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IMIDOMETHYLATION OF NITROBENZENE BY FRIEDEL-CRAFTS REACTION

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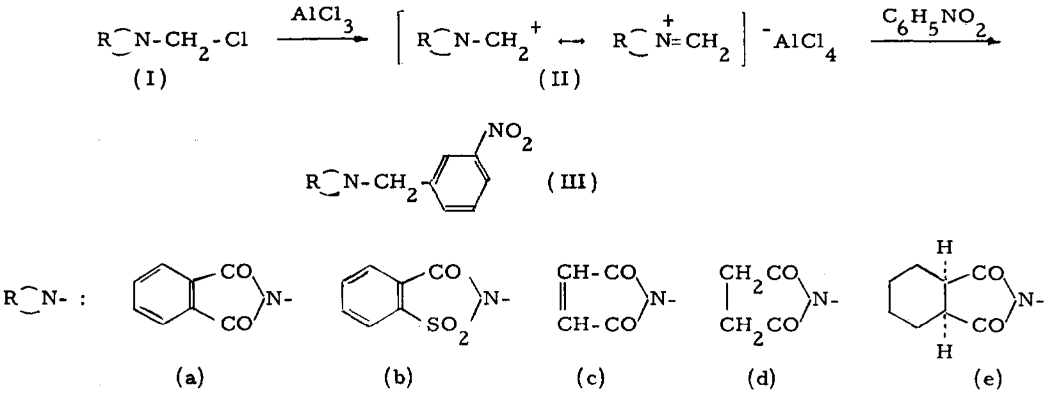
Nitrobenzene has been employed widely as a solvent for the Friedel-Crafts reaction because of its good dissolving power and large complex forming ability with the catalyst. It is known that nitrobenzene cannot be alkylated by means of the ordinary Friedel-Crafts procedure owing to the powerful electron-withdrawing effect of the nitro group.(1) However, a few exceptions have been found. For example, nitrobenzene gives m-nitrobenzyl chloride and/or m,m'-dinitrodiphenylmethane in low yields in the reaction with chloromethyl ether(2) or paraformaldehyde(3) in the presence of mineral acid. Reaction of benzamidomethanesulphonic acid,(4) N-ethoxymethyl- or N-hydroxymethylphthalimide(4, 5) gives amidomethylated nitrobenzene in a poor yield. While active nitrobenzene derivatives such as nitroanisole or nitrotoluene are more readily imidomethylated with N-chloromethylphthalimide(6) or -maleinimide(7) in the presence of zinc chloride, the imidomethylation of nitrobenzene itself has not been found in literatures.

Friedel-Crafts reactions of nitrobenzene with some N-chloromethylimides (I) were carried out in the presence of aluminium chloride and it was observed to give N-(m-nitrobenzyl)-imides (III) in fair yields.

N-Chloromethylimides were treated with aluminium chloride in excess of nitrobenzene (serving both substrate and solvent) at 120-140° and the reaction products were purified by column chromatography. In order to determine the position of the introduced group, each imide was hydrolyzed to nitrobenzylamine followed by oxidation to carboxylic acid and m-nitrobenzoic acid was obtained. Thus the imidomethylated products were proved to be N-(m-nitrobenzyl)imides accompanied by a small amount of by-product. These results are listed in Table I. The polarized complex (II) resulted from N-chloromethylimide and aluminium chloride attacked the meta-position of nitrobenzene analogously to other electrophilic substitution such as nitration and halogenation.

In the reaction of N-chloromethylmaleinimide (Ic), N-(m-nitrobenzyl)malimide (IV) was obtained in a small yield besides N-(m-nitrobenzyl)maleinimide (IIIc). Acid-catalyzed hydration of the double bond may occur in some case.

m,m'-Dinitrodiphenylmethane (V) was obtained in the reaction of N-chloromethylsaccharin (Ib). Other imidomethylations gave no such product (V). It may be considered that the formation of V proceeded via the further alkylation of nitrobenzene with IIIb because of



the more electron-withdrawing effect of saccharino group than the other imido groups.$^{(8)}$ This consideration was confirmed by the experiment that V was obtained in 3.7% yield in a reaction of IIIb with nitrobenzene under similar condition. The analogous benzylation was found in a reaction of Ib with excess of benzene when diphenylmethane (79%) and saccharin (100%) were obtained, while N-benzylsaccharin was obtained in 86% yield when nitrobenzene was used as a solvent.

The success of imidomethylation of nitrobenzene shows that the structure of alkylating reagents plays an important rôle in the Friedel-Crafts reaction with nitrobenzene. Nitrobenzene is so strongly deactivated in the electrophilic substitution that it is not attacked in such low temperature as the reaction of an ordinary alkyl halide. In an ordinary Friedel-Crafts alkylation, it is considered that a complex of alkyl halide and aluminium chloride may decompose at elevated temperature before it obtains sufficient activation energy for the reaction to nitrobenzene. While, the complex (II) formed in imidomethylation is so stable in such a drastic condition owing to the carbonium-immonium mesomerie that the attack to nitrobenzene occurs.

In the case of Id and Ie, yields of imidomethylated products were rather worse than the others. This may be explained by the conjugation system in complex (II) which have some influences on its stability.

The reaction of nitrobenzene with N-α-chloroethylphthalimide did not give N-(α-m-nitrophenylethyl)phthalimide, but the decomposition product phthalimide.

Starting materials, N-chloromethylimides, were prepared from thionyl chloride and N-hydroxymethylimides obtained by the reaction of the corresponding imides with formaldehyde. This chlorination was easier and gave better yields than the reported methods in which concentrated hydrochloric acid, phosphorous tri- or pentachloride was used.

Table I. Friedel-Crafts Imidomethylation of Nitrobenzene

Starting material	Reaction condition[a]		Yield and melting point of the product	
N-Chloromethyl-imide (mp, °C)	Temp. (°C)	Time (hr)	N-(*m*-Nitrobenzyl)imide (mp, °C)	By-product (mp, °C)
Ia	135	12	IIIa, 69.7% (165-166°)[9]	
Ib	135	6	IIIb, 56.8% (177-179°)[b]	V, 4.1% (175-176°)[3]
Ic	120	5	IIIc, 70.3% (127-128°)[b]	
Id	130	20	IIId, 26.2% (115-116°)[b]	IV, 16.3% (145-146°)[b]
Ie (87-88°)[b]	135	17	IIIe, 50.5% (85.5-86°)[b]	

a) These conditions gave maximum yields of III.

b) These new compounds gave correct elementary analyses and consistent IR spectra.

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