

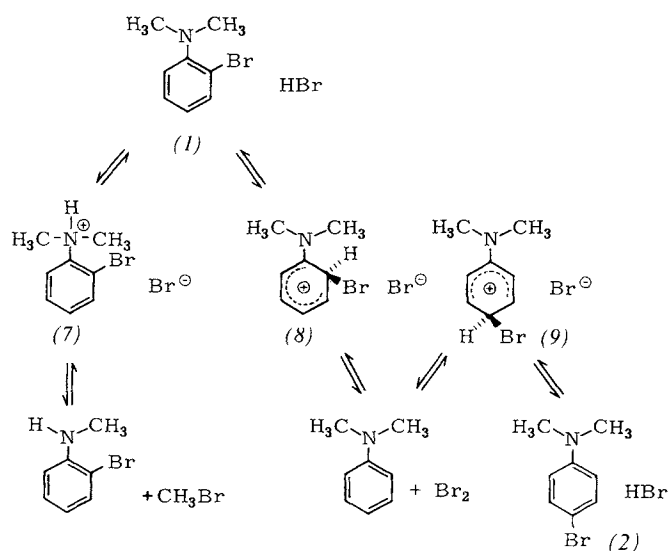
Reversibility of the Bromination of *N*-Alkylanilines^[1]

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Except for alkylation, sulfonation, and iodination, electrophilic substitution of aromatic compounds is held to be irreversible^[2]. However, isomerization, disproportionation, and dehalogenation have also been observed when brominated aromatic compounds are heated in the presence of Lewis acids^[3].

Stabilization of the intermediate σ -complexes which may be influenced by steric and electronic factors is essential for ease of the reverse reaction in electrophilic substitutions^[3,4]. Since NR_2 substituents stabilize cationic intermediates particularly effectively^[5], isomerization and dehalogenation are most likely to be observed with *N,N*-dialkylhaloanilines.

Upon heating 0.1 M solutions of the hydrobromides (1) to (6) in CHCl_3 at 120°C in a sealed vessel for 3 hours, the aniline mixtures listed in Table 1 are obtained; even under these rather mild conditions we find large amounts of



isomerization, dehalogenation, and dealkylation products. Though much slower, these reactions take place already at 80°C; at 60°C, 160 hours' heating is necessary to effect significant changes.

Isomerization and disproportionation of *p*-bromophenols at room temperature have recently been reported^[6]. In

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view of our results, however, this does not seem to be a true reversal of aromatic substitution by way of σ -complexes; an alternative route *via* tautomeric quinonoid intermediates is rather more likely. The efficiency of substituents in stabilizing a positive charge in the transition state is given

Our results show the electronic influence of the NR_2 group to be decisive for isomerization and dealkylation. Due to steric hindrance of mesomerism, *ortho*-substituents favor *N*-protonation and thus dealkylation, as shown by the reactions of (4) and (6).

Table 1. Mixtures of anilines obtained by heating the anilinium bromides (1) to (6).

Hydrobromide of	<i>N,N</i> -dimethylaniline		Products (mol-%) [a]		
			<i>N</i> -methylaniline		<i>-aniline</i>
2-Bromo- <i>N,N</i> -dimethylaniline (1)	2-Br	8.2 (4.2) [b]	2-Br	22.9 (16.5) [b]	
	4-Br	35.0 (14)	4-Br	5.8 (8.5)	
	2-H	16.3 (18)	2-H	3.7 (13.0)	
			2,4-Br ₂	8.1 (19.5)	
4-Bromo- <i>N,N</i> -dimethylaniline (2)	4-Br	75.0	4-Br	4.8	
	4-H	13.4			
	2,4-Br ₂	2.3	2,4-Br ₂	4.5	
2,4-Dibromo- <i>N,N</i> -dimethylaniline (3)	2,4-Br ₂	35.4	2,4-Br ₂	50.3	
	4-Br	14.3			
2,6-Dibromo- <i>N,N</i> -dimethylaniline (4)	2,6-Br ₂	30.0	2,6-Br ₂	54.3	2,6-Br ₂
			2-Br	5.6	10.1
2,4-Dibromo- <i>N</i> -ethyl- <i>N</i> -methylaniline (5)			2,4-Br ₂	6.6	2,4-Br ₂ - <i>N</i> -Et- <i>N</i> -Me
					33
					4-Br- <i>N</i> -Et- <i>N</i> -Me
					20
				2,4-Br ₂ - <i>N</i> -Et	
				30	
				aniline	
				8	
2,6, <i>N,N</i> -Tetramethylaniline (6)	2,6-Me ₂	75.6	2,6-Me ₂	24.4	

[a] The bases were liberated by passing in NH_3 ; the product composition was determined by gas chromatography, the individual compounds being identified by comparison of the retention times with those of pure substances. *W. Blum* has confirmed the assignments by a GC-MS combination Finnigan system DA-150.

[b] Product compositions in parentheses are those obtained after heating for 160 hours at 120°C.

by the σ_p^+ values which are -0.92 for OH and -1.70 for $\text{N}(\text{CH}_3)_2$ ^[7]. Thus, reversibility of electrophilic bromination of phenols should be achieved only under appreciably more vigorous conditions than those required for *N,N*-dialkylanilines.

We assume the anilines obtained to be formed *via* cationic intermediates (7)–(9), as formulated for reaction of (1) in the above scheme. In an $\text{S}_{\text{N}}2$ reaction cation (7) is dealkylated by the Br^- . *C*-Protonation of (1) affording (8) is followed by dehalogenation to dimethylaniline which then gives the isomerization product (2) *via* (9). Incorporation of labeled $^*\text{Br}$ in the course of the reaction of *N,N*-dimethyl-*p*-bromoaniline· H^+Br^- is proof that (2) may be dehalogenated again by way of (9), and that free Br_2 must occur during the overall reaction. The large proportion of starting material recovered when (2) is heated must be ascribed to preferential rebromination of dimethylaniline at the *para*-position. Longer reaction times favor dealkylation, as shown by the product composition after 160 hours' heating of (1) at 120°C. These also are not equilibrium concentrations, though, since irreversible oxidations (discoloration) become more and more pronounced with longer reaction times.

Since CH_3 rather than C_2H_5 is lost preferentially from (5), the dealkylation is indicated to be of $\text{S}_{\text{N}}2$ type. If HBr is replaced by acids with less nucleophilic anions, the share of isomerization and dealkylation products decreases; *N,N*-dialkylbromoanilinium perchlorates remain practically unchanged under our experimental conditions.

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