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SOLVOLYTIC REACTIVITY OF 1-(1-METHYL-2-PYRROLYL)-2,2,2-TRIFLUOROETHYL p-NITROBENZOATE

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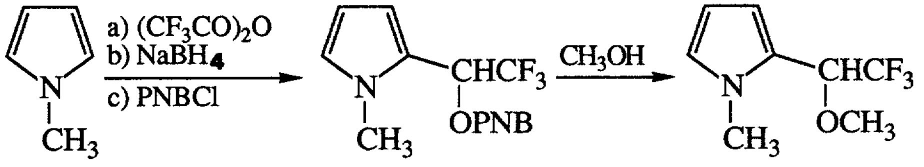
Abstract. 1-(1-Methyl-2-pyrrolyl)-2,2,2-trifluoroethyl p-nitrobenzoate (**1**) solvolyses to form a carbocation intermediate **4** as evidenced by the dependence on the solvent ionizing power $\mathbf{Y_{OTs}}$ and the formation of substitution products. The rate ratio $k(H)/k(CF_3)$ of only 40 indicates strong electron donation to the destabilized carbocation.

Pyrrole is known to be highly electron rich,[1] as evidenced by its high reactivity towards electrophilic aromatic substitution,[2] and also by the ease of side-chain carbocation formation alpha to a pyrrolyl group.[3]

By contrast the CF_3 group has been found to be strongly deactivating toward carbocation formation, and in many systems $k(H)/k(CF_3)$ rate ratios of 10^6 are observed.[4] The effect of a strong donor substituent on $k(H)/k(CF_3)$ rate ratios has also been examined. Thus for protonation of $CH_2{=}C(OCH_3)R$ to form the corresponding carbocation the ratio exceeds 10^6 despite the presence of the strongly stabilizing methoxy group adjacent to the carbocation center,[4d] whereas for solvolysis of 4-$XC_6H_4CH(OTs)R$ the ratio decreases from 4×10^5 for X=H to 4×10^3 for $X{=}CH_3O$.[4f]

In order to further examine this phenomenon in which the magnitude of the rate-decellerating effect due to the destabilizing effect of CF_3 is sometimes but not always reduced by the presence of a strong donor group we have now examined the influence of the 1-methyl-2-pyrrolyl group on the CF_3 substituent effect.

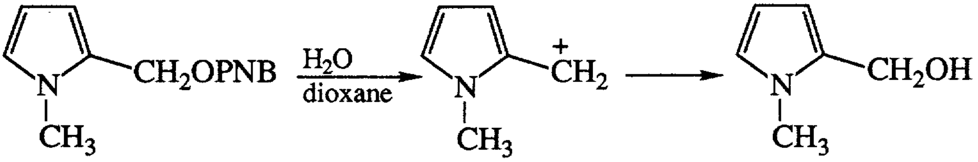
The title compound (**1**) was prepared as shown in Eq. 1. Solvolysis rates in various solvents were measured by UV and the derived rate constants are given in Table I. The major product from the reaction of **1** in CH_3OH was identified as the methyl ether **2**.



1 **2**

(1)

The reactivity of **1** can best be compared to that of (1-methyl-2-pyrrolyl)methyl p-nitrobenzoate (**3**), as studied by Noyce and Fraser.[3b] The latter compound and several ring substituted analogues were thoroughly examined and shown to react by carbocation formation in polar solvents with formation of substitution products, as illustrated for 70% H_2O/dioxane (Eq. 2).[3b] Extensive studies of other side-chain substituted heterocycles revealed similar behavior.[5]

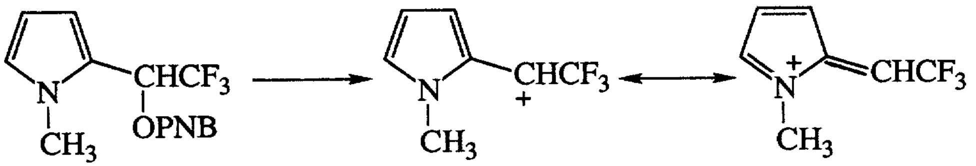


3

(2)

The solvent polarity of 70% aqueous dioxane as measured by the Y_{Cl} parameter is 0.01,[6a] or essentially the same as 80% EtOH (defined as 0.0),[6] so that rates in these media can be compared directly. The rate constant for **3**[3b] in 70% dioxane of 1.84×10^{-2} s^{-1} and that for **1** of 4.40×10^{-4} in 80% EtOH give a rate ratio k(H)/k(CF_3) of only 40, or the smallest yet reported for solvolysis of a secondary 2,2,2-trifluoroethanol derivative.

The relatively high reactivity of **1** despite the presence of the strongly electron withdrawing CF_3 group is strong evidence for formation of a carbocation in this reaction, as shown in Eq. 3, with a high degree of charge transfer to the pyrrole ring in the rate-determining transition state that has the character of the carbocation.[4]



(3)

4

Correlation of the reactivity of 1 with the solvent ionizing parameter Y_{OTs} leads to the relationship log k = 0.55 Y_{OTs} - 3.37, r = 0.986 (Fig. 1). The correlation coefficient is only fair but solvent polarity parameters Y_{OPNB} have not been reported and different scales have proven necessary for different leaving groups.[6] There are few cases for which solvolysis rates of any p-nitrobenzoate substate in a variety of solvents have been measured,[4e,6f] and the general question of the solvent dependence of p-nitrobenzoate leaving groups is still open.

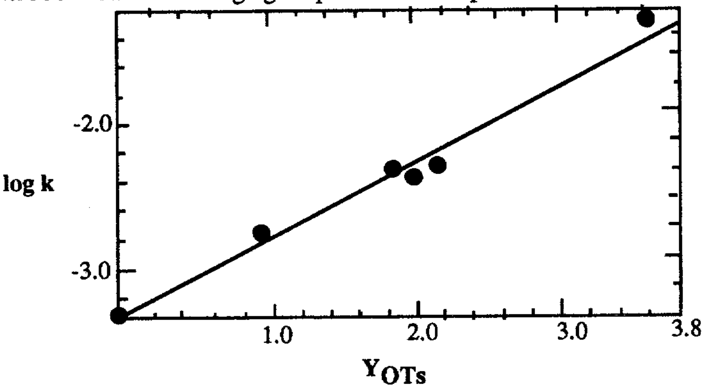


Figure I. Solvolysis rates of 1 as a function of Y_{OTs}

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Table I. Solvolytic Rate Constants for **1** in Different Solvents at 25°C

Solvent[a]	Y[b]	k_{obs} (s^{-1})[c]
97 HFIP	3.61	5.27×10^{-2}
97 TFE	1.83	4.36×10^{-3}
70 TFE	2.00	3.68×10^{-3}
50 TFE	2.14	4.63×10^{-3}
80 EtOH	0.00	4.40×10^{-4}
60 EtOH	0.92	1.71×10^{-3}

[a] Solvents are v/v mixtures with H_2O, HFIP is $(CF_3)_2CHOH$, TFE is CF_3CH_2OH. [b] Ref. 6a.

[c] Average of at least two runs in each case, ±2%.

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