

The Methylenation of Several Allylbenzene-1,2-diol Derivatives in Aprotic Polar Solvents

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The aprotic polar solvents, such as DMF (*N,N*-dimethylformamide) and DMSO (dimethyl sulfoxide), accelerated very effectively the methylenation of 1,2-dihydroxy-4- (I), 1,2-dihydroxy-3,4-dimethoxy-5- (II), and 1,2-dihydroxy-3-methoxy-5-allylbenzene (III) in the presence of bronze and cupric oxide as catalysts.

Recently, there are many effective insecticides derived from safrole. There have been many studies undertaken in an attempt to form an ether linkage of methylenedioxy compounds,¹⁻¹⁰ and these derivatives are being commercially produced. However, studies of the methylenation of 1,2-dihydroxyallylbenzenes have been discontinued since Perkin and Trikojus.⁴ Although some 1,2-dihydroxybenzene derivatives containing an aldehyde group were methylenated in the presence of copper and related catalysts,^{3,10} the yields of the products were poor.

The present authors studied the conditions for synthesizing methylenedioxy derivatives from 1,2-dihydroxy-4- (I), 1,2-dihydroxy-3,4-dimethoxy-5- (II), and

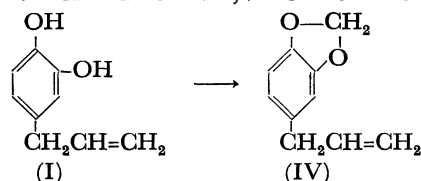
1,2-dihydroxy-3-methoxy-5-allylbenzene (III) in aprotic polar solvents in the presence of bronze and copper oxides, as no studies of the methylenation of these 1,2-dihydroxyallylbenzene derivatives in the presence of such catalysts in aprotic polar solvents (DMF and DMSO) were available.

Results and Discussion

The results are shown in Tables 1—3.

As Table 1 shows, acetone, methanol, and pyridine gave only a small amount of the product, whereas the

TABLE 1. METHYLENATION OF 1,2-DIHYDROXY-4-ALLYLBENZENE

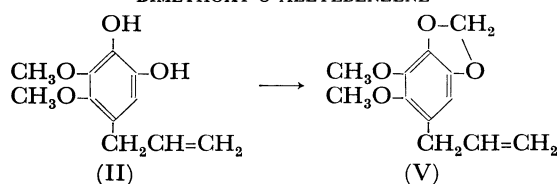


No.	(I) g	CH ₂ I ₂ g	Catalyst g	Solvent ml	K ₂ CO ₃ g	Yield of (IV) %
1	10	20	None	MeCOMe 50	20	7.9
2	10	20	CuO 1.0	MeCOMe 50	20	8.7
3	10	20	Bronze 1.0	MeCOMe 50	20	9.5
4	5	10	None	MeOH 50	10	poor
5	5	10	CuO 0.5	MeOH 50	10	poor
6	5	10	Bronze 0.5	MeOH 50	10	poor
7	5	10	None	C ₅ H ₅ N ^{a)} 50	10	12.1
8	5	10	CuO 0.5	C ₅ H ₅ N ^{a)} 50	10	15.0
9	5	10	Bronze 0.5	C ₅ H ₅ N ^{a)} 50	10	14.5
10	10	20	None	DMF 100	20	54.1
11	10	20	Cu 1.0	DMF 100	20	53.3
12	10	20	Cu ₂ O 1.0	DMF 100	20	52.9
13	10	20	CuO 1.0	DMF 100	20	73.0
14	10	20	Bronze 1.0	DMF 100	20	74.3
15	5	10	None	DMSO 50	10	59.6
16	5	10	Cu 0.5	DMSO 50	10	57.2
17	5	10	Cu ₂ O 0.5	DMSO 50	10	55.5
18	5	10	CuO 0.5	DMSO 50	10	82.2
19	5	10	Bronze 0.5	DMSO 50	10	78.1

a) C₅H₅N: pyridine. The reactions were carried out in N₂ gas atmosphere, for 3 hr. The reaction temperature: No. 1—9, refluxed; No. 10—19, 120—125 °C (oil bath temp.).

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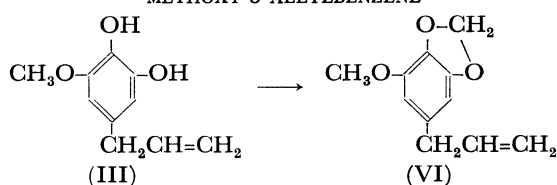
TABLE 2. METHYLENATION OF 1,2-DIHYDROXY-3,4-DIMETHOXY-5-ALLYLBENZENE



Catalyst	Solvent	Yield of (V) %
None	DMF	55.4
CuO	DMF	74.1
Bronze	DMF	69.5
None	DMSO	61.0
CuO	DMSO	84.8
Bronze	DMSO	81.4

The reactions were carried out in N_2 gas atmosphere, at 120–125°C (oil bath temp.) for 3 hr. An amount of each reactant: (II) 10 g, CH_2I_2 20 g, K_2CO_3 20 g; an amount of each catalyst, 1.0 g; an amount of each solvent, 100 ml.

TABLE 3. METHYLENATION OF 1,2-DIHYDROXY-3-METHOXY-5-ALLYLBENZENE



Catalyst	Solvent	Yield of (VI) %
None	DMF	54.1
CuO	DMF	72.3
Bronze	DMF	70.5
None	DMSO	59.0
CuO	DMSO	81.3
Bronze	DMSO	80.0

Each reaction was carried out as is described in the footnote to Table 2.

yields of the product were more than 50% when DMF and DMSO were used. The addition of bronze and cupric oxide as catalysts increased the yields about 20%, while the yields of the products in the presence of copper powder and cuprous oxide were about the same as the yields in the reactions without any catalyst. Therefore, in the methylenation of (II) and (III) DMF and DMSO were used as solvents. In these cases, the addition of bronze and cupric oxide as catalysts also increased the yields about 20%, as is shown in Tables 2 and 3, and DMSO was a little better than DMF as a solvent.

From these results, the authors found that cupric oxide and bronze were better catalysts than other catalysts in methylenation using a definite amount of catalysts, though no remarkable difference was remarked between the two catalysts. The addition of anhydrous potassium carbonate to the reactions would

give good results in the case of solvents, DMF and DMSO, that greatly accelerate the nucleophilic substitution reaction, judging from the results that these aprotic polar solvents, DMF and DMSO, gave 54–61% yields for (IV), (V), and (VI). Further, it appeared that DMSO accelerated the reaction more effectively than DMF, judging from the fact that DMSO, being more stable than DMF in a basic solvent, gave the best results in the presence of alkali in these reactions. Therefore, DMSO should be a very effective solvent in the methylenation of 1,2-dihydroxy-allylbenzene derivatives.

Experimental

Catalysts. The bronze (Cu 65%, Zn 23%, Sn 1.5%, Fe 2%, Pb 0.3%) and copper powder were commercial products. The cuprous and cupric oxide were prepared according to the methods of Tomita *et al.*¹¹⁾

Reagents. The potassium carbonate and methylene diiodide were commercial products.

Solvents. The acetone, methanol, pyridine, DMF, and DMSO were purified by the distillation of commercial products.

Materials. The 1,2-dihydroxy-4- (I), 1,2-dihydroxy-3,4-dimethoxy-5- (II), and 1,2-dihydroxy-3-methoxy-5-allylbenzene (III) were prepared according to the methods of Perkin, and Trikojus,¹²⁾ Baker *et al.*,¹³⁾ and Trikojus and White¹⁴⁾ respectively.

General Synthetic Procedure. The materials, the methylene diiodide, the anhydrous potassium carbonate, and the catalysts were added to the solvents; then the mixture was reacted on an oil bath with stirring, as is shown in the tables. The reaction mixture was extracted with ether, washed with 3% HCl, 3% NaOH and water successively, and dehydrated with anhydrous Na_2SO_4 . Then the product was obtained by distillation *in vacuo* after the removal of the solvent.

1,2-Methylenedioxy-4-allylbenzene (Safrole). Bp 94.0–94.5°C/4 mmHg (lit,¹²⁾ bp 100–101.5°C/10–11 mmHg). Beilstein's test for halogen: negative. n_D^{20} 1.5380 (lit,¹²⁾ n_D^{20} 1.5381). IR (KBr): 2786, 929, 717 cm^{-1} (O–CH₂–O). (Found: C, 74.08; H, 6.26%. Calcd for $C_{10}H_{10}O_2$: C, 74.05; H, 6.22%).

1,2-Methylenedioxy-3,4-dimethoxy-5-allylbenzene (Dillapiole). Bp 172–172.5°C/16 mmHg (lit,¹³⁾ bp 172–173°C/16 mmHg). Beilstein's test for halogen: negative. n_D^{20} 1.5276. IR (KBr): 2779, 926, 719 cm^{-1} (O–CH₂–O). (Found: C, 64.80; H, 6.39%. Calcd for $C_{12}H_{14}O_4$: C, 64.85; H, 6.35%).

1,2-Methylenedioxy-3-methoxy-5-allylbenzene (Myristicin). Bp 149–149.6°C/15 mmHg (lit,¹⁴⁾ bp 95–97°C/0.2 mmHg). Beilstein's test for halogen: negative. n_D^{20} 1.5409 (lit,¹⁴⁾ n_D^{20} 1.5426). IR (KBr): 2789, 928, 715 cm^{-1} (O–CH₂–O). (Found: C, 68.69; H, 6.31%. Calcd for $C_{11}H_{12}O_3$: C, 68.73; H, 6.29%).

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