A Mild and Convenient Procedure for Conversion of Aromatic Compounds into Their Iodides Using Ammonium Hexanitratocerate(IV)

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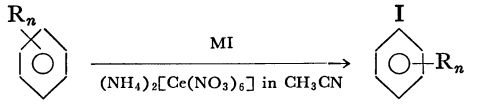
Synopsis. Polymethylbenzenes, polymethoxybenzenes, and naphthalene are iodinated with tetrabutylammonium iodide, alkali metal iodides, or molecular iodine in the presence of ammonium hexanitratocerate(IV). Ammonium hexanitratocerate(IV) behaves as a catalyst in the latter system, whereas it is a reagent in the fomer two.

Although there are some reports on direct iodination of aromatic compounds, it presents rather complicated problems; molecular iodine is the least reactive of the halogens in aromatic substitution; the reaction is reversible and hydrogen iodide produced in the reaction must be removed to allow the reaction to be completed.[1]

During the course of a study on one-electron-transfer reaction, the author found a novel and regioselective iodination of aromatic compounds using ammonium hexanitratocerate(IV) (CAN), a potential one electron oxidizing agent.

The results from iodination of some polymethylbenzenes are summarized in Table 1.



$R=CH_3$ (n=2, 3, 4, 6) or OCH_3 (n=1, 2, 3)
$M=n\text{-}Bu_4N$, Li, Na, K, I

There are two remarkable feautures in the present iodination. First, the reaction takes place only on the aromatic ring. It is noteworthy that, even hexamethylbenzene affords iodopentamethylbenzene as the sole iodinated product. This is a marked contrast with the oxidation of polymethylbenzenes promoted by CAN in acetic acid where the reaction on side-chains are predominated.[2] Secondary, the iodination proceeds with ortho-para orientation with respect to methyl substituents. In particular, the result from *o*-xylene shows that para substitution occurs in preference to ortho substitution (the ortho:para-ratio being 1:6).

The present reaction proceeds under mild conditions. The yield, however, decreases as the number of methyl groups increases probably because of some side reactions.

Alkali metal iodides and molecular iodine as well as tetrabutylammonium iodide can be used as iodinating agents (Table 2).

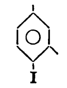
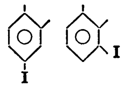
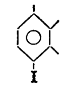
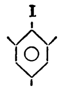
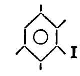
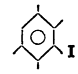
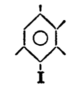
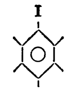
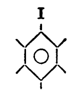
In the case of iodination with molecular iodine, 0.5 mmol of iodine for 1.0 mmol of substrate is enough to complete the reaction in 80% yield based on aromatics. In general, one-half part of the molecule is discarded when molecular iodine is used as an iodinating agent. However, this economical disadvantage is overcome in the present reaction.

The substrate can be extended to polymethoxybenzenes and fused-ring aromatic as shown in Table 3. Evidentry, as the number of methoxyl groups attached on benzene ring increases, the reactant is consumed more rapidly. However, the yield of iodinated compounds are not parallel with the number of methoxyl groups.

Attempts to iodinate aromatic compounds bearing an electron-withdrawing substituent such as nitro- and chlorobenzenes, were unsuccessful, and these unchanged reactants were recovered from the reaction mixture. On the other hand, phenols and anilines were not iodinated, although they were consumed completely.

Among several possible reaction mechanisms, the author favors the one which involves the reaction of aromatic compound with a cationic halogen species, which is produced by the interaction between the halogen source and CAN. The argument is based on the facts that; (1) the only aromatics bearing electron donating substituents react with halogen species, (2) the iodination shows an ortho-para orientation, and (3) the reaction occurs only on an aromatic ring.

Table 1. Iodination of polymethylbenzenes with $n\text{-}Bu_4NI$

Substrate	Product	Conversion/%	Yield/%[a]
m-Xylene		100	71 (75)
o-Xylene		95	69 (75)
1,2,3-Trimethylbenzene[b]		86	74 (77)
Mesitylene		100	70 (83)
1,2,4,5-Tetramethylbenzene		98	—(21)
1,2,4,5-Tetramethylbenzene[c]		92	56 (60)
1,2,3,5-Tetramethylbenzene[b]		100	54 (60)
Hexamethylbenzene[b]		100	—(16)
Hexamethylbenzene[c]		95	—(17)

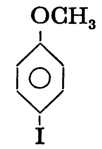
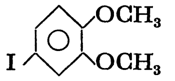
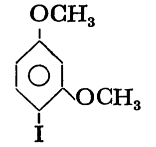
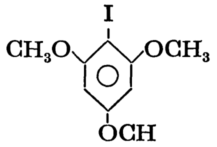
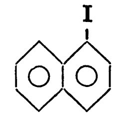
a) Isolated yield based on the substrates used. Numerical values in parentheses are the yields determined by GLC. b) Time: 48 h. c) At room temperature for 10 d.

Table 2. Iodination of polymethylbenzenes with alkali metal iodide or molecular iodine

Substrate	Iodinating agent[a)]	Time h	Conversion %	Yield[b)] %
Mesitylene	LiI	24	100	65 (77)
Mesitylene	NaI	24	18	15 (18)
Mesitylene	KI	24	96	48 (57)
m-Xylene	I_2	24	100	68 (80)
Mesitylene	I_2	24	100	86 (90)
1,2,3-Trimethylbenzene	I_2	24	85	58 (64)
1,2,4,5-Tetramethylbenzene	I_2	168	100	33 (35)
1,2,3,5-Tetramethylbenzene	I_2	48	100	58 (67)
Hexamethylbenzene	I_2	168	100	— (16)

a) MI: 8.0 mmol, CAN: 8.0 mmol, or I_2: 2.0 mmol, CAN: 2.0 mmol. b) Isolated yield based on the substrates used. Numerical values in parentheses are the yields determined by GLC.

Table 3. Iodination of methoxybenzenes and naphthalene with *n*-Bu_4NI

Substrate		*n*-Bu_4NI	CAN	Temp	Time	Product	Conversion	Yield[a)]
Compound	mmol	mmol	mmol	°C	h		%	%
Methoxybenzene	4.2	14.4	14.4	60	48		100	84 (87)
o-Dimethoxybenzene	4.0	12.0	12.0	60	48		93	72 (77)
m-Dimethoxybenzene	3.3	4.0	4.0	r. t.	24		85	78 (80)
1,3,5-Trimethoxybenzene	3.8	7.6	7.6	r. t.	1		100	87 (90)
Naphthalene	0.5	1.0	1.0	60	48		91	— (45)

a) Isolated yield based on the substrates used. Numerical values in parentheses are the yields determined by GLC.

Experimental

General Procedure. Into a solution of 4.0 mmol of an aromatic compound and 4.0 mmol of tetrabutylammonium iodide in 40 ml of acetonitrile was added a solution of 8.0 mmol of CAN (dried at 90—100 °C for 2 h) in 40 ml of acetonitrile. The mixture was stirred for 24 h at 60 °C, poured into 80 ml of water, and extracted with benzene (4×30 ml). The combined benzene layers were treated with sodium thiosulfate, washed with water, dried over $CaCl_2$, and the benzene was removed, carefully, under reduced pressure. The residue was purified by distillation, column chromatography (Woelm Akt I: hexane–benzene), and/or preparative gas chromatography (10% silicon OV-17). The isolated product was weighed and identified by comparing their IR, MS, and ^1H-NMR spectra with those of corresponding authentic samples. Elemental analyses also gave satisfactory results. The yield was, also, determined by analytical gas chromatography.

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References

1) P. B. D. De La Mare and J. H. Ridd, "Aromatic Substitution Nitration and Halogenation," Butterworths Scientific Publications (1959), p. 110.

2) E. Baciocchi, L. Mandolini, and C. Rol, *Tetrahedron Lett.*, **1976**, 3346; E. Baciocchi, C. Rol, and L. Mandoliin, *J. Org. Chem.*, **42**, 3682 (1977).