

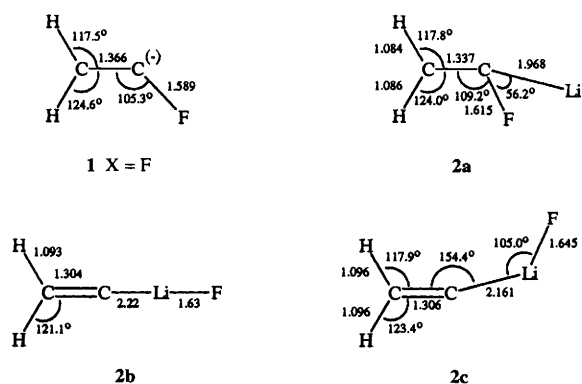
# Preparation and direct observation by $^{19}\text{F}$ NMR spectroscopy of 1-fluoro-1-lithioalkenes

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Two 2,2-diaryl substituted 1-fluoro-1-lithioalkenes (fluorine stabilised alkenyl carbanions) have been synthesised and their half lives estimated by  $^{19}\text{F}$  NMR spectroscopy.

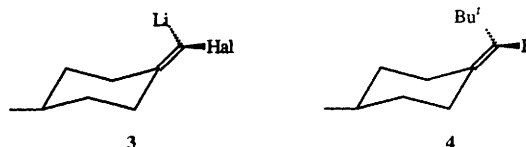
We have published *ab initio* gas phase calculations on the stability of carbanions  $\text{CH}_2=\bar{\text{C}}\text{-X}$  **1** ( $\text{X} = \text{Be}, \text{B}, \text{C}, \text{O}, \text{N}, \text{F}$ ),<sup>1</sup> which indicate that stabilisation peaks at  $\text{X} = \text{B}$  and the next highest stabilisation occurs when  $\text{X} = \text{F}$ . We have now carried out preliminary calculations at the MP2/3-21 + G level of the neutral molecule  $\text{CH}_2=\text{CHLiF}$  **2** and found a global minimum **2a** in good agreement with the global minimum found by 3-21G calculations.<sup>2</sup> For **2a**,  $E = -183.053\ 142$  au‡ (singlet). This may be compared with **1** ( $\text{X} = \text{F}$ ) also calculated at the same level. The geometries of **1** ( $\text{X} = \text{F}$ ) and **2a** are very similar and **2a** can be regarded as **1** ( $\text{X} = \text{F}$ ) weakly complexed to a lithium



cation. This point is emphasised by energy calculations. Thus, for **2a**,  $E = -183.053\ 142$  au (singlet). For **1** ( $\text{X} = \text{F}$ ),  $E = -175.659\ 006$  au and for  $\text{Li}^+$ ,  $E = -7.187\ 535$  au. Thus,  $E [\text{1} (\text{X} = \text{F}) + \text{Li}^+] = -182.846\ 543$  au, which subtracted from  $E$  (**2a**) gives the lithium affinity in **2a** as  $-0.206\ 811$  au =  $-543.0$  kJ mol<sup>-1</sup>. For comparison the  $\text{H}^+$  affinity of  $\text{C}_2\text{H}_2\text{F}^-$  is  $-1703.7$  kJ mol<sup>-1</sup>, also at the MP2/3-21 + G level. The proton affinity is 3.198 times that of the lithium affinity.

In **2a** the lithium carries almost no charge and therefore **2a** should behave as a strongly nucleophilic carbenoid, in a fashion to be expected from the fully formed anion **1** ( $\text{X} = \text{F}$ ). The same calculations give a further minimum, **2b**, and also transition state, **2c**, with energies relative to **2a** of +25.9 and +36.3 kJ mol<sup>-1</sup>, respectively. Both **2b** and **2c** would be electrophilic, form **2c** being close to the species postulated<sup>3</sup> to occur in 'metal assisted ionisation' (MAI). Both forms could lead on to the Fritsch-Buttenberg-Wiechell (FBW), 1,2-rearrangement.<sup>4</sup> Some low temperature  $^{13}\text{C}$  NMR spectra of carbenoids derived from  $\text{sp}^3$  hybridised carbon atoms indicated that they could be electrophilic.<sup>5,6</sup>

Few 1-fluoro-1-lithioalkenes have been made,<sup>7,8</sup> and these have generally been polyfluorinated and thus expected to have extra stabilisation.<sup>2</sup> Elegant studies on racemic and optically active **3** have recently shown that in all cases the halogen is lost with extreme ease as compared with the corresponding  $\text{R}_2\text{C}=\text{CHHal}$  compound. This was attributed to MAI,<sup>3</sup> which was most marked when  $\text{Hal} = \text{F}$ , despite solvolyses of alkyl fluorides being some  $10^6$ – $10^7$  times slower than the corresponding alkyl chlorides. This implicates lithium in the departure of fluorine, the increase in rate of decomposition being due to the strong acceptor-donor character of lithium and fluorine, respectively. Compounds **3** can behave as electrophiles and, for example, react with *tert*-butyllithium to give **4** on protonation. The reaction goes mainly with inversion but there is some racemisation due either to the carbene and/or to a linear species such as **2b** or by halogen migration from one side of the double bond to the other, using lithium as a pivot.



Knowledge of the stability of 1-lithio-1-fluoroalkenes would be very useful as 1-fluoroalkenyl units are frequently used to incorporate fluorine into biologically active molecules,<sup>9</sup> but by indirect processes.<sup>10</sup> Direct incorporation would therefore be valuable. For this reason and because of the discrepancy between computational data, which predict carbanion stabilisation by a geminal fluorine atom, and real systems which are unstable even at  $-90$  to  $-110$  °C, we decided to study some simple 1-fluoro-1-lithioalkenes, using  $^{19}\text{F}$  NMR spectroscopy as our probe. Although  $^{19}\text{F}$  NMR spectroscopy has been used for the analysis of some stable polyfluoroalkyl carbanions<sup>11</sup> and also some low temperature  $^{13}\text{C}$  and  $^6\text{Li}$  NMR spectra of 1-halogeno-1-lithioalkanes have been published,<sup>5</sup> no attempts have been made to exploit the selectivity and sensitivity of  $^{19}\text{F}$  NMR spectroscopy to estimate the stability of *gem*-fluorolithioalkanes or alkenes.

We chose to study carbenoids **9–12**, prepared by lithium-bromine exchange<sup>12</sup> from **5–8**§ using butyllithium in tetrahydrofuran (THF) at low temperatures. The carbenoids **9–12** were chosen to illustrate the effect of dialkyl or diaryl substitution on the carbenoids and because, in the first instance,

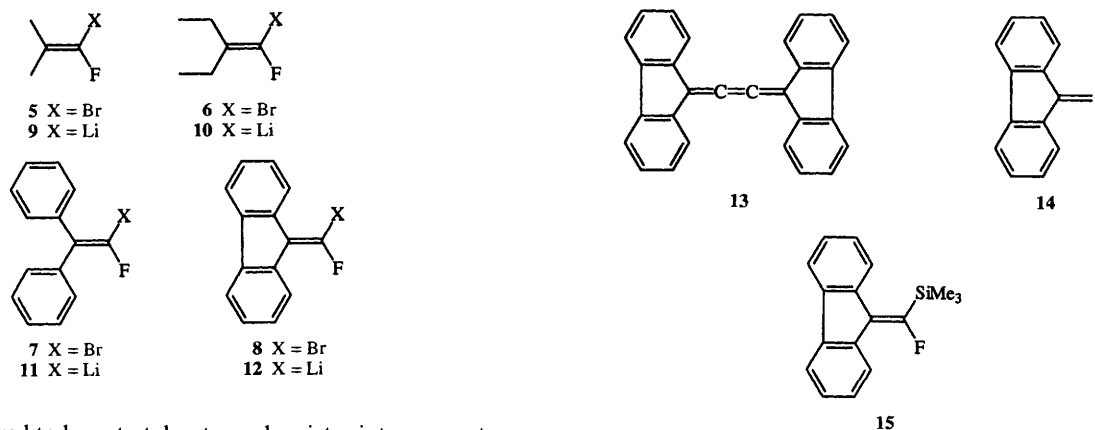
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‡ 1 au  $\approx 26\ 235 \times 10^{-2}$  J mol<sup>-1</sup>.

§ Details of the syntheses of **5–8** will be given in a full paper. The most successful and general route to such compounds is the condensation of  $(\text{EtO})_2\text{POCFLiCO}_2\text{Et}$  with aliphatic or aromatic ketones. Hydrolysis of the resulting unsaturation esters to the acids was followed by brominative decarboxylation (S. Eddarin, Ch. Franceschi, H. Mestadagh and C. Rolando, *Tetrahedron Lett.*, 1990, **31**, 4449).

**Table 1** Estimated half lives of **11** and **12**

<b>11</b>			<b>12</b>			<b>12 + TMEDA</b>		
<i>T</i> /°C	<i>t</i> <sub>1/2</sub> /h	δ <sub>F</sub> <sup>a</sup>	<i>T</i> /°C	<i>t</i> <sub>1/2</sub> /h	δ <sub>F</sub>	<i>T</i> /°C	<i>t</i> <sub>1/2</sub> /h	δ <sub>F</sub>
-96	8	-66.0	-40	∞	-40.6	-100	∞	-40.6, -38.9
-80	0.1	-66.0	-30	12	-40.6	-70	3	-40.6
			-20	0.8	-40.6	-40	0.015	-40.6

<sup>a</sup> CFCl<sub>3</sub> used as external standard. Spectra obtained in a mixture of THF and light petroleum in the ratio of 95 : 5.



it was not desired to have to take stereochemistry into account. In practise we could not identify major products from **9** and **10**. However we were able to generate **11** which, though quite stable at  $-90\text{ }^{\circ}\text{C}$  (Table 1) quickly decomposed at  $-80\text{ }^{\circ}\text{C}$ . Decomposition proceeded through the FBW rearrangement<sup>4</sup> in a fashion similar to known diphenyl-1-halogenocarbanions,<sup>12</sup> to yield diphenylethyne, the production of which was confirmed in a separate, preparative experiment.

In order to prevent sterically the FBW rearrangement whilst still generating a diarylcarbenoid we prepared the fluorene derived carbenoid **12**. This proved to be stable at  $-40\text{ }^{\circ}\text{C}$  (Table 1) and had a reasonable half life even at  $-20\text{ }^{\circ}\text{C}$ . The isolated product of decomposition of **12** was the cumulene **13**, presumably derived from the carbene **14**. To check that **12** had formed, it was treated with trimethylsilyl chloride (TMSCl) to give **15** in 65% isolated yield.

Interestingly, the addition of *N,N,N',N'*-tetramethylethylenediamine TMEDA, often used to stabilise carbanions, led to a decrease in the half life of **12** (Table 1). This is akin to the observation that CF<sub>2</sub>=CFLi is stable up to  $-30\text{ }^{\circ}\text{C}$  in pure diethyl ether but decomposes at  $-80\text{ }^{\circ}\text{C}$  in THF.<sup>8</sup> At  $-100\text{ }^{\circ}\text{C}$ , in the presence of TMEDA, **12** shows two signals (Table 1). These consist of the usual one at  $-40.6$  plus another at  $-38.9$  in the ratio of 6 : 4, respectively. At  $-70\text{ }^{\circ}\text{C}$ , the higher field signal totally disappears. Further NMR spectroscopic and theoretical studies are being carried out to try to probe further in the reactions and species described.

To our knowledge these observations are the first to use <sup>19</sup>F NMR spectroscopy for the observation of geminal lithium-fluorine compounds. Previously,<sup>8</sup> trapping experiments have been carried out and inferences made regarding the species leading to the isolated products. This indirect approach suffers from the assumptions made with regard to the trapping reactions used. The <sup>19</sup>F NMR spectroscopic method is direct, convenient and useful for the estimation of the temperature-stability relationship of fluorocarbenoids and we are applying it to a variety of systems that carry stereochemical information.

### Acknowledgements

We thank the Royal Society for support of this work.

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Paper 5/04821D

Received 21st July 1995

Accepted 5th September 1995