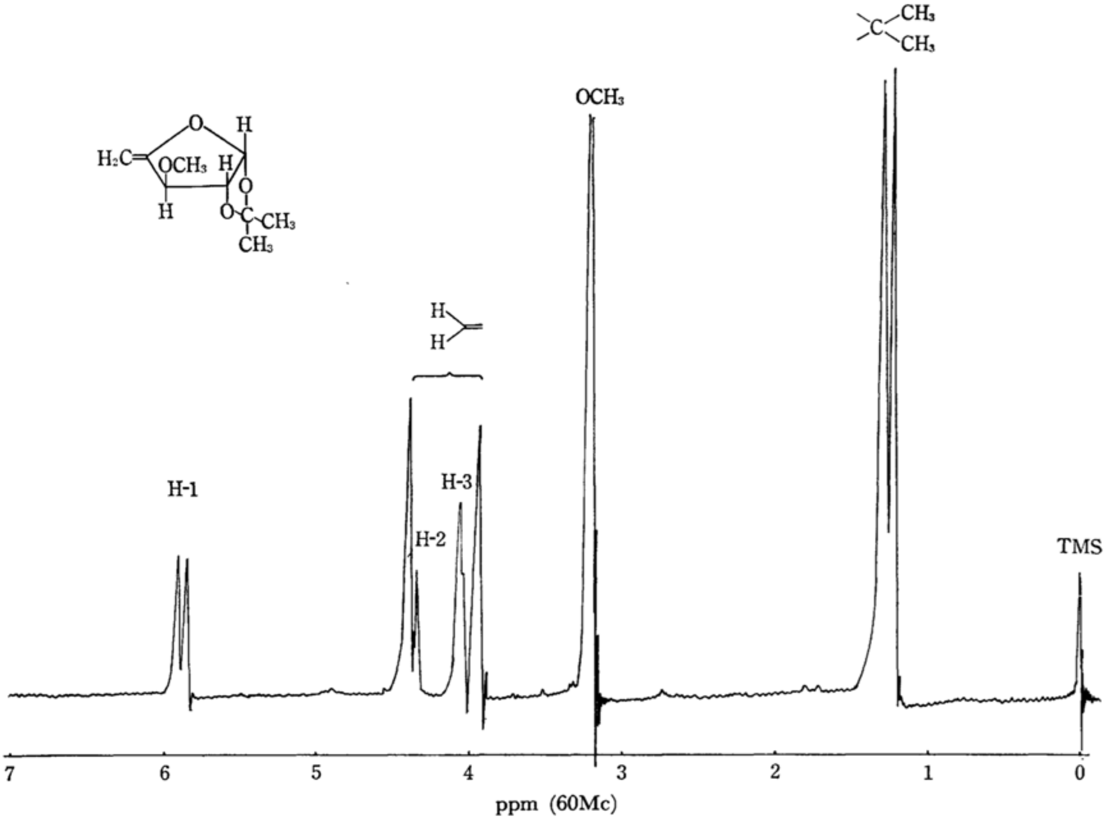

Fig. 1. NMR spectrum of 5-deoxy-1,2-*O*-isopropylidene-3-*O*-methyl-α-D-xylofuranose-4-ene (liq.).

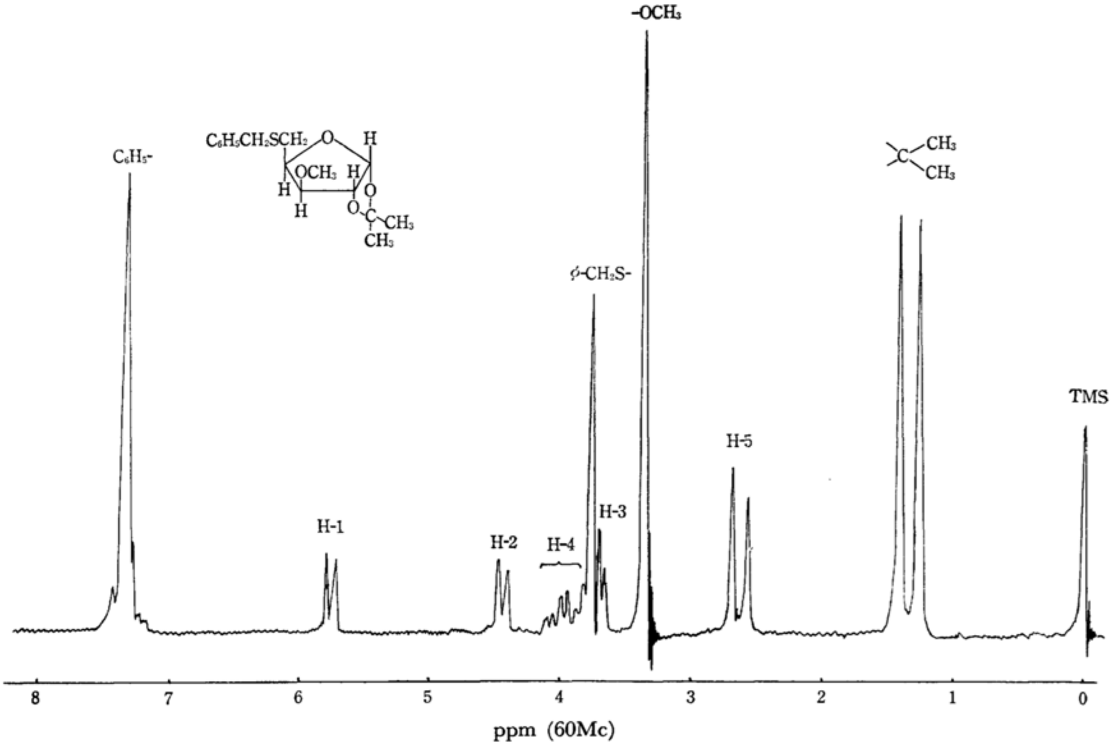

Fig. 2. NMR spectrum of 5-benzylthio-5-deoxy-1,2-*O*-isopropylidene-3-methyl-α-D-xylofuranose (in CCl_4).

benzine to give colorless prisms of [2] (9.1 g, 72% yield), mp 116—117°C.

5-Bromo-5-deoxy-1,2-*O*-isopropylidene-3-*O*-methyl-*α*-D-xylofuranose [3]. A solution of 5 g of [2] and 10 g of tetramethylammonium bromide in 100 m*l* of DMF was heated at 100°C for 14 hr and then concentrated *in vacuo*. After the subsequent addition of water, the solution was extracted with chloroform three times, and the combined extracts were washed thoroughly with water, dried over sodium sulfate, and concentrated *in vacuo* to give a sirup. The fractional vacuum distillation of the sirup gave, in a 73% yield (3.8 g), pure [3]. bp 67°C/0.2 mmHg, $[\alpha]_D^{18}$ −77.6° (*c* 10, chloroform).

Found: C, 40.1; H, 5.72%. Calcd for $C_9H_{15}O_4Br$: C, 40.5; H, 5.66%.

5-Deoxy-1,2-*O*-isopropylidene-3-*O*-methyl-*α*-D-xylofuranose-4-ene [4]. A mixture of 5 g of [3] and 7 g of silver fluoride in 40 m*l* of dry pyridine was warmed at 50°C for 30 hr. The product and the pyridine were separated from the inorganic salts by repeated extractions with ether. After filtration, the combined extracts were washed with an aqueous sodium carbonate solution and water, dried over sodium sulfate, and concentrated *in vacuo*. The fractional vacuum distillation of the resulting sirup gave, in a 60% yield (2.1 g), pure [4], bp 80°C/7 mmHg, $[\alpha]_D^{18}$ −66.0° (*c* 10, chloroform), NMR data (see Fig. 1).

Found: C, 57.8; H, 7.63%. Calcd for $C_9H_{14}O_4$: C, 58.2; H, 7.53%.

5-Benzylthio-5-deoxy-1,2-*O*-isopropylidene-3-*O*-methyl-*α*-D-xylofuranose [5]. i) A solution of 3 g of [4] in 5 m*l* of redistilled benzylmercaptan in a Vycor tube was irradiated for 1 hr with a high-pressure mercury ultraviolet lamp (100 W) under a nitrogen atmosphere. The solution was then concentrated *in vacuo*, and the residue was recrystallized from methanol to give, in a 82% yield (3.9 g), colorless needles of [5], mp 68°C, $[\alpha]_D^{18}$ +25.6 (*c* 5, chloroform), NMR data (see Fig. 2).

Found: C, 61.3; H, 7.20%. Calcd for $C_{16}H_{22}O_4S$: C, 61.9; H, 7.09%.

ii) To a solution of 0.1 g of metallic sodium in 2 m*l* of ethanol, 2 m*l* of redistilled benzylmercaptan and 1 g of [4] were added, and the whole was refluxed for 3 hr under a nitrogen atmosphere. The solution was then concentrated *in vacuo*, the residue was extracted with ether, and the extracts were washed with water, dried over sodium sulfate, and concentrated *in vacuo* to give crystals. Recrystallization from methanol yielded, in a 40% yield (0.6 g), colorless needles of [5], mp 68°C.

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