

UNCATALYZED 1,3-ACYL MIGRATION FROM CARBON TO NITROGEN.

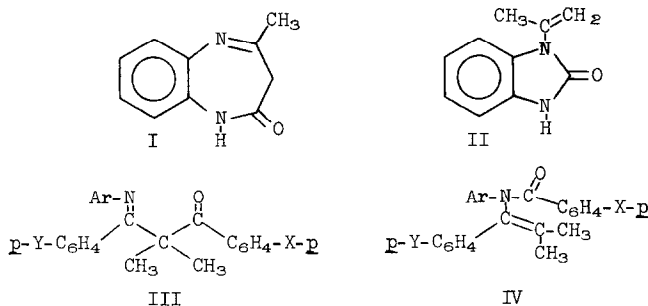
CONVERSION OF  $\beta$ -IMINOKETONES TO ENAMIDES (1)

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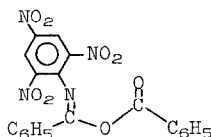
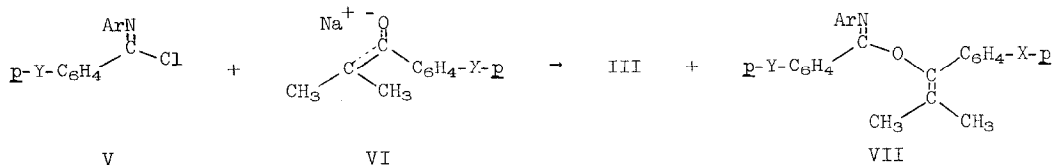
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Uncatalyzed 1,3-acyl migrations to or from a carbon atom of an unsaturated triad system have been rarely observed and except in unusual circumstances have proceeded only at elevated temperatures (2). A recent report (3) has described a C-to-N migration in the rearrangement of condensed dihydrodiazepinone to the corresponding imidazolones at temperatures of 185° or above (for example the conversion of I to II). No study of the reaction mechanism was reported but there was postulated an intramolecular rearrangement. This prompts us to report our discovery of the rearrangement in good yield of  $\beta$ -diketone imines III to the enamides IV and evidence that this process involves an intramolecular C-to-N acyl transfer.



Synthesis of imino ketones analogous to III had not been described and attempts to prepare such compounds from the diketone failed. A synthetic method with general applicability was found to involve the reaction of an imidoyl chloride V with the sodium salt VI of the appropriate isobutyrophenone suspended in benzene under reflux. In addition to the desired imino ketone in yields of not less than 40% there was obtained some of the O-substituted product VII from which III could be separated by crystallization. Structures of the imino ketones III were assigned on the basis of strong ir maxima near 1680 (C=O) and 1630 (C=N)  $\text{cm}^{-1}$  and by the nmr spectra which showed in addition to the aromatic proton resonance a singlet (area 6) at  $\tau$ 8.40 $\pm$ 0.02 due to the  $=\text{C}(\text{CH}_3)_2$  group. The imino ketones III so prepared together with their physical constants are



VIII

listed in Table I. At temperatures above 185° these compounds undergo rearrangement to the enamide IV in good yield either in the melt or in solution in tetradecane or 1,2,4-trichlorobenzene. The products described in Table I were characterized by the carbonyl ir absorption near 1650  $\text{cm}^{-1}$  and by the  $=\text{C}(\text{CH}_3)$  absorptions in the nmr spectrum; one methyl fell in the region  $\tau$ 8.17-8.24 and the other, when it was resolved from the first, fell in the region  $\tau$ 8.08-8.16. Chemical evidence for the structure of the methoxy enamide IIIe was provided by hydrolysis with KOH-methanol to *p*-methoxyisobutyrophenone; the enediamide IIIg could be similarly hydrolyzed to isobutyrophenone. In each case the product was identified by comparison of its properties with those of an authentic sample. The rates of rearrangement reported in Table I were found to be first order to greater than 90% completion. That the reaction of IIIe was first order was confirmed by the demonstration that a 17-fold increase in concentration of the starting material increased the rate constant only 10%. Additional evidence that these reactions are intramolecular rearrangements of the neutral imino ketone was provided by the observation that the rate of reaction of IIIa was not changed substantially by the addition of 5 mole-% anhydrous HCl and that reaction of IIIa occurred in liquid 9,10-dihydroanthracene with no effect on the yield of IV and no evidence of the formation of benzaldehyde, a product to be expected from trapping by the dihydroanthracene of any benzoyl radical present as a reaction intermediate (4).

The effect of substituents on the migrating benzoyl group may be seen from the rate data in Table I to be that expected for a carbonyl addition reaction; there is acceleration by *p*-Cl and deceleration by *p*-dimethylamino or *p*-methoxy with a Hammett  $\rho$  of +1.1. Replacement of a bromine atom of the dibromo imino ketone IIIa with a methoxy group either on the aryl ring attached to nitrogen (as in IIIf) or on the non-migrating aryl ring attached to carbon (as in IIIe) leads to

Table I  
Properties of the Imino Ketones (III) and Rearrangement Products (IV)  
and Rates of Rearrangement

X	Y	Ar <sup>c</sup>	Imino Ketones III <sup>a</sup>		Eneamides IV <sup>a</sup>		Rate of Rearrangement <sup>b</sup> of III 10 <sup>5</sup> k <sub>1</sub> (sec <sup>-1</sup> ) and St. dev.
			M. p. (°C)	Infrared Maxima <sup>d</sup> (cm <sup>-1</sup> )	M. p. (°C)	Infrared Maxima (cm <sup>-1</sup> )	
a	H	BrC <sub>6</sub> H <sub>4</sub>	186.8-188	1670 1629	154.1-154.9 <sup>e</sup>	1645 <sup>d</sup>	13.80±0.04
b	(CH <sub>3</sub> ) <sub>2</sub> N	BrC <sub>6</sub> H <sub>4</sub>	178.5-179.6	1656 1628	150-154	1849 <sup>f</sup>	1.50±0.02
c	CH <sub>3</sub> O	BrC <sub>6</sub> H <sub>4</sub>	177.5-178.5	1679 1631	156-157	1655 <sup>f</sup>	4.62±0.01
d	Cl	BrC <sub>6</sub> H <sub>4</sub>	169.5-170.2	1680 1630	169-170.5	1661 <sup>f</sup>	21.71±0.06
e	H	CH <sub>3</sub> O	136.7-137.2	1681 1626	151.5-152.5	1659 <sup>f</sup>	56.01±0.24
f	H	Br	103.8-106	1680 1626	97.2-101	1640 <sup>d</sup>	53.61±0.14
g	H	H	96.4-97.4	1674 1643	139.5-141	1690 <sup>d</sup> 1659	1.36±0.23

<sup>a</sup> Carbon, hydrogen and nitrogen analyses were within 0.3% of theoretical. <sup>b</sup> Analyses of aliquots withdrawn at various times were carried out by determination of the uv spectra of the mixture and calculation of the composition by a method of least squares using a comparison of absorbances at a number of wavelengths with known absorbances of starting material and product with the computer program UVANL written by D. B. Pendergrass, Jr. The rate constants were calculated by program which varied the infinity value of the product concentration to give the least squares value of the rate constant k<sub>1</sub>. (In all cases the % of product at infinity so calculated was 95-100%). <sup>c</sup> The substituent is *para* in every case. <sup>d</sup> CHCl<sub>3</sub> solvent. <sup>e</sup> From cyclohexane a solvate was obtained, melting at 88-96° was followed by resolidification and remelting at 154°, the same mp obtained with crystals from ethanol. <sup>f</sup> CCl<sub>4</sub> solvent.

acceleration by a factor of about 4. The reaction of IIIa showed a substantial dependence on solvent, being 4 times faster in 1,2,4-trichlorobenzene at 170.48° and 5 times faster in dihydroanthracene-benzonitrile 27:73 at 182.35° than in tetradecane at the corresponding temperature.

These reactions seem best formulated as [1,3] sigmatropic shifts (5) as was proposed by Israel, Jones, and Modest (3) for the rearrangements of the dihydrodiazepinone. It is of interest that extrapolation of the rate of rearrangement of IIIa to 42.9° shows that the reaction is slower by a factor of about 10<sup>6</sup> than the rearrangement of the dinitro imino ester VIII studied previously (2). It seems likely that a substantial part of the large rate difference between the two systems is due to the availability in the latter case only of a planar four-center

transition state by virtue of the unshared electron-pairs in non-bonding orbitals on both the oxygen and nitrogen atom as discussed previously (2).

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