

Nitrenoids LiRN-OR¹ in Electrophilic Amination Reactions of Organolithium Compounds. A Theoretical Study

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The lithium alkoxyamides LiRN-OR¹ (**2**), in contrast to the alkoxyamines HRN-OR¹ (**1**), react with the organolithium compounds R²-Li to provide the amines HRN-R² (on hydrolysis); M.O. calculations indicate that the facile substitution of R¹O⁻ in (**2**) is due to (i) the formation of a LiRN-OR¹·LiR² dimer, (ii) a long N-O bond in (**2**), and (iii) the high stability of LiNH⁺.

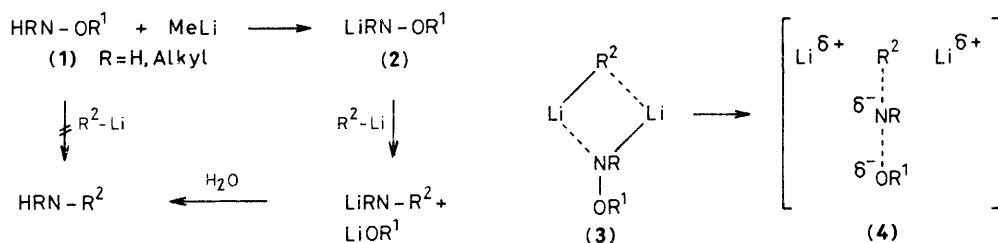
Beak *et al.* have recently established¹ that the alkoxyamine derivatives (**1**) bearing at least one proton on nitrogen are activated by methyl-lithium to give the lithium alkoxyamides (**2**) which react with the organolithium reagents R²-Li to provide amines (on hydrolysis) (Scheme 1).²

Although it was concluded^{1a} that this electrophilic amination reaction³ 'involves reaction of two anionic species, an interaction that should be repulsive,' a transition state (**4**) was suggested. It was proposed that the latter was reached from the dimer (**3**).

In order to investigate why the nitrenoids LiRN-OR¹ (**2**) are more electrophilic than the corresponding non-lithiated alkoxyamines HRN-OR¹ (**1**) we carried out some model

calculations. The results are summarized in Figure 1 and Table 1.

Figure 1 reveals that besides the bridged structure of (**6**) the main difference between the hydroxylamine (**5**) and *N*-lithiohydroxylamine (**6**) is the much longer N-O bond in (**6**). MNDO calculations indicate that the HOMO is raised (-11.242 → -6.967 eV) and the LUMO is lowered (+6.318 → +0.495 eV) on going from (**5**) to (non-bridged) (**6**). In accordance with a low-lying LUMO mainly at the lithium atom of (**6**), the MNDO structure (**7**) is calculated for the LiHN-OH·MeLi complex [corresponding to Beak's (**3**)]. Thus, the proximity of the nucleophilic carbon of R²-Li to the nitrogen atom of LiRN-OR¹ (**2**)^{1a} (as already suggested by



Scheme 1

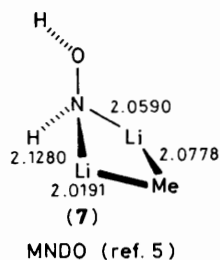
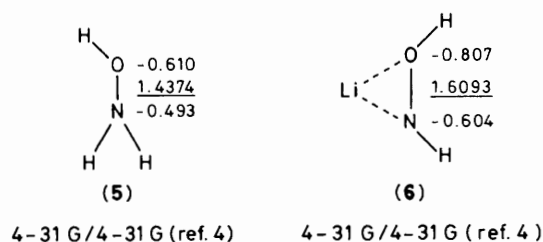


Figure 1. $4-31\text{ G}/4-31\text{ G}$ charges (Mulliken population) and bond distances (in Å, underlined) in (5) and (6), and the MNDO structure of $\text{LiHN-OH}\cdot\text{MeLi}$ (7).

Table 1.^a $\Delta\Delta E$ (kcal/mol)^a for the isodesmic reactions (a) $\text{NH}_2^+ + \text{LiNH}_2 \rightleftharpoons \text{NH}_3 + \text{LiNH}^+$, (b) $\text{NH}_2^+ + \text{LiNHOH} \rightleftharpoons \text{NH}_2\text{-OH} + \text{LiNH}^+$, and (c) $\text{CH}_3^+ + \text{LiCH}_3 \rightleftharpoons \text{CH}_4 + \text{LiCH}_2^+$

	MNDO/ MNDO ^b	$4-31\text{ G}/$ MNDO ^b	$4-31\text{ G}/$ $4-31\text{ G}^b$	$6-31\text{ G}^*/$ $4-31\text{ G}^b$
(a)	-74.1	-92.1	-95.1	-88.4
(b)	-72.9	-97.8	-79.7	-82.8
(c)	-63.2	-77.9	-77.6	-78.1

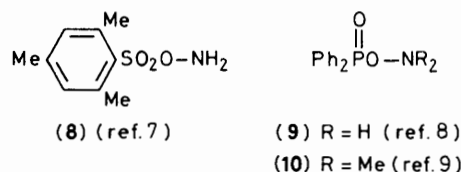
^a 1 kcal = 4.18 kJ. ^b Energy/geometry optimization.

Beak^{1a}) and the weakened N-O bond in the latter[†] favour a nucleophilic reaction at the N atom of the lithium alkoxyamides (2).

Table 1 reveals a point which may be even more important: LiNH^+ , either formed by removal of H^- (a) or OH^- (b), is strongly stabilized compared to NH_2^+ . All calculational methods indicate a higher stabilization of LiNH^+ than of the carbon analogue LiCH_2^+ (c). A rather favourable reaction of the nitrenoids LiRN-OR^1 (2), therefore, should involve separation into the ion pairs LiRN^+OR^- , which is in agreement with the high electrophilicity of (2).

The nitrenoids (2) thus have a similar amination potential to *O*-(mesitylsulphonyl)-, *O*-(diphenylphosphinoyl)-, and *O*-(diphenylphosphinoyl)-*N,N*-dimethyl-hydroxylamine [(8), (9), and (10), respectively]. Compounds (8), (9), and (10) possess excellent leaving groups. Only in the nitrenoids (2) does the alkoxide R^1O^- become an equally good leaving group.

It should be mentioned that the structural aspects and reactivity pattern of nitrenoids are very similar to those of



carbenoids. It has long been known that carbenoids undergo nucleophilic substitution reactions.¹⁰ *Ab initio* calculations on the model carbenoid CH_2FLi indicate $\text{CH}_2\text{Li}^+\text{F}^-$ ion pair character.¹¹ ¹³C and ⁶Li N.m.r. investigations on many types of carbenoids are in agreement with a high s-character for the C-Li bond; as a consequence the C-Hal bond has an increased p-character (strong polarization of this bond).¹²

We thank the Fonds der Chemischen Industrie and the Deutschen Forschungsgemeinschaft for financial support, and Professor W. Thiel, Gesamthochschule Wuppertal, for valuable discussions.

Received, 16th July 1984; Com. 1014

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[†] We have not yet been able to calculate the structure of (7) with $4-31\text{ G}/4-31\text{ G}$ owing to convergence problems in the SCF part. Since MNDO calculations tend to give short N-O bonds (ref. 5), we refer only to the results of the $4-31\text{ G}/4-31\text{ G}$ calculations as far as bond lengths are concerned.