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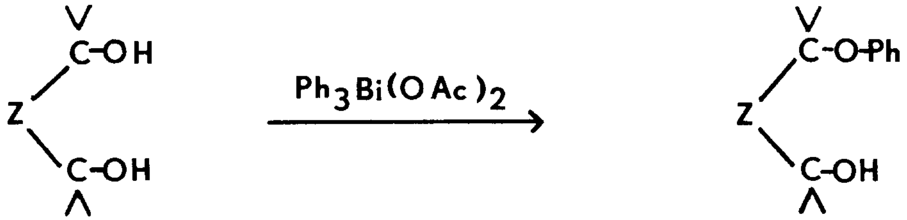
SELECTIVE PHENYLATION IN MILD CONDITIONS OF ONE HYDROXY GROUP IN GLYCOLS WITH TRIPHENYLBISMUTH DIACETATE : A NEW SPECIFIC GLYCOL REACTION.

Serge David* and Annie Thieffry
Département de Chimie Organique, Bâtiment 420, Université de Paris-Sud,
91405 Orsay Cédex, France.

Abstract. Refluxing for 4-5 h a dichloromethane solution of a diol in the presence of an equimolecular quantity of triphenylbismuth diacetate gave the monophenyl ether in good to excellent yield.

The usefulness of tri-, tetra-, and pentaaryl derivatives of pentavalent bismuth as reagents for the oxidation of alcohols, the cleavage of vicinal glycols, and the C-phenylation of carbonyl compounds, phenols and enols has been demonstrated by D.H.R. Barton *et coll.* in recent papers.[1,2] Also, *isolated* hydroxy groups in some fairly acidic derivatives such as phenols and enols could be phenylated by tetraphenylbismuth monotrifluoroacetate.[3] On the other hand, in the course of a study of stannylene cleavage with bismuth reagents, it was observed in our laboratory[4] that, in the absence of base, *trans* cyclohexane-1,2-diol was smoothly mono O-phenylated by triphenylbismuth diacetate. Thus, it appeared that the phenylation of an alcoholic hydroxy group could also be achieved, and this in mild conditions, provided a second one was also present in the same molecule. We now report a preliminary study of the scope of this phenylation, which should be considered as a new, typical glycol reaction :



Refluxing for a few hours a dichloromethane solution containing equimolecular quantities of a glycol and triphenylbismuth diacetate gave in most cases very good yields of phenoxy alcohols (Table). Inspection of the table shows that the reaction was practically quantitative with *bis* primary and *bis* secondary vicinal diols (Entries 1, 2, 3, 7 and 8) but gave a low yield with pinacol and no phenyl ether with tetraphenyl glycol. Expectedly the treatment of primary-secondary vicinal diols gave mixtures (Entries 11 and 12), but only the secondary alcoholic function was converted to a phenyl ether in secondary-tertiary vicinal glycols (Entries 13 to 16).

Such a smooth phenylation of an alcoholic hydroxy group does occur only if another one is present in the same molecule : refluxing for 24 hours a mixture of cyclohexanol and triphenylbismuth diacetate in dichloromethane solution gave at most 3% phenoxycyclohexane, while the conversion of cyclohexane-1,2-diol with the same reagent was practically complete in 4 hours. No etherification of octan-1-ol could be detected under conditions which generated monophenyl ethers of diols in more than 60% yield.[5] Finally, the formation of diphenyl ethers was never observed under our conditions : this is another indication of the relative unreactivity of monoalcohols towards triphenylbismuth diacetate. In this connection, we may also note that even with the best reagent available, tetraphenylbismuth trifluoroacetate, the reported phenylation of isolated hydroxy groups in phenols and enols[3] appears to be a slow process, which needs longer times and higher temperatures than the reactions of the Table.

All this suggests that the more rapid etherification now reported is a specific glycol reaction. The simplest interpretation is that at some intermediate stage both hydroxy groups of the glycol bind more or less tightly to some of the core atoms of the reagent, most probably both to the bismuth atom, as already suggested.[2] Thus, the proximity of one hydroxy group would make easier the migration of the phenyl group onto the other one. Now coming back to the Table, we see that the O-phenylation of tertiary hydroxy groups only occurs in forcing conditions, and then, in low yield (Entry 9). On the other hand, the secondary hydroxy group, which is unreactive in cyclohexanol, is phenylated smoothly when vicinal to a tertiary hydroxy group (Entries 15 and 16). Thus the binding site to the participating hydroxy group is much less sterically demanding than the binding site to the hydroxy group to be phenylated. The definitive mechanism should also explain why successful phenylations always began with a fairly long, two hours induction period when seemingly nothing happened by t.l.c. examination, and then proceeded quickly.

Such a participation involves a ring-closure, and this suggested that the reaction might be extended to any diol which can close a ring without excessive difficulties. Actually, monophenyl ethers of 1,3- and 1,4-diols could be prepared in excellent yield (Entries 17, 18 and 21). The yield decreased with 1,5- and 1,6-diols, but not dramatically (Entries 19 and 20) and another mechanism may be operative.

Glycol splitting was observed in a few cases (Entries 4, 10 and 14). For instance, 1,2-diphenylpropane-1,2-diol gave no phenyl ether under the general conditions, but the yield of cleavage products could be repressed to 26% by the addition of one equivalent of acetic acid to the mixture. Some acetic acid was normally evolved in the course of our reactions of O-phenylation.

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Table. Reaction of glycols with triphenylbismuth diacetate.[a]

Entry	Glycol	Reaction time, h	Product(s)[6]	Isolated yield, %
1	CH_2OHCH_2OH	4	CH_2OPhCH_2OH (1)	85
2	(±)$CH_3CHOHCHOHCH_3$	4	$CH_3CHOPhCHOHCH_3$ (2)	86
3	(±)$CH_3(CH_2)_2CHOHCHOH(CH_2)_2CH_3$	6	$CH_3(CH_2)_2CHOPhCHOH(CH_2)_2CH_3$ (3)	91
4	*meso* PhCHOH-CHOH-Ph	5	PhCHOPhCHOHPh (4)	37
5	*cis*-cyclopentane-1,2-diol	7	*cis*-2-phenoxycyclopentanol (5)	41
6	*trans*-cyclopentane-1,2-diol	4	*trans*-2-phenoxycyclopentanol (6)	51
7	*cis*-cyclohexane-1,2-diol	4	*cis*-2-phenoxycyclohexanol (7)	87
8	*trans*-cyclohexane-1,2-diol	4	*trans*-2-phenoxycyclohexanol (8)	88
9	$(CH_3)_2C(OH)C(CH_3)_2OH$	24	$(CH_3)_2C(OPh)C(CH_3)_2OH$ (9)	15
10	$Ph_2C(OH)CPh_2OH$	24		0
11	$CH_3CHOHCH_2OH$	4	$CH_3CHOHCH_2OPh$ (10), $CH_3CHOPhCH_2OH$ (11)	92[b]
12	$PhCHOHCH_2OH$	4	$PhCHOHCH_2OPh$ (12)	43
			$PhCHOPhCH_2OH$ (13)	48
13	$(CH_3)_2C(OH)CHOHCH_3$	4	$CH_3CHOPhC(CH_3)_2OH$ (14)	84
14	$CH_3PhC(OH)CHOHPh$	5	$PhCHOPhC(CH_3)PhOH$ (15)	50
15	*trans*-1-methylcyclohexane-1,2-diol	4	*trans*-1-methyl-2-phenoxycyclohexanol (16)	88
16	*trans*-1-phenylcyclohexane-1,2-diol	4	*trans*-2-phenoxy-1-phenylcyclohexanol (17)	74
17	$CH_2OHCH_2CH_2OH$	4	$CH_2OPhCH_2CH_2OH$ (18)	87
18	$CH_2OH(CH_2)_2CH_2OH$	4	$CH_2OPh(CH_2)_2CH_2OH$ (19)	80
19	$CH_2OH(CH_2)_3CH_2OH$	5	$CH_2OPh(CH_2)_3CH_2OH$ (20)	50
20	$CH_2OH(CH_2)_4CH_2OH$	5	$CH_2OPh(CH_2)_4CH_2OH$ (21)	40
21	*Z*-$CH_2OHCH{=}CHCH_2OH$	5	(*Z*)-$CH_2OPhCH{=}CHCH_2OH$ (22)	75

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[a] One molar equivalent of triphenylbismuth diacetate was added to a 0.2 M solution of the diol in dichloromethane. The mixture was heated at reflux for the time indicated and evaporated to dryness. Silica gel column chromatography of the residue then gave the phenoxy alcohol in the pure state. The eluant was a 95:5 hexane-ethyl acetate mixture for the separation of 15 and dichloromethane in all the other cases.

[b] Combined yield of mixed phenyl ethers.

References and notes.

1. D.H.R. Barton, J.P. Kitchin and W.B. Motherwell, *J.Chem.Soc., Chem.Comm.*, 1099 (1978); D.H.R. Barton, D.J. Lester, W.B. Motherwell and M.T. Barros Papoula, *J.Chem.Soc., Chem.Comm.*, 705 (1979); D.H.R. Barton, D.J. Lester, W.B. Motherwell and M.T. Barros Papoula, *J.Chem.Soc., Chem.Comm.*, 246 (1980); D.H.R. Barton, J.C. Blazejewski, B. Charpiot, D.J. Lester, W.B. Motherwell and M.T. Barros Papoula, *J.Chem.Soc., Chem. Comm.*, 827 (1980).
2. D.H.R. Barton, W.B. Motherwell and A. Stobie, *J.Chem.Soc., Chem.Comm.*, *in the press*.
3. D.H.R. Barton, J.C. Blazejewski, B. Charpiot and W.B. Motherwell, *J.Chem.Soc., Chem. Comm.*, 503 (1981).
4. S. David and A. Thieffry, *Tetrahedron Letters*, 2885 (1981).
5. Phenylation of octan-1-ol may be observed in forcing conditions.
6. All the phenoxy alcohols were liquids except : **8**, m.p. 82°C (ether-light petroleum); **12**, m.p. 58°C (light petroleum); **13**, m.p. 81°C (light petroleum); **17**, m.p. 89°C (light petroleum). The homogeneity of the samples was checked by VPC on a SE 30 column, at the following optimum furnace temperatures : 160°C, for **1**, **2**, and **18**; 180°C, for **7** and **14**; 190°C, for **3**, **5**, **6**, **9**, **16**, **20**, and **22**; 200°C, for **17**; 220°C, for **4**, **15**, and **21**. All the products **1**-**22** gave satisfactory elemental analyses and 250 MHz ^{1}H NMR and infrared spectra. Phenylation of one hydroxy group brought about a 0.2-1 p.p.m. deshielding of the geminal proton(s). In electron impact m.s. examination of the products the prominents peaks were found to correspond to the molecular ion, to phenol, and to a fragment $PhOCR^1R^2$. This was most intense when arising from the breaking of the bond between two oxygenated carbons (products **1**-**5**, **9**, **12**-**15**), was perhaps superimposed onto the molecular ion in the case of cyclic diols, and much less intense when the vicinal carbon bore no hydroxy group (products **18**-**22**).

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