

Palladium-catalyzed Cross-Coupling Reaction of Trialkylaluminiums with Aryl Triflates: Facile Conversion of a Phenolic Hydroxy Group into an Alkyl Group

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Palladium-catalyzed cross-coupling of aryl trifluoromethanesulphonates with trialkylaluminiums gives the corresponding alkylarenes in high yields, a reaction which provides a convenient method for the conversion of a phenolic hydroxy group into an alkyl group.

Some transition-metal-catalyzed cross-coupling reactions of organometallics with aryl and alkenyl halides, *e.g.* the nickel-catalyzed cross-coupling of Grignard reagents, are of great synthetic value.¹ The use of aryl and alkenyl trifluoromethanesulphonates (triflates) instead of the halides can also be effective in such reactions,² and the palladium-catalyzed cross-coupling of alkenyl and aryl triflates with organometallics containing tin³ and zinc⁴ has been described. Here we describe an example of the cross-coupling of aryl triflates with the readily available trialkylaluminiums,⁵ in which a phenolic hydroxy group is converted into an alkyl group.

Aryl triflates (**2**),⁶ prepared by treatment of aromatic hydroxy compounds (**1**) with trifluoromethanesulphonic anhydride, were employed for the cross-coupling without purification. In order to establish the optimum reaction conditions the coupling reactions of phenyl triflate with trimethylaluminium were carried out under a variety of conditions (catalyst, solvent, and temperature). Palladium catalysts were found to induce the cross-coupling to give high yields of toluene with no by-product. A typical procedure is as follows. A mixture of phenyl triflate (1 mmol), tetrakis(triphenylphosphine)palladium (0.05 mmol), and trimethylaluminium (AlMe₃) (2 mmol) in dry tetrahydrofuran was refluxed under a nitrogen or an argon atmosphere for

3 h to give toluene in 91% yield (entry 1 in the Table). The yield of toluene was determined by g.c. analysis of the reaction mixture. Experiments with varying amounts of AlMe₃ indicate that only one methyl group of the reagent is used for the coupling reaction.

An examination of the applicability of the reaction (see Table) showed that, with few exceptions, the cross-coupling products (**3**) were obtained in high yields. It is worth noting that the coupling occurred efficiently even when a bulky alkylaluminium reagent, *e.g.* Al(Bu)¹₃ (entries 4 and 12), was used. In the reaction of resorcinol with AlMe₃, both hydroxy groups were converted into methyl groups (entry 10). Heterocyclic aryl triflates also coupled with trimethylaluminium to give good results (entries 13 and 14), the only limitations noted being that *p*-methoxyphenyl triflate afforded a low yield of the coupling product (entry 9) and *p*-nitrophenyl triflate failed to react with AlMe₃. Probably reaction of the aluminium with the functional groups is unfavourable to the cross-coupling reaction.

The coupling reaction was also applied to the triflate of 5-hydroxyuracils to give an 83% yield of 1,3-dimethylthymine (entry 15).

When phenyl methanesulphonate and phenyl toluene-*p*-sulphonate were used instead of phenyl triflate, the two

Table. Palladium-catalyzed cross-coupling of aryl triflates (**2**) with trialkylaluminiums

Entry	ArOH (1)	AlR ₃	Time (h)	Product (3)	Yield (%) ^a
1	PhOH	AlMe ₃	3	C ₆ H ₅ Me	91
2		AlEt ₃	3	C ₆ H ₅ Et	94
3		AlPr ₃	16	C ₆ H ₅ Pr	97
4		AlBu ¹ ₃	39	C ₆ H ₅ Bu ¹	52 (83) ^b
5	<i>o</i> -C ₆ H ₄ (Me)OH	AlMe ₃	10	<i>o</i> -C ₆ H ₄ Me ₂	53 (90) ^b
6	<i>m</i> -C ₆ H ₄ (Me)OH	AlMe ₃	6	<i>m</i> -C ₆ H ₄ Me ₂	89
7	<i>p</i> -C ₆ H ₄ (Me)OH	AlMe ₃	7	<i>p</i> -C ₆ H ₄ Me ₂	94
8	<i>p</i> -C ₆ H ₄ (Cl)OH	AlMe ₃	3	<i>p</i> -C ₆ H ₄ (Cl)Me	97
9	<i>p</i> -C ₆ H ₄ (OMe)OH	AlMe ₃ ^c	36	<i>p</i> -C ₆ H ₄ (OMe)Me	25 (71) ^b
10	<i>m</i> -C ₆ H ₄ (OH) ₂	AlMe ₃ ^c	7	<i>m</i> -C ₆ H ₄ Me ₂	64
11	1-Naphthol	AlMe ₃	16	1-Methylnaphthalene	92 (81) ^d
12		AlBu ¹ ₃	12	1-Isobutylnaphthalene	98 (67) ^d
13	2-Hydroxypyridine	AlMe ₃	16	α -Picoline	92
14	3-Hydroxypyridine	AlMe ₃	16	β -Picoline	96
15	5-Hydroxy-1,3-dimethyluracil	AlMe ₃	3	1,3-Dimethylthymine	83 ^{d,e}

^a Yields were determined by g.c. analysis unless otherwise noted. ^b Yield in parentheses based on consumed triflate (**2**). ^c Four equiv. of AlMe₃ were employed. ^d Isolated yield. ^e 1,3-Dimethyluracil was obtained as a by-product (13%).

sulphonates were recovered unchanged. This observation underlines the high efficiency of the aryl triflates as a substrate for the palladium-catalyzed cross-coupling with trialkylaluminiums.

Experimental

1-Isobutyl-naphthalene (Entry 12 in Table).—Trifluoromethane-sulphonic anhydride (0.2 ml, 1.2 mmol) was added to a mixture of 1-naphthol (144 mg, 1 mmol) and triethylamine (130 mg, 1.2 mmol) in dry dichloromethane (5 ml). The mixture was stirred at -20°C for 16 h, poured into water, and extracted with chloroform. The extract was washed with dilute hydrochloric acid and water, dried, and evaporated to dryness to give crude 1-naphthyl triflate quantitatively. To a solution of the triflate in dry tetrahydrofuran (5 ml) were added tetrakis(triphenylphosphine)palladium (58 mg, 0.05 mmol) and a 21% hexane solution of tri-isobutylaluminium (2.6 ml, 2 mmol). The mixture was refluxed under argon atmosphere for 12 h. The reaction solution was evaporated to dryness, chloroform (10 ml) was added to the residue, and the insoluble material was filtered off. The filtrate was washed with water, dried, and evaporated to dryness. Chromatography on silica gel with hexane as eluant yielded 1-isobutyl-naphthalene (124 mg, 67%), oil; [Found: M^+ , 184.1243. $\text{C}_{14}\text{H}_{16}$ requires 184.1252]; δ_{H} (60 MHz; CDCl_3) 1.06 (6 H, d, J 6 Hz, Me \times 2), 1.67–2.47 (1 H, m, CH), 2.92 (2 H, d, J 7 Hz, CH_2), and 7.15–8.10 (7 H, m, ArH); m/z 184 (M^+ , 20%) and 141 ($M^+ - \text{Pr}^i$, 100%).

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