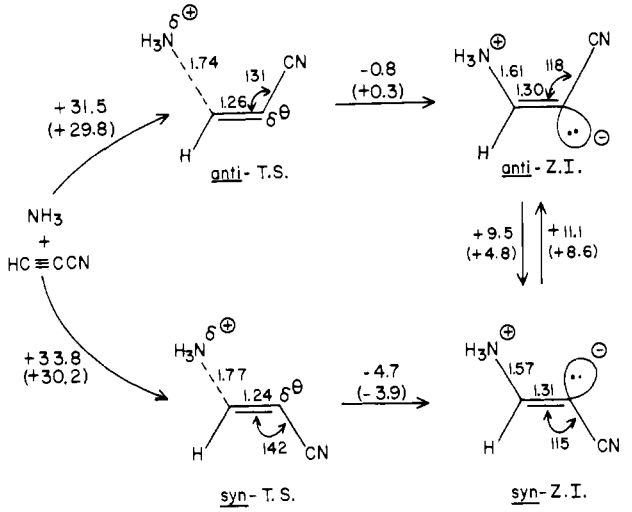

Figure 2. Geometrical parameters and relative energies (kcal/mol) of reactants, transitions states, and intermediates by STO-3G (4-31G).

tonation is slow compared to inversion, which will have a barrier of approximately 4 kcal/mol in solution, then the "syn" zwitterion will be formed. Subsequent protonation involving the intervention of solvent molecules will give the syn product preferentially. This corresponds to one of the mechanisms proposed earlier by Huisgen.[5]

This reaction contrasts to the water–formaldehyde reaction, where no stable zwitterion is found to be stable computationally.[1] We attribute this difference to the greater nucleophilicity and lower acidity of ammonia as compared to water and to the relatively high stability of the cyanovinyl anion. In the absence of the cyano group, ammonia adds to acetylene by the same mechanism as found for water plus formaldehyde.[16]

Acknowledgment. We are grateful to the National Science Foundation for financial support of this work and to the Louisiana State University, University of Pittsburgh, and Institute for Molecular Science (Okazaki, Japan) Computer Centers for computer time. We thank Professor Huisgen for inspiration, and apologize for the belated birthday wish.

Stabilization of the Monoanion of 1,8-Diaminonaphthalene by Intramolecular Hydrogen Bonding. A Novel Case of Amide Ion Homoconjugation in a Superbase Solution

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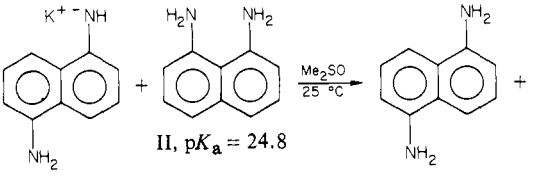
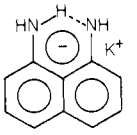
One of the most important means for stabilizing ammonium and oxonium cations in solution is through hydrogen bonding to basic nitrogen or oxygen sites in the solvent.[1] Likewise, oxyanions in hydroxylic solvents are strongly hydrogen bonded.[2,3] However, there is no evidence, of which we are aware, for significant stabilization by this means of nitroanions, such as amide ions. Thus, although alkoxy and phenoxy ions are strongly homoconjugated in Me_2SO by their conjugate acids (e.g., ROH—$^-$OR), there is no evidence for a similar stabilizing factor in the deprotonation of aniline bases.[4]



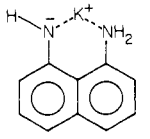


In the hope of discovering homoconjugate nitroanion stabilization, we chose to compare the deprotonation of 1,8-diaminonaphthalene (II) with its 1,5 isomer (I).

In the strongly basic medium K^+DMSYL^-/Me_2SO, I is less acidic than its peri isomer, 1,8-diaminonaphthalene (II), by *4.4* pK_a units. The thermodynamics of the exchange reaction are presented in Table I, providing dramatic evidence of a special proximity effect.

Although the unusual acidity of II might be considered at first sight to be obviously predictable in view of the high basicity of Proton Sponge [1,8-bis(dimethylamino)naphthalene], the driving forces for proton transfer in the two systems are quite different. As R. W. Alder et al.[5] have shown, Proton Sponge is a strong base primarily because of lone-pair repulsion in the neutral molecule which is relieved by protonation. Also, steric inhibition of resonance in neutral Proton Sponge prevents delocalization of the lone-pair electrons into the aromatic system. In fact, II is only 0.5 pK_a units more basic than I in aqueous media whereas Proton Sponge is more basic by 7.7 pK_a units.

We can visualize readily two reasonable explanations for the striking acidity difference between the isomers I and II: (a) the 1,8 nitroanion is stabilized by an internal hydrogen bond from the adjacent amino group, as shown in the above equation; (b) the 1,8 nitroanion from II forms a chelated ion pair (III) that is more stable than its 1,5 isomer which cannot chelate.



III

Evidence against the ion-pairing possibility is provided by titrations[6] with and without Kryptofix which indicate no measurable interaction of K^+ with anion II. Also the order of the gas-phase acidities,[7] which were determined in the complete absence of cations, rules out this possibility (Table I).

One might also suggest that neutral diamine II is relatively destabilized by lone-pair repulsions between the amine nitrogens as in the case of Proton Sponge but that seems unlikely to begin with since it would require that there should be less electron repulsion in the anion of II than in its initial neutral state. Certainly, sterically enforced electron repulsion in neutral Proton

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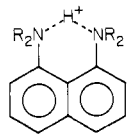
Table I. Thermodynamics of Deprotonation of Aromatic Amines in Two Alkali Superbase Systems and the Gas Phase at 25 °C

		K^+DMSYL^-/Me_2SO				KAPA	gas phase	
compd	pK_a[a]	$\Delta G°$ [a,e]	ΔH_D[b,e]	$\Delta H°_i$[b,e]	$\Delta S°_i$[f]	ΔH_D[c,e]	$\Delta G°_{acid}$[d,e]	$\delta\Delta G°_{acid}$[e]
II	24.8	+33.8	−12.3 ± 0.8	35.7 ± 1.1	6.3 ± 3.7	−28.7 ± 0.5	346.6 ± 2	−13.2 ± 0.5
isopropyl mercaptan			−28.5 ± 0.3	19.5 ± 0.9			349.3 ± 2	−10.5 ± 0.5
m-chloroaniline	28.5	+38.9	−11.0 ± 0.5	37.0 ± 0.9	−6.3 ± 2.7		353.8 ± 2	6.0 ± 0.5
I	29.2	+39.8	−8.5 ± 0.4	39.5 ± 0.9	−1.1 ± 3.0	−28.7 ± 0.5	351.9 ± 2	−7.9 ± 0.5
aniline	30.7	+42.0	−7.1 ± 0.2	40.9 ± 0.8	−3.7 ±	−14.5 ± 0.8	359.8 ± 2	0

[a] pK_a's for aniline and *m*-chloroaniline are from ref 1b. [b] Arnett, E. M.; Small, L. E. *J. Am. Chem. Soc.* 1977, *99*, 808. $\Delta H°_i$ and ΔH_D are defined in this reference. [c] For earlier work on ΔH_D's in KAPA see ref 7. [d] $\Delta G°_{acid}$ for isopropylmercaptan and *m*-chloroaniline are from ref 2. $\Delta G°_{acid}$ is the standard Gibbs free energy change for the reaction $AH = A^- + H^+$ at 298 K. [e] Values in kcal/mol. [f] Values in gibbs/mol. $\Delta S_i = [(\Delta H_i - 1.364)/298.15] \times 10^3$

Sponge is a reasonable driving force for its enhanced basicity since neither unmethylated II nor the mono-, di-, or trimethylated homologues are nearly as basic although they should all be capable of forming a peri hydrogen bonded ammonium ion (IV). However, if relief of electron repulsion is a driving force for protonation, it is hard to see how it can also promote deprotonation.



IV

As noted before,[8] a fairly close parallel is found between enthalpies and free energies of ionization for many weak acids in $DMSYL^-/Me_2SO$ and the compounds in Table I fall close to the $\Delta G°_i/\Delta H°_i$ correlation line. The entropy differences between I, II, and aniline are probably statistically significant but do not merit interpretation in such a complex system.

A second point of interest concerning the interplay of deprotonation and homoconjugation is shown in the pattern of acidities for I, II, and aniline in the superbase KAPA[9] which is strikingly different from that in K^+DMSYL^-. Since KAPA is the stronger base by 10^5–10^6 times,[10] we propose that both I and II lose two protons in KAPA in contrast to aniline which loses but one. Since the dianion of II should not be able to enjoy stabilization from an internal hydrogen bond, there is no reason why the difference between the ΔH_D of I and II seen in $DMSYL^-/Me_2SO$ should be repeated in KAPA.

Intramolecular hydrogen-bonding stabilization of oxyanions by neighboring hydroxyl or carboxylate groups has been well demonstrated in dipolar aprotic media,[11] and we have found a difference of 4 pK_a units between catechol and hydroquinone in Me_2SO. A rather delicate trade-off between the acid–base and hydrogen bond donor and acceptor properties of the intramolecular functions vs. those of the external medium may be required as shown by our results in Me_2SO and KAPA and those of Kolthoff and Chantooni.[11a–c]

The gas-phase acidities were obtained by using pulsed ion cyclotron resonance to produce monodeprotonation in every case as shown by monitoring of the M − 1 peak from the parent. The method of stair-step comparisons[7] was required to cover the large differences between aniline, I, and II. Clearly, the acidity differences seen in Me_2SO are increased greatly in the gas phase. We attribute the greater gas-phase acidity difference between I and aniline to the larger polarizable π system of the former which should be more effective for anion stabilization in the gas phase than in solution where polarization of the medium can attenuate charge dispersal.

The difference between ΔH_D for I and II is nearly the same in Me_2SO as in the gas phase which is consistent with the above argument since I and II have π systems of nearly equal size. The enormous difference between the gas-phase and liquid-phase values for deprotonation of the mercaptan relative to the aromatic system is again to be expected on the basis of polarizability.

Acknowledgment. We are grateful for the support of this work by NSF Grants CHE-80-06202 to E.M.A., CHE-80-24269 to R.T.M., and CHE-80-07844 to F.G.B.

Registry No. I, 2243-62-1; II, 479-27-6; isopropylmercaptan, 75-33-2; *m*-chloroaniline, 108-42-9; aniline, 62-53-3; K^+DMSYL, 15590-26-8; KAPA, 54856-92-7.

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Chemical Excision of Apurinic Acids from RNA. A Structurally Modified Yeast $tRNA^{Phe}$

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Apurinic (apyrimidinic) acids are of considerable importance in the chemistry and biochemistry of nucleic acids. Such species can be formed chemically from DNA and RNA at high temperature and extreme pH[1] and by the action of mutagens;[2] their potential role in cell lethality[3] and mutagenesis[2] is suggested strongly by the existence of endonucleases that mediate incision (and permit subsequent repair) at such lesions.[4] Apurinic acids are also key intermediates in nucleic acid sequencing,[5] can be formed selectively from certain modified nucleosides in RNA's,[6]

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