An Improvement of the Aluminium Iodide Method for Ether Cleavage: Catalysis by Quaternary Ammonium Iodides

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Many methods for the dealkylation of aryl alkyl ethers have appeared in the literature, and have been collected in a review¹. This review mentions the rarely studied but effective aluminium iodide as a reagent for the cleavage of aryl alkyl ethers.

We have found that the efficiency of this reagent can be improved if a catalytic amount of a quaternary ammonium iodide (such as tetra-n-butylammonium iodide) is added to the reaction mixture. The iodide ions will then act as more powerful nucleophiles.

Reaction times were found to be remarkably shortened and yields were improved. The example of anisole (1; $R = CH_3$, $Ar = C_6H_5$) is illustrative (Table 1).

Table 1. Cleavage^a of Anisole (1, R = CH₃, Ar = C₆H₅) with Aluminium Iodide

Solvent	Molar Ratio $1/(n-C_4H_9)_4N^{\oplus}J^{\ominus}$	Reaction Time	Yield [%] of Phenol 2		
benzene	360	0.3 h	~ 100		
cyclohexane	360	0.3 h	~100		
cyclohexane		1.5 h	85		
carbon disulphide	360	0.3 h	91		
carbon disulphide	And a	1.5 h	81 1		

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Table 2. Cleavage of Ethers 1a-1 by Aluminium Triiodide in the Presence of Catalytic Amounts of Tetra-n-butylammonium Iodide

Ether	Produc;*	Solvent	Molar Ratios of AlJ ₃ /1 1/(n-C ₄ H ₉) ₄ N [⊕] J [⊕]		Reaction Time ^b	Yield [%]°
B CCCH ₃	OH OH	benzene	1	360	0.3 h	94
H ₃ C OCH ₃	H³C →OH	cyclohexane	2	100	0.7 h	98
-0C ₂ H ₅	⊘ -o+	cyclohexane	1	360	1.0 h	90
	⊘ -o⊦	benzene	1	360	1.0 h	trace
OCH ₃	OH OH	benzene	3	180	0.5 h	95
о=сн-{^}_ос	н₃ о=сн-√Урон	benzene	1	360	0.5 h	78
0=CH	· _ /	cyclohexane	1	360	0.5 h	80
О_СН₃	о=сн >-он	benzene	1.	360	0.5 h	84
O=CH OH	0=CH OH	ben <i>z</i> ene	4.8	360	1.5 h	88 ^d
0=CH OCH ₃	о=сн ———— он	cyclohexane	5.5	120	2.5 h	14 ⁸
O=CH	он О=сн О=сн	cyclohexane	4.5	120	1.5 h	84 ^d
сн=о		cyclohexane	1.5	100	14.0 h	88ª
H ₃ CO-(-)OCI	н₃ н₃со⊸(У)—он	cyclohexane	3.3	100	1.5 h	90 ^d
·)=/	` ` <u>}</u> =/	cyclohexane	5.5	100	1.5 h	91 d
H₃CÓ OCH₃	H₃CO OH	cyclohexane och ₃	10.0	50	10.0 h	85 ^d
о=сн-{_}-сс	Н₃ А: О=СН-√У-ОСН₃ +	=CH——OH cyclohexane	1.5	100	12.0 h	7(A) ⁴
,осн ³) ОН ОН	осн _з cyclohexane	3.3	100	6.0 h	16(A)
E	B: 0=CH-(OH +	=CH—COCH ₃ cyclohexane	5.5	100	15.0 h	84(B) ^d 10(A) ^d 81(B) ^d

The products were identified by b.p., m.p., or ¹H-N.M.R. (JEOL PMX 60 spectrometer) data.

We also found that the reactions are preferably conducted in inert solvents such as benzene and cyclohexane, which are more suitable for large scale handling.

In contrast to earlier studies¹, this ether cleaving reagent was applied to aromatic systems containing formyl and hydroxy functions, in addition to the alkoxy group in the ring. It was found that the AlJ₃/ether 1 rat o may be critical, both for the reaction time and the product distribution (Table 2).

Aluminium Triiodide1.2:

Aluminium powder (2.5 g, 93 mmol) and iodine (19.0 g, 150 mmol) are mixed and refluxed in benzene (120 ml, or cyclohexane) until the red colour of iodine has disappeared (1.5-2 h).

Cleavage of Anisole (1; $R = CH_3$, $Ar = C_6H_5$); Typical Procedure: To a cooled suspension of aluminium triiodide (50 mmol) in cyclohexane (120 ml), a solution of anisole (5.4 g, 50 mmol) and tetra-n-butylanmonium iodide (0.05 g, 0.14 mmol) in cyclohexane (25 ml) is added dropwise. The mixture is refluxed for 20 min, then cooled in an ice/water bath and hydrolysed with water (150 ml). The resulting two layers are separated, and the water phase is extracted with diethyl ether (2 × 25 ml). The extracts are collected and extracted with 2 molar sodium hydroxide solution (30 ml). The water phase is separated, acidified with concentrated hydrochloric acid (to pH = 1), and extracted with diethyl ether (3 × 25 ml). The organic phases are dried with sodium sulphate and evaporated to give pure, crystalline phenol (2; $Ar = C_6H_5$); yield: ~ 100 %; m. p. 41-42°C (Ref. 1.3, m. p. 39-42°C).

^b The reactions were monitored by T.L.C. (SiO₂).

[°] Yield of pure, isolated product.

^d Products isolated by column chromatography (silica, Merck 60).

The different isomers of A and B could not be completely separated on a silica column.

Cleavage of 1,2,3-Trimethoxybenzene (1e); Typical Procedure:

To a cooled suspension of aluminium triiodide (150 mmol) in benzene (120 ml), a solution of 1,2,3-trimethoxybenzene (1e; pyrogallol trimethyl ether; 8.4 g, 50 mmol) and tetra-n-butylammonium iodide (0.1 g, 0.28 mmol) in benzene (25 ml) is added dropwise. After refluxing for 0.5 h, the mixture is hydrolysed with water (150 ml). The benzene phase is separated and washed with water (2 \times 20 ml). The water phases are collected and extracted with ethyl acetate (6 \times 25 ml). The ethyl acetate extracts are dried with sodium sulphate, and the solvent is evaporated to give pure, crystalline pyrogallol (2e); yield: 95% m.p. 131–133 °C (Ref.³, m.p. 132–133 °C).

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¹ Bhatt, M.V., Kulkarni, S.U. Synthesis 1983, 253.

² Cabiddu, S., Gelli, G., Maccioni, A., Secci, M. Ann. Chim. (Rome) 1972, 62, 505.

³ The Merck Index, 9th Edn., Merck & Co. Inc., Rahway, N.J., U.S.A. 1976.