

On the Syntheses of the Guaiacyl Ethers of 1-Veratryl-2-propanol and 1-Guaiacyl-2-propanol

FRANCISKA SUNDHOLM

Department of Chemistry, University of Helsinki, Helsinki, Finland

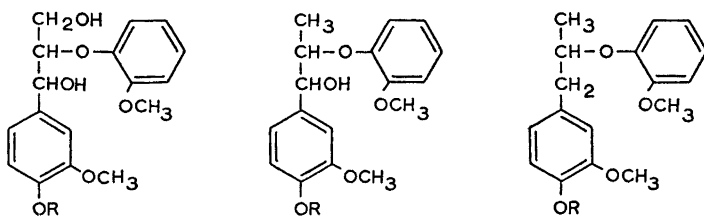
Syntheses of the guaiacyl ethers of 1-veratryl-2-propanol and 1-guaiacyl-2-propanol (5,6)* are described for the first time. The infrared spectra of these compounds and some of the intermediates formed in the syntheses have been recorded and assignments are given for the main bands.

o-Methoxyphenols with *para*-located propane side-chains carrying ether-linked aromatic units in the β -position are of great interest in lignin chemistry. Adler *et al.* synthesized the β -guaiacyl ether of veratrylglycerol (1) in 1952¹ and in 1955² stated that the β -guaiacyl ether of guaiacylglycerol (2) had been synthesized by a similar method. However, the details of the latter synthesis were not published. In 1959 Kratzl³ published a detailed description of the synthesis of guaiacylglycerol β -guaiacyl ether (2). In 1964 the present author⁴ synthesized a number of lignin model compounds including the β -guaiacyl ethers of isoeugenol glycol (3) and 1-(3,4-dimethoxyphenyl)propanediol-1,2 (4). These syntheses were conducted in much the same way as the syntheses of the other mentioned compounds. Adler *et al.* described in 1966⁵ the syntheses of 3 and 4 as well as the separation of the diastereoisomers of these compounds.

In order to add to the series of lignin model compounds with β -guaiacyl ether-linkages and similar oxygen functions in the side-chain, the present author in 1966⁶ synthesized 1-veratryl-2-propyl guaiacyl ether (5). This synthesis was described at the 1966 Meeting of the Finnish Chemical Society in Oulu.

More detailed descriptions of the synthesis of 1-veratryl-2-propyl guaiacyl ether (5) as well as of the hitherto unpublished synthesis of 1-guaiacyl-2-propyl guaiacyl ether (6) were believed to be of interest. The two compounds were prepared by the same method. Veratrum aldehyde and vanillin, respectively,

* In the present paper a guaiacyl group stands for a 3-methoxy-4-hydroxyphenyl group, and a veratryl group stands for a 3,4-dimethoxyphenyl group, as is usual in lignin chemistry.

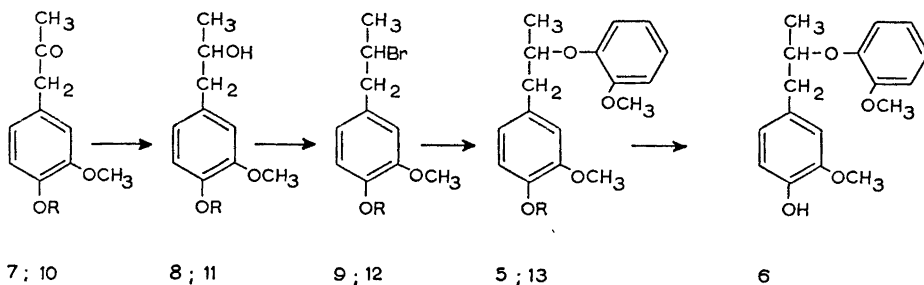


1. R = CH₃
2. R = H

3. R = H
4. R = CH₃

5. R = CH₃
6. R = H

were used as starting materials. The aldehydes were condensed with nitroethane in the presence of potassium carbonate and methylamine hydrochloride to the corresponding substituted 1-phenyl-2-nitropropenes.⁷ The unsaturated nitro compounds were reduced and converted into the corresponding phenylacetones by treatment with iron, hydrochloric acid and ferric chloride.⁸ At this stage the phenolic hydroxyl group was protected with a benzoate ester group, which was finally split with the aid of lithium aluminium hydride. The ketone carbonyl groups (7,10) were reduced to hydroxyl groups with sodium borohydride (8,11) and the hydroxyl groups were replaced by bromine (9,12) in a benzene-petroleum ether solution containing pyridine. The bromides were condensed with guaiacol (5,13) by boiling in a methyl ethyl ketone solution in the presence of potassium carbonate.



5; 7; 8; 9 R = -CH₃

10; 11; 12; 13 R = -CO-C₆H₅

To establish the structures of the synthesized compounds, their infrared spectra were measured on a Perkin-Elmer grating spectrometer model 237. The spectra were recorded for potassium bromide wafers.

The frequencies of the bands in the infrared spectra of the compounds are collected in Table 1. Where no specific papers are referred to, see Refs. 9 and 10.

Table 1. Position of absorption bands in spectra of model compounds, (cm⁻¹).

Compounds Assignments	(7)	(8)	(9)	(5)	Guaiacyl-acetone	(10)	(11)	(12)	(13)	(6)
OH-stretch		3350			3400		3400			3480
CH-stretch in methyl and methylene groups	3000	3050	3000	3000	3000	3050	3080	3060	3060	3060
	2940	2980	2960	2940	2960	2940	2980	2960	2960	2940
	2840	2940	2940	2900	2930	2920	2940	2920	2915	2900
		2840	2840	2840	2850	2820	2880	2840	2850	2840
CO-stretch in esters and ketones	1710				1705	1730	1740	1740	1750	
						1700				
Aromatic skeletal vibrations	1600	1615	1600	1600	1600	1600	1600	1600	1600	1600
	1510	1515	1510	1500	1510	1500	1505	1497	1500	1500
	1420	1425	1420	1420	1435	1450	1420	1450	1430	1420
CH-deformation in methyl and methylene groups	1470	1470	1460	1470	1465	1465	1460	1465	1460	1465
	1450	1450								1455
Symmetric CH-deformation	1360	1380	1340		1360	1370	1360	1380	1370	
Guaiacylic ring breathing with CO-stretching	1270	1270	1270	1270	1270	1270	1250	1250	1270	1260
	1240	1240	1240	1250	1240	1245	1200	1230	1250	1240
	1140	1150	1135	1140	1125	1130	1120	1120	1120	1140
CH in-plane deformation	1160	1170	1160	1170	1150	1170	1150	1160	1160	1175
	1020	1040	1060	1030	1035	1060	1060	1060	1060	1030
CO-stretch in sec. alcohol		1070					1070			
Aromatic CH out-of-plane vibrations	940	970	920	920	930	930	930	970	1000	920
	870	900	870	880	860	850	870	880	880	850
	825	810	830	810	800	800	800	810	810	810
	800	770	770	780	750	730	750	750	750	750

Aromatic skeletal vibration bands were found in all the spectra at 1600, 1520–1500, and 1450–1420 cm^{-1} . The first two bands have been well recognized as typical aromatic vibration modes (see Ref. 4 and the references cited there). The assignment of the 1450–1420 cm^{-1} has been uncertain,¹¹ but in a study of the spectra of guaiacyl and syringyl models, Sarkanen *et al.* established that this band is associated with the ring stretching modes similar to the 1500 cm^{-1} band.¹² Sarkanen *et al.* also assigned the bands in the 1160 and 1050 cm^{-1} regions to C–H in-plane deformations associated with aromatic skeletal vibrations, and these assignments have been adopted in the present work.

The carbonyl stretching frequencies of ketone carbonyls and ester carbonyls are found, as expected, at 1710 and 1750 cm^{-1} , respectively.

Methyl and methylene groups absorb in the 1470–1460 cm^{-1} region.^{9,10} A band is found at 1370 cm^{-1} in all the spectra except those of 5 and 6. This band is probably due to deformation vibrations of C–H groups, and the absence of these two bands in the cases mentioned might be due to coupling effects of some kind in the molecules.

The assignments of the bands between 1300 and 1000 cm^{-1} are doubtful since they probably result from complex coupled vibration modes. Sarkanen *et al.*, however, found that the bands at 1270, 1240, and 1150 cm^{-1} are typical of guaiacyl and veratryl models; and the spectral data for the compounds discussed in this paper seem to be in agreement with this conclusion.

Several absorption bands due to aromatic out-of-plane C–H vibrations in variously substituted aromatic rings are observed at frequencies below 1000 cm^{-1} .

EXPERIMENTAL

1-Veratryl-2-propanol (8). 1 g of veratrylacetone (7) was heated with an excess of sodium borohydride in 50 ml of diglyme (1,2-dimethoxyethane) for 1 h. Water and acetic acid were then added to destroy the sodium borohydride. The mixture was extracted with ether, after which the ether solution was dried and the ether evaporated. The yield of an oily mass was 0.8 g (80 %). (Found: C 67.13; H 8.27. Calc. for $\text{C}_{11}\text{H}_{16}\text{O}_3$: C 67.32; H 8.22).

1-Veratryl-2-propyl bromide (9). 1 g of 1-veratryl-2-propanol (8) was dissolved in 50 ml of benzene-petroleum ether (9:1) containing 5 % pyridine, and hydrogen bromide was bubbled through the solution with stirring for 1 h. The reaction mixture was washed with water, saturated sodium bicarbonate solution and water, dried and evaporated to dryness. The yield of an oil which crystallized upon standing in white needles melting at 79–83°C was 0.6 g (45 %). (Found: C 50.55; H 5.63. Calc. for $\text{C}_{11}\text{H}_{16}\text{O}_2\text{Br}$: C 50.79; H 5.81).

1-Veratryl-2-propyl guaiacyl ether (5). To a solution of 50 mg of 9 in 30 ml of methyl ethyl ketone, 37 mg of guaiacol and 50 mg of potassium carbonate were added with stirring. The reaction mixture was refluxed for 1 h, allowed to cool and diluted with 100 ml of ice-water. The solution was neutralized with dilute hydrochloric acid and extracted with ether. The ether solution was washed with sodium hydroxide solution, dried and evaporated. The yield of an oil was 30 mg (51 %). (Found: C 70.49; H 7.33. Calc. for $\text{C}_{17}\text{H}_{22}\text{O}_4$: C 70.32; H 7.64).

Guaiacylacetone benzoyl ester (10) was prepared by the method of Leopold.¹³

1-(Benzoylguaiacyl)-2-propanol (11) was prepared by the same method as 8. The yield of partly crystallized oil was 80 %. (Found: C 71.49; H 6.21. Calc. for $\text{C}_{17}\text{H}_{18}\text{O}_4$: C 71.31; H 6.33).

1-(Benzoylguaiacyl)-2-propyl bromide (12) was prepared by the same method as 9. The yield of an oil which crystallized upon standing and melted at 122–124°C was 49.5 %. (Found: C 58.30; H 4.89. Calc. for $\text{C}_{17}\text{H}_{17}\text{O}_3\text{Br}$: C 58.47; H 4.91).

1-(Benzoylguaiacyl)-2-propyl guaiacyl ether (13) was prepared by the same method as *5*. The yield of a light yellow oil, giving one spot in three different solvent systems (2 % acetic acid in methyl ethyl ketone:xylene (1:9), 2 % ethanol in chloroform, benzene:acetone (3:2)) on thin layer chromatograms, was 53 %. (Found: C 60.33; H 5.32. Calc. for $C_{23}H_{24}O_5$: C 59.99; H 5.25).

1-Guaiacyl-2-propyl guaiacyl ether (6). To a solution of 0.35 g of *13* in 15 ml of dry tetrahydrofuran, 0.30 g of lithium aluminium hydride was added with stirring and the mixture was refluxed on a water bath for 3 h. The excess of lithium aluminium hydride was destroyed by cautiously adding acetone and water. The reaction mixture was acidified with dilute sulphuric acid and the volume reduced by evaporation *in vacuo*. The solution was extracted with benzene and the extract was washed, dried and evaporated. The yield of an oil, giving one spot with differing R_F values from those of *13* in the three solvent systems on thin layer chromatography (see above), was 0.15 g (79 %). (Found: C 70.49; H 6.61. Calc. for $C_{17}H_{20}O_4$: C 70.81; H 6.99).

Acknowledgement. The author wishes to express her appreciation to *Neste Oy:n Säätiö Tutkimus- ja Korkeakouluopetustyön Tukemiseksi* for a fellowship.

REFERENCES

1. Adler, E., Lindgren, B. O. and Saedén, U. *Svensk Papperstid.* **55** (1952) 245.
2. Adler, E. and Eriksoo, E. *Acta Chem. Scand.* **9** (1955) 341.
3. Kratzl, K., Kisser, W., Gratzl, J. and Silbernagel, H. *Monatsh.* **90** (1959) 771.
4. Sundholm, F. *Soc. Sci. Fennica, Commentationes Phys.-Math.* **30** (1965) 11.
5. Adler, E., Delin, S. and Miksche, G. *Acta Chem. Scand.* **20** (1966) 1035.
6. Sundholm, F. *Suomen Kemistilehti A* **39** (1966) 124.
7. Kauffmann, K. *Ber.* **52** (1919) 1431.
8. Eastham, A. M., Fisher, H. E., Kulka, M. and Hibbert, H. *J. Am. Chem. Soc.* **66** (1944) 30.
9. Bellamy, L. J. *The Infrared Spectra of Complex Molecules*, Methuen, London 1962.
10. Nakanishi, K. *Infrared Absorption Spectroscopy*, Holden-Day, San Francisco, and Nankodo Co., Tokyo 1962.
11. Hergert, H. *J. Org. Chem.* **25** (1960) 405.
12. Sarkanen, K. V., Houming Chang and Ericsson, B. *Private communication* to Professor J. J. Lindberg, Department of Chemistry, University of Helsinki, Helsinki.
13. Leopold, B. and Hägglund, E. *Acta Chem. Scand.* **3** (1949) 1358.

Received September 7, 1967.