Effect of β-Substituents on the Configurational Stability of α-Fluorocyclopropyl Radicals

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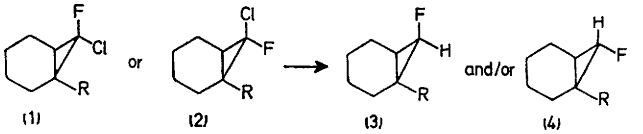
Summary The stereospecificity of the reduction of 1-methyl- (**1a**, **2a**), 1-methoxy- (**1b**, **2b**), and 1-unsubstituted-7-chloro-7-fluorobicyclo[4.1.0]heptane (**1c**, **2c**) with tri-n-butyltin hydride has been found to decrease in the order (**a**) > (**c**) > (**b**), suggesting that the configurational stability of the α-fluorocyclopropyl radical is affected by the nature of the β-substituents.

TABLE. Reduction of compounds (**1**) and (**2**)

Starting halide	Temp/°C	Catalyst	Time/h	Yield/%	Isomer ratio in product
(**1a**)	80	AIBN	10	70	(**3a**) : (**4a**) = 100:0
	140	DTBP	4	82	100:0
(**2a**)	80	AIBN	10		(**4a**) : (**3a**) = 100:0
	140	DTBP	4		100:0
(**1b**)	80	AIBN	4	74	(**3b**) : (**4b**) = 94:6
	140	DTBP	1·5	75	79:21
(**2b**)	80	AIBN	4		(**4b**) : (**3b**) = 88:12
	140	DTBP	1·5		32:68
(**1c**)	80	AIBN	8	66	(**3c**) : (**4c**) = 100:0
	140	DTBP	4	74	96:4
(**2c**)	80	AIBN	8	68	(**4c**) : (**3c**) = 98:2
	140	DTBP	4	81	89:11

RECENTLY, much work has been done on the configurational stability (or the energy barrier for inversion) of vinyl[1] and cyclopropyl[2] radicals, depending on the nature of the α-substituents. However, no studies have been made on the effects of β-substituents, except the theoretical study by Dewar *et al.*[3]

We now report the first experimental evidence of the effect of β-substituents on the configurational stability of the 7-fluorobicyclo[4.1.0]hept-7-yl radical, one of the most stable radicals known.



(1) (2) (3) (4)

a; R = Me, b; R = OMe, c; R = H

The reaction used was the reduction of 1-methyl- (**1a**, **2a**), 1-methoxy- (**1b**, **2b**), and 1-unsubstituted-7-chloro-7-fluorobicyclo[4.1.0]heptane (**1c**, **2c**) with tri-n-butyltin hydride.

The starting halides were prepared by the addition of chlorofluorocarbene, generated by the reaction of methyl dichlorofluoroacetate with sodium hydride and methanol at 30°C,[4] to the corresponding cyclohexene. [(**1a** + **2a**), 48% yield, b.p. 60·5—61·5 °C at 20 mmHg, $n_{\rm D}^{20}$ 1·4581, *endo*-F: *exo*-F = 25:75, $\delta_{\rm F}$ (external CF_3CO_2H) 70·0 ($J^{vic}_{\rm HF}$ 9·8 Hz) (isomer **1a**), 55·5 ($J^{vic}_{\rm HF}$19·4) (isomer **2a**); (**1b** + **2b**), 59% yield, b.p. 88·0—89·0 °C at 21 mmHg, $n_{\rm D}^{18}$ 1·4637, *endo*-F: *exo*-F = 43:57, $\delta_{\rm F}$ (external CF_3CO_2H) 72·1 ($J^{vic}_{\rm HF}$ 11·9 Hz) (isomer **1b**), 63·9 ($J^{vic}_{\rm HF}$ 24·7 Hz) (isomer **2b**); (**1c** + **2c**) 51% yield, b.p. 47·5—49·0 °C at 14 mmHg, $n_{\rm D}^{28}$ 1·4565, *endo*-F:*exo*-F = 34:66.] Preparative g.l.p.c. [1·5m × 10 mm column; 15% TCP at 80 °C for (**1a** + **2a**) and (**1c** + **2c**), and 10% Triton X-305 at 100 °C for (**1b** + **2b**)] was used to separate the isomers, (**1**) and (**2**) (more than 99% pure). Each isomer was reduced with tri-n-butyltin hydride by adding the latter (1·2 equiv.) to the halide in the presence of a small amount of azobisisobutyronitrile (AIBN) or di-t-butyl peroxide (DTBP) at a constant temperature. The isomeric composition of the products was determined by g.l.p.c. [3 m × 3 mm column; 7% TCP at 80 °C for (**3a**) and (**4a**), 7% TCP at 120°C for (**3b**) and (**4b**), and 7% Apiezon L at 50 °C for (**3c**) and (**4c**)]. The configurations of the isomers (**3**) and (**4**) were determined from their ^{1}H n.m.r. spectra; (**3a**) δ 4·01 (dd, CHF, *J* 7·6 and 67·6), (**4a**) 4·11 (dd, CHF, *J* 2·0 and 65·2), (**3b**) 4·36 (dd, CHF, *J* 8·0 and 65·0), (**4b**) 4·04 (dd, CHF, *J* 3·0 and 63·0), (**3c**) 4·39 (dt, CHF, *J* 6·2 and 68·0), (**4c**) 4·13 (dt, CHF, *J* 1·8 and 64·0 Hz).

The results and reaction conditions are summarized in the Table.

The stereospecificity of the reduction decreases in the order (**a**) > (**c**) > (**b**). This suggests that the 1-methyl and the 1-methoxy substituents, which are situated β to the radical centre, have the effect of stabilizing and destabilizing, respectively, the pyramidal structure of the 7-fluorobicyclo[4.1.0]hept-7-yl radical intermediate relative to its planar structure. It should be noted that, as pointed out by Dewar *et al.*,[3] this order is opposite to the one expected from the electronegativity effect of the substituents alone.

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