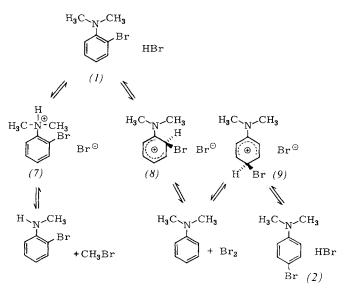
Reversibility of the Bromination of *N*-Alkylanilines^[1]

By Franz Effenberger and Peter Menzel^[*]

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 NR₂ 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 CHCl₃ 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 NR₂ 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 aniline	s obtained by heating	the anilinium bromides	(1) to	0 (6)	J.
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Hydrobromide of	-N,N-dimethylaniline		Products (mol-%) [a] -N-methylaniline		-aniline	
2-Bromo-N,N-dimethylaniline (1)	2-Br 4-Br 2-H	8.2 (4.2) [b] 35.0 (14) 16.3 (18)	2-Br 4-Br 2-H 2,4-Br ₂	22.9 (16.5) [b] 5.8 (8.5) 3.7 (13.0) 8.1 (19.5)	<u>.</u>	
4-Bromo-N,N-dimethylaniline (2)	4-Br 4-H 2,4-Br ₂	75.0 13.4 2.3	4-Br 2,4-Br ₂	4.8 4.5		
2,4-Dibromo-N,N-dimethylaniline (3)	2,4-Br ₂ 4-Br	35.4 14.3	2,4-Br ₂	50.3		
2,6-Dibromo-N,N-dimethylaniline (4)	2,6-Br ₂	30.0	2,6-Br ₂ 2-Br	54.3 5.6	2,6-Br ₂	10.1
2,4-Dibromo-N-ethyl-N-methylaniline (5)			2,4-Br ₂	6.6	2,4-Br ₂ -N-Et-N-Me 4-Br-N-Et-N-Me 2,4-Br ₂ -N-Et aniline	33 20 30 8
2,6,N,N-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 N(CH₃)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 $S_N 2$ reaction cation (7) is dealkylated by the Br^{\ominus} C-Protonation of (1) affording (8) is followed by dehalogenation to dimethylaniline which then gives the isomerization product (2) via (9). Incorporation of labeled *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 Br₂ 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 S_N2 type. If HBr is replaced by acids with less nucleophilic anions, the share of isomerization and dealkylation products decreases; N_sN -dialkylbromoanilinium perchlorates remain practically unchanged under our experimental conditions.

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