

Dynamic $^1\text{H-NMR}$ study of synthesized enamines from reaction between isocyanides and N,N' -dimethylbarbituric acid

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Abstract: Reaction of alkyl or aryl isocyanides with N,N' -dimethylbarbituric acid leads to pull-push olefinic systems which exhibit dynamic effects around the formed carbon-carbon double bond. Using this technique free-energy of activation (ΔG^\ddagger) were calculated for restricted rotation around the polarized carbon-carbon double bonds.

Keywords: Restricted rotation, Enamines, Polarized carbon-carbon double bonds, Isocyanides.

Introduction

There is considerable attention to structure of enamines because of the synthetic applications of them [1-5]. Enamines are often obtained from a condensation reaction between a secondary amine and an aldehyde or a ketone [6]. However, some synthetic routes are available for preparation of enamine scaffolds such as hydroamination of alkynes [7]. Recently, efficient synthesis of some enamines have been reported in which isocyanide reacts with CH-acid [8,9]. Further investigations showed that these synthesized enamines exhibit dynamic effects. The NMR spectroscopy supplies interesting information on molecular structures. One of the powerful techniques for the study of the kinetic investigations is dynamic NMR spectroscopy [10].

In continuation of our investigations on development of efficient synthesis of enamines, we now describe the dynamic effects around the polarized carbon-carbon double bonds in synthesized enamines.

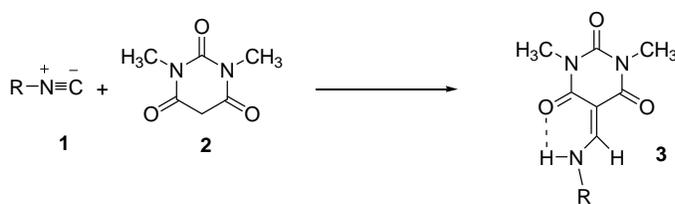
Results and discussion

The reaction between alkyl or aryl isocyanides **1** and N,N' -dimethylbarbituric acid **2** led to enamines **3** in fairly high yields. All compounds have stable crystalline structures which have been supported with spectroscopic data (Scheme 1).

While the configurational properties of polarized ethylenes with strong electron-donating substituents, such as dialkylamino groups, on one carbon atom and electron-withdrawing groups, on the other carbon have been studied both experimentally [11-14], and theoretically [11,14], published experimental data on the configurational features of pull-push ethylenes with an NH group, such as **3a-d** is meager.

These compounds are expected to show higher rotational energy barriers, as a result of extensive intramolecular hydrogen bond formation between the NH and vicinal carbonyl groups [15]. The combination of the strong electron-donating ability of the NH and the strong electron-attracting carbonyl groups give rise to a polarized olefine which exhibits a dynamic ^1H NMR effect in the near of 100°C for the double bond rotation..

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3	R	% Yield
a	2, 6-dimethylphenyl	65
b	benzyl	70
c	cyclohexyl	74
d	<i>t</i> -butyl	62

Scheme 1: Synthesis of enamines containing *N,N'*-dimethylbarbituric acid.

The ^1H NMR spectrum of **3a** in 1,2-dichlorobenzene solution at ambient temperature displayed three sharp singlets for the methyl groups: one due to the $\text{Ar}-\text{CH}_3$ protons at δ 2.36 and two for the $\text{N}-\text{CH}_3$ protons at δ 3.35 and 3.38 ppm. About the 80°C , the resonances arising from *N*-methyl protons are appreciably broadened when compared to the bands in the spectrum measured at room temperature, while the $\text{Ar}-\text{CH}_3$ resonances are remains unchanged. The *N*-methyl protons coalescence near 88°C and appear as a fairly sharp symmetrical band at 110°C .

Although, an extensive line-shape analysis in relation to the dynamic ^1H NMR effect observed for **3a** was not undertaken in the present work, the variable temperature spectra are sufficient to calculate the free-energy barrier (if not the enthalpy and entropy of activation) for the restricted carbon-carbon double bond rotation in the **3a**. From the coalescence of the *N*-

methyl proton resonances and using the expression: $k = \pi\Delta\nu/\sqrt{2}$, we calculate that the first-order rate constant (k) for the carbon-carbon double bond rotation in **3a** is 23 s^{-1} at 100°C .

Application of the absolute rate theory with a transmission coefficient of 1 gives a free-energy of activation (ΔG^\ddagger) of 82.5 ± 2 kJ/mol, where all known source of errors are estimated and calculate [16]. The experimental data available are not suitable for obtaining meaningful values of ΔH^\ddagger and ΔS^\ddagger , even though the errors in ΔG^\ddagger are not large [17].

The ^1H NMR shifts and kinetic data for the other enamines **3b-d** are given in Table 1. The largest difference in ΔG^\ddagger values, that for **3a** and **3d** may be attributed to enhanced intramolecular hydrogen-bonding in **3d**.

Table 1: selected proton chemical shifts (in ppm, TMS) and activation parameters (kJ/mol) for **2a-d** in 1,2-dichlorobenzene.

Compound	Temp ($^\circ\text{C}$)	<i>N-CH</i> ₃	$\Delta\nu(\text{Hz})$	$k(\text{s}^{-1})$	$T_c(^\circ\text{K})$	ΔG^\ddagger ^{<i>i</i>}
3a	20	3.35 3.37	10	23	361	80.0 ± 2
	110	3.36				
3b	20	3.28 3.31	2.7	6	463	108.0 ± 2
	120	3.29				
3c	20	3.30 3.32	10	22	379	83.8 ± 2
	125	3.30				
3d	20	3.29 3.31	11	25	383	84.3 ± 2
	130	3.30				

i: Dynamic ^1H NMR spectra for compounds **3a**, **3c** and **3d** have been taken by BRUKER DRX-500 AVANCE and for compound **3b** by JEOL EX-90A instrument, respectively.

Conclusion

In conclusion, dynamic NMR effects were observed in the ^1H NMR spectra of synthesized enamines **3a-d** and were attributed to restricted rotation around the carbon-carbon double bonds. The free-energy of activation (ΔG^\ddagger) for interconversion of these enamines is about $(80-84)\pm 2$ kJ/mol.

Experimental

All dynamic ^1H NMR spectra were measured on a BRUKER DRX-500 AVANCE and JEOL EX-90A instruments with 1,2-dichlorobenzene as a solvent at 500 and 90 MHz.

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