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IMINE–ENAMINE TAUTOMERISM—VI[a]

C- vs N-ALKYLATION OF IMINES WITH ELECTROPHILIC OLEFINS

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Abstract—Recently described results concerning in particular the reaction between N-isopropylidene-cyclohexylamine **1b** and methyl acrylate were reinvestigated, due to the claim that only N-alkylation takes place. Our results show that in fact several reactions do occur, particularly the C-alkylation yielding iminoesters **3b** and **5**, but that no N-alkylation takes place. The principal side reaction is the "aldolisation-crotonisation" of imine **1b** which yields mesityl oxide imine **8** and cyclohexylamine which in turn adds on methyl acrylate to give β-aminoester **9**.

Enamine **4b** which would have arisen by N-alkylation of imine **1b** was independently prepared by enamination of acetone with secondary amine **9** and shown to spontaneously cyclize to enaminoketone **12**, which compound was totally absent from the alkylation experiments. It is thus demonstrated that N-alkylation of imine **1b** does not occur with methyl acrylate, not even reversibly.

Alyklation of carbonyl compounds via their imine derivatives, with electrophilic olefins,[1] seems to be an excellent complementary method to Stork's procedure using enamines,[2] particularly for methylketones and α,α-disubstituted aldehydes.

With enamines, only C-alkylation can lead to the formation of stable products,[2] but with imines the possibility of N-alkylation can *a priori* also be considered[1b] (Scheme 1).

A literature survey concerning the reactions of type 1 imines (R^1, R^2 = H, alkyl; R = alkyl, aryl) with conjugated olefins[c] (α,β-ethylenic esters, nitriles and amides, maleic anhydrides, maleimides) reveals that in all reported studies, only C-alkylation products of type 3 (or derivatives) were observed.[1,4]

More recently, Atta-ur-Rahman *et al.*[5] challenged our results[d] and reinvestigated our work. For unspecified reasons they selected similar examples, which we had not studied. In particular, with N-isopropylidene-cyclohexylamine **1b** and methyl acrylate **2b**, the Pakistani group isolated only one compound with a 55% yield, and

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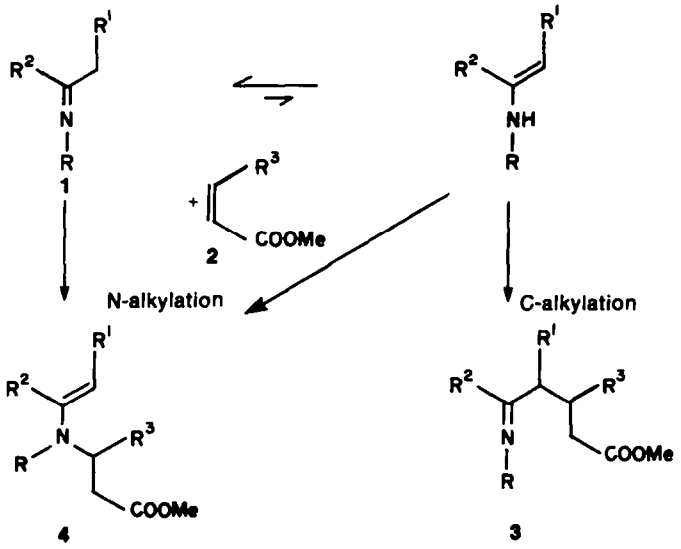
[c]With α,β-acetylenic esters, only compounds resulting from N-alkylation are formed.[3]

[d]Particularly with an acetone imine, N-isopropylidene-isopropylamine **1a** and one equivalent of methyl maleate **2a** refluxed in benzene, we obtained an 86% yield of the C-alkylation product **3a**. No investigations were performed to isolate any possible by-product of type **4** (or derivative thereof) which could have arisen through N-alkylation.[1a,b]



a: R = Me_2CH, R^1 = H, R^2 = Me, R^3 = COOMe
b: R = cyclohexyl, R^1 = H, R^2 = Me, R^3 = H

Scheme 1.

they claimed that this compound resulted from N-alkylation of the imine.

Consequently it seemed necessary for us to reinvestigate the work of these authors, by using the same compounds, under identical reaction conditions.

In this study we describe a balance of the products obtained, which shows that under these conditions several reactions take place, in particular the C-alkylation. No N-alkylation was observed. Also we show that the conclusions are due to a wrong interpretation concerning the formation of the compound the authors isolated.[5]

RESULTS AND DISCUSSION

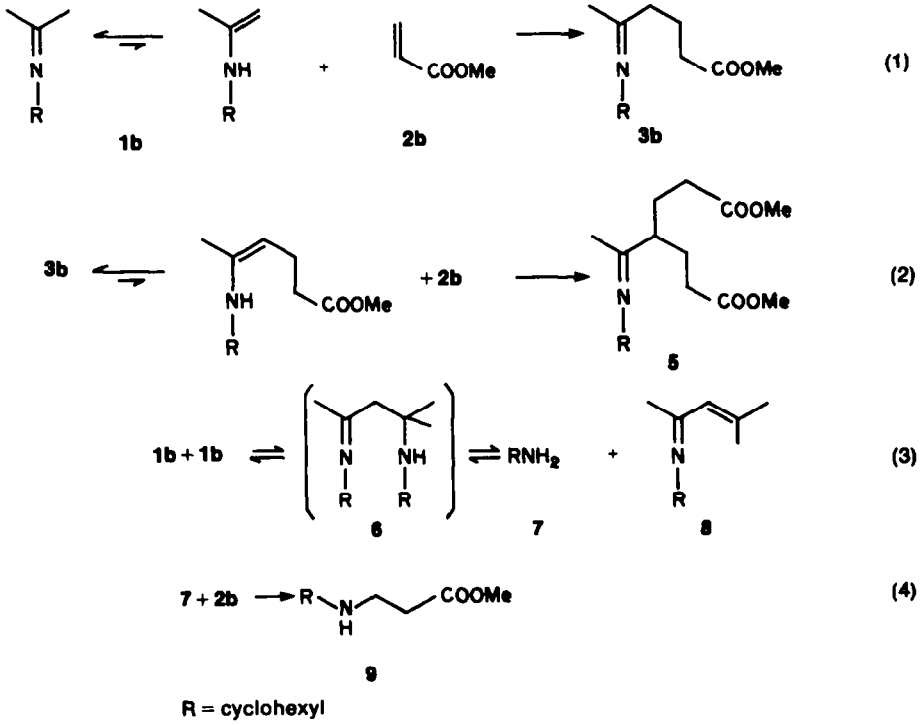
Equimolecular quantities (0.01 mole) of imine **1b** and ester **2b** were refluxed for 14.5 hr at different concentrations[a] in anhydrous benzene. After cooling, vpc of the crude mixtures showed the presence of several compounds (Table 1, Scheme 2) and some imine **1b** and ester **2b** (conversions ranged from 30–50%). In one example

[a] As concentrations were not stated in Atta-ur-Rahman's paper,[5] three experiments were achieved using 0.2 M and 0.8 M solutions as well as 1.4 M which we used before.[1b]

Table 1. Reaction of N-isopropylidene-cyclohexylamine (**1b**) with methyl acrylate (**2b**)[a]

concentr. (M)	0.2	0.8	1.4	b	c
	% d,e				
compound					
3b	43	49	41	40	4
5	19	14	26	52	86
9	12	20	15	6	8
7	10	6	5	0	1
8	16	11	13	2	1

[a] Equimolecular quantities refluxed for 14.5 h in benzene. VPC determinations on crude mixture. [b] No solvant, room temperature, 13 days. [c] Two equivalents of methyl acrylate, no solvant, room temperature, 2 months (no VPC determinations made before). [d] Relative % areas of the products present in the mixture at the exclusion of solvant, starting compounds 1b and 2b and about ten unknown impurities amounting in totality for less than 8 % in all cases. [e] ± 4 %.



Scheme 2.

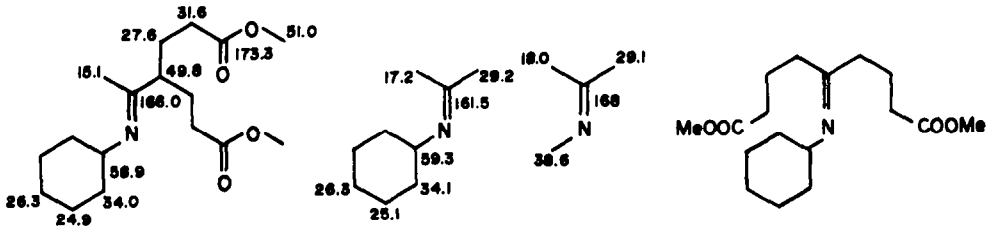
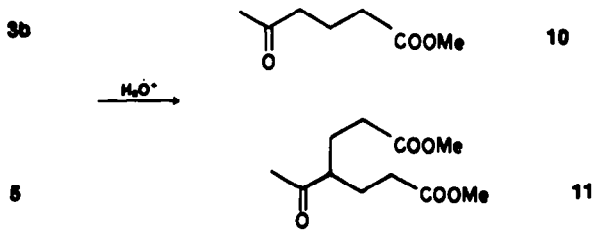


Fig. 1.



Scheme 3.

(1.4 M experiment) the benzene solution was evaporated and distilled under reduced pressure; as virtually no residue was left, the compounds observed by vpc represent the totality of the reaction products.

The five compounds formed in the reaction were isolated by fractional distillation and purified by preparative vpc, then identified with authentic samples by vpc, IR and ^{1}H NMR (7, 8, 9) or characterized by their spectral properties and by derivatives (3b, 5).

Thus, authentic imine 8 was obtained by reaction of mesityl oxide with cyclohexylamine in benzene under azeotropic conditions[f,g] and authentic β-aminoester 9 by Michaël addition of cyclohexylamine to methyl acrylate (mere mixing of the compounds as described before for similar examples[10]).

IR spectrums show characteristic imine and ester absorptions for compounds 3b (1658 and 1738 cm^{-1}) and 5 (1657 and 1740 cm^{-1}). ^{1}H NMR and mass spectrums of both products are in agreement with their structures. For compound 5, ^{13}C NMR allowed to eliminate completely the possibility of an α,α'-bis-adduct alternative structure 5' (Fig. 1).

Its spectrum corresponds to a ketimine with blocked configuration. The eleven nuclei could be assigned according to their chemical shifts, their "off resonance" multiplicity and by comparison with the spectrums of imines 1b and 14.[11] As two tertiary carbons are present, structure 5' can be disregarded. The observation of a shielded Me group (15.1 ppm) indicates by comparison with compound 14[11] that imine 5 has an *E* configuration.

Imine hydrolysis of compounds 3b and 5 led to keto-esters 10 and 11 (Scheme 3) whose IR and ^{1}H NMR data agree with published spectrums of these compounds.[12] Elemental analyses of the 2,4-DNPH derivatives as well as their ^{1}H NMR spectrums confirmed their structures.

Scheme 2 describes the different reactions which account for the observed compounds. Four further experiments followed by vpc were undertaken to confirm that reactions (3) and (4) do occur under conditions used for the alkylation experiments. (1) Imine 1b refluxed in benzene gives cyclohexylamine and imine 8. (2) Conversely, under the same conditions, an equimolecular mixture of compounds 7 and 8 yields imine 1b, showing the reversibility of reaction (3). (3) Under the same conditions, reaction (4) was shown to proceed with ease. (4) In refluxing benzene, β-aminoester 9 is stable.

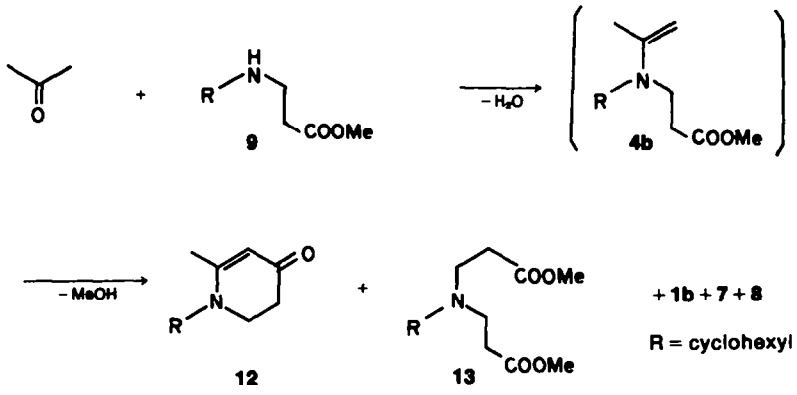
Reaction (3) of the aldolisation-crotonisation type with imines is known with aldimines.[13] Examples with ketimines are scarce (acetone anils,[7a,14] N-isopropylidene-isopropylamine[7b,14])[h]. In the first experiment just described, as cyclohexylamine is not removed from the medium, the process is inefficient, due to the reversibility of the reaction. In the actual alkylation experiments, cyclohexylamine is trapped by methyl acrylate (reaction 4) allowing reaction (3) to proceed more efficiently to the right, thus becoming competitive with C-alkylation reaction (1) (Table 1). At room temperature however, aldolisation is not anymore competitive (Table 1).

In the alkylation experiments we did not observe the hypothetical N-alkylation compound 4b (Scheme 1). To check the stability of any enamine 4b which could have been formed, we tried to synthesize this compound by another pathway, namely by enamination of acetone with the secondary amine 9, using silica-alumina catalyst and molecular sieves.[15] Performing the experiment at 50° in benzene, a very slow reaction took place yielding a

[f] Although imination of α,β-ethylenic aldehydes is well documented,[6] fewer examples of the reaction with α,β-ethylenic ketones are described (mesityl oxide,[7] cyclohexenones[8]) due to the fact that in this case the isolated reaction products are usually the corresponding β-aminoketones.[9]

[g] Although, in our conditions, vpc shows only one peak for compound 8, spectral NMR evidence (Experimental) points to a mixture of four isomers: the α,β-ethylenic derivatives *E* and *Z* (60% and 30%) as well as the β,γ-ethylenic derivatives *E* and *Z* (5% each).

[h] To our knowledge a retro-aldolisation-crotonisation reaction of type (3), i.e. the reaction of an amine with the imine of an α,β-ethylenic carbonyl compound to give an imine of a simple carbonyl compound, has not been reported before.



Scheme 4.

major compound 12[f] (Scheme 4) isolated by vpc and small amounts of cyclohexylamine, imines **1b** and **8**, as well as tertiary amine **13**, isolated by vpc and identified with an authentic sample (vpc, IR) prepared by Michaël addition of the secondary amine **9** on methyl acrylate as described before for similar examples.[10]

Dieckmann-like cyclisation of N-(2-carbalkoxyethyl)-cycloalkanone enamines to yield enaminoketones of type **12** has been reported.[18]

Imine **1b** (and its crotonisation product **8**) presumably arises from C–N scission of enamine **4b**. A similar behaviour has been observed in one of the above mentioned examples[18a] as well as in other related systems.[4b,19] The absence of C-alkylation compounds **3b** and **5** can be rationalized in this instance, taking into account the competition of imine **1b** and amine **9** for methyl acrylate; the latter, present in large excess, gives rise to tertiary amine **13** (formation of amine **13** from amine **9** and methyl acrylate in the same conditions–benzene solution, 50°—has been independently established).

Compound **12** is totally absent from the vpc's corresponding to the experiments described in Table 1. To eliminate the possibility of any specific influence upon the cyclisation of intermediate **4b** by the presence of silica-alumina/molecular sieves, we did run under the same conditions (14h30, benzene reflux) the alkylation reaction of imine **1b** with methyl acrylate in presence of these agents. Vpc showed both C-alkylation compounds **3b** and **5** as well as products **7**, **8** and **9**, but the relative proportions of these compounds were different from the usual ones, the aldolisation reaction being accelerated by the catalyst (Experimental and Table 1). Enaminoketone **12** was totally absent.

These results do show that at least in the case of the reaction of imine **1b** with methyl acrylate in refluxing benzene (Atta-ur-Rahman's conditions[5]) as well as at room temperature,[f] N-alkylation giving rise to compound **4b** does not take place, not even reversibly, since no cyclised compound **12** is detected.

The various experiments described in this paper explain the Pakistani results.[5] Indeed, the N-alkylation "proof" was only indirectly obtained by these authors. After the stated reaction time, the mixture was distilled and via column chromatography, the pure product isolated was not analysed but was characterized by an oxalate derivative, which proved to be the oxalate of β-aminoester **9** (55% yield). Although compound **4b** was not itself characterized, the authors state that these results "clearly showed that N-alkylation of the ketimine had occured followed by hydrolysis of the resulting enamine during work-up to afford the secondary amine". In fact, it is obvious that compound **9** was already present in the reaction mixture (Table 1). The observation of a greater amount of this compound compared to ours is no doubt due to the fact that in the stated reaction conditions a large quantity of both reactants is still present and that trivial hydrolysis of imine **1b** can take place, followed by cyclohexylamine addition to methyl acrylate, giving an additional amount of aminoester **9**.

From the results obtained in this study the following considerations can be outlined.

Table 1 reveals that no significative change in the mixture's composition is noticed at various concentrations of reactants. The actual yields of C-alkylation products, based on reacted methyl acrylate, can be estimated from the figures at about 50% for the monoalkylated compound **3b** and 30% for the dialkylated compound **5**. At room temperature, aldolisation is minimized to the benefit of C-alkylation (yields of about 30% for compound **3b** and 60% for compound **5**). The increased ratio of the dialkylated compound **5** relative to the monoalkylated compound **3b** merely reflects the large conversion of reactants in this case (*ca.* 95%). With two equivalents of methyl acrylate, at room temperature (*ca.* 95% conversion), a 79.8% yield of isolated pure C-dialkylated compound **5** has been achieved.

In refluxing benzene, the total yield of the C-alkylation compounds (*ca.* 80%) is of the same order than the one observed with methyl maleate and N-isopropylidene-

[f]Characterized by its spectral properties (Experimental). It appears that the enaminoketone **12** obtained is the first example of the intermediacy of an enamine of acetone, trapped intramolecularly. Indeed, to our knowledge, all attempts to synthesize an acetone enamine have given rise only to polyaldolisation compounds[16] although intermolecular trapping has been achieved.[17]

[f]The same author has claimed that alkylation of harmaline (a methylated cyclic imine) by methyl acrylate gives rise to a 72% yield of the (cyclised) N-alkylated product if conducted in refluxing benzene and to a 90% yield of the C-alkylated compound if conducted at room temperature.[20]

isopropylamine (86%)[1a,b] but the reaction is slower in the former case. No dialkylated compound was observed with the maleate ester; the lack of dialkylation is presumably due in this case to steric reasons.

EXPERIMENTAL

IR, UV and mass spectrums were recorded with a Perkin–Elmer 297, Cary 15 and AEI MS 30 spectrometers respectively. ^{1}H NMR spectrums ($CDCl_3$) were obtained with a Varian T 60 model and ^{13}C NMR spectrums (concentrated C_6D_6 solutions) with a Varian CFT 20 spectrometer operating at 20 MHz. In both cases chemical shifts δ were measured relatively to TMS taken as internal standard. Microanalyses were made by the "Centre de spectrochimie-Microanalyse" of the University Pierre et Marie Curie (Paris VI). Analytical vpc's were performed with a Varian 1440 model and a Varian CDS 101 integrator. A 3 m × 1/8 in. column filled with 5% SE 52 on chromosorb AW 80–100 mesh was used. Analyses were achieved with a 4°/mn program starting at 50° and ending at 230° (no cooling). In these conditions, the compounds under study have the following retention times in minutes: acetone (3.37), **2b** (4.52), benzene (5.42), mesityl oxide (8.09), **7** (12.48), **1b** (19.78), **10** (20.33), **8** (28.42), **9** (31.66), **11** (36.62), **3b** (37.91), **13** (44.85), **12** (49.01) and **5** (53.48).

Preparative vpc's were achieved with a Varian 90 gaz chromatograph equiped with a 3 m × 3/8 in. column filled with 5% SE 52 on chromosorb AW 40–60 mesh.

Analytical pure benzene was distilled on $MgSO_4$, conserved on Na and redistilled before use. Methyl acrylate (Fluka purum) was redistilled prior to use and collected on a few hydroquinone crystals. Cyclohexylamine (Fluka puriss) was used directly.

All the experiments were preceded by bubbling N_2 through the reactants.

N-isopropylidene-cyclohexylamine (**1b**): $C_9H_{17}N$ (M = 139.24). The imine was prepared according Norton's procedure.[21] E_{20} 75°. Mass *m/e*: 139 (5%), M+; 124 (35%), $(M-CH_3)^+$; 96 (45%), $(M-C_3H_7)^+$; 83 (50%), $(C_6H_{11})^+$; 58 (100%) $[(CH_3)_2C{=}NH_2]^+$. IR (neat): 1663 cm^{-1} (C=N). ^{1}H NMR: 3.22, m (CHN); 1.88, s (CH_3–(*E*))[k]; 1.78, *s* (CH_3–(*Z*));[k] 2.03–0.95, m (5 CH_2).

N-(1,3)dimethyl-2-butenylidene)-cyclohexylamine (**8**). $C_{12}H_{21}N$ (M = 179.31). 24.8 g (0.25 mole) of cyclohexylamine and 24.5 g (0.25 mole) of mesityl oxide were added to 100 ml of benzene containing a few mg of *p*-toluene-sulfonic acid. The soln was refluxed in a Dean-Stark apparatus during 24 hr. After removal of the solvant, the residue was distilled at 14 Torr; mesityl oxide, cyclohexalamine and imine **1b** were thus removed and the residue was further distilled at 0.1 Torr. The fraction 40–70° (3.0 g) was collected and showed to consist in a 1:1 mixture of imine **1b** and imine **8**. The latter, shown by NMR (see below) to be a mixture of the *Z* and *E* isomers of the conjugated and the non-conjugated imines, was obtained by preparative vpc.

Mass *m/e*: 179 (35%), M^+. IR (CCl_4): 1656 cm^{-1} (non conjug. C=N); 1635 cm^{-1} (conjug. C=N); 1615 cm^{-1} (C=C). ^{1}H NMR (Varian FT 80): 5.73, m and 5.48, m (CCH=C); 4.73, m and 4.57, m (CH_2=C); 3.35, m (CHN); 2.1–0.9, m (CH_2); 2.09–1.42, array of CH_3 signals. Assignments were made after comparison with the spectrums of authentic conjugated and non-conjugated mesityl oxide, thus allowing to show that four isomers of compound **8** were present (footnote[e]). ^{13}C NMR (Varian FT 80) confirmed the presence of the four isomers.

Methyl 3-cyclohexylaminopropionate (**9**): $C_{10}H_{19}NO_2$ (M = 185.26). According to the method A of Ref. 10, 9.9 g (0.1 mole) of cyclohexylamine and 8.6 g (0.1 mole) of methyl acrylate were mixed and kept 24 h at room temp. Distillation gave 16.7 g (90% yield) of pure amino-ester **9**. $E_{0.1}$ 75°. Mass *m/e*: 185 (15%), M^+; 142 (100%) $(M-C_3H_7)^+$; 112 (30%) $(M-CH_2COOCH_3)^+$. IR (CCl_4): 1737 cm^{-1} (C=O). ^{1}H NMR: 3.70, s (CH_3O); 3.0–2.15, m (CH_2N, CH_2CO, CHN); 2.15–0.70, m (5 CH_2, NH).

[k]Methyl chemical shifts for ^{1}H NMR have been correlated with those for ^{13}C NMR through the "off resonance" technique. Thus the methyl-(*Z*) appears at high field in ^{13}C (see text) as well as in ^{1}H NMR.

N,N-Bis-(2-carbomethoxyethyl)-cyclohexylamine (**13**): $C_{14}H_{25}NO_4$ (M = 271.36)

According to the method F of Ref. 10, 9.9 g (0.1 mole) of cyclohexylamine and 43.0 g (0.5 mole) of methyl acrylate yielded a mixture of compounds **9** and **13** which was distilled reduced pressure. 4.7 g (17% yield) of pure aminodiester **13** was collected. $E_{0.1}$ 105°. Mass *m/e*: 271 (10%), M^+; 228 (85%), $(M-C_3H_7)^+$; 198 (80%), $(M-CH_2COOCH_3)^+$; 59 (30%), $(COOCH_3)^+$; 57 (100%) $(CH_2NHCH_2CH_2)^+$. IR (neat): 1735 cm^{-1} (C=O). ^{1}H NMR: 3.48, s (2 CH_3O); 2.85–2.0, m (2 CH_2N, 2 CH_2CO, CHN); 2.0–0.70, m (5 CH_2).

Room temperature alkylations (*Table* 1 (*b, c*)). These experiments were made respectively with 13.9 g (0.1 mole) and 4.59 g (0.033 mole) of imine **1b** mixed with 8.61 g (0.1 mole) and 5.68 g (0.066 mole) of methyl acrylate.

Distillation at 0.1 Torr of the mixture obtained from the equimolecular experiment yielded the following fractions: (1) <25° (**1b, 2b, 7**); (2) 25–92° (**1b, 2b, 3b, 7, 8, 9**); (3) 92° (**3b, 9**); (4) 92–150° (**3b, 5**); (5) 150° (**3b, 5**). Compounds **3b** (3), **5** (5), **7** (1), **8** and **9** (2) were obtained in pure form by preparative vpc.

Distillation of the mixture obtained from the 1:2 mole experiment gave 8.2 g (79.8% yield) of pure iminodiester **5**.

Methyl 5-cyclohexyliminohexanoate (**3b**): $C_{13}H_{23}NO_2$ (M = 225.32). $E_{0.1}$ 90°. Mass *m/e*: 225 (3%), M^+; 139 (60%), $(M-CH_2CHCOOCH_3)^+$; 83 (100%), $(C_6H_{11})^+$; 55 (80%), $(C_6H_{11}-C_2H_4)^+$. IR (CCl_4): 1738 cm^{-1} (C=O); 1658 cm^{-1} (C=N). ^{1}H NMR: 3.70, s (CH_3O); 3.18, m (CHN); 2.60–0.80, m (8 CH_2); 1.85, s (CH_3C=N).

Dimethyl 4-(1-cyclohexyliminoethyl) adipate (**5**): $C_{17}H_{29}NO_4$ (M = 311.41). $E_{0.1}$ 150°. Mass *m/e*: 311 (1%), M^+; 238 (20%), $(M-CH_2COOCH_3)^+$; 225 (25%), $(M-CH_2CHCOOCH_3)^+$; 152 (40%), $(238-CH_2CHCOOCH_3)^+$; 83 (100%), $(C_6H_{11})^+$; 55 (65%) $(C_6H_{11}-C_2H_4)^+$. IR (CCl_4): 1740 cm^{-1} (C=O); 1657 cm^{-1} (C=N). ^{1}H NMR: 3.67, s (2 CH_3O); 3.25, m (CHN); 2.50–0.80, m (9 CH_2, CHC=N); 1.77, s (CH_3C=N). ^{13}C NMR: see text.

Hydrolysis of imines **3b** *and* **5**. 1 g of each derivative was dissolved in 15 ml of water-dioxan (1:2) and kept 24 h at room temp. The residue of evaporation contained no more imine (vpc): Preparative vpc yielded the pure cetoesters **3b** and **5**.

Methyl 5-oxohexanoate (**10**): $C_7H_{12}O_3$ (M = 144.17). Mass *m/e*: 144 (2%), M^+; 74 (30%), $(M-CH_2CHCOCH_3)^+$; 43 (100%), $(CH_3CO)^+$. IR (neat): 1740 cm^{-1} (C=O ester); 1720 cm^{-1} (C=O ketone). Litt.[12] (neat): 1750 and 1720 cm^{-1}. ^{1}H NMR: 3.68, s (CH_3O); 2.70–1.50, m (3 CH_2); 2.17, s (CH_3C=O). Litt.[12] in agreement.

Methyl 4-acetylpimelate (**11**): $C_{11}H_{18}O_5$ (M = 236.26). IR (neat): 1740 cm^{-1} (C=O ester); 1713 cm^{-1} (C=O ketone). Litt.[12] (CCl_4): 1750 and 1723 cm^{-1}. ^{1}H NMR: 3.68, s (2 CH_3O); 2.80–1.60, m (4 CH_2, CH); 2.18, s (CH_3C=O). Litt.[12] in agreement.

2,4-Dinitrophenylhydrazones of compounds **10** *and* **11**. Both derivatives were obtained in the usual way, in MeOH. Crystals were filtered off after 3 days and recrytallized 3 times from MeOH-water.

2,4-DNPH of cetoester **10**: $C_{13}H_{16}N_4O_6$ (M = 324.29). Yellow needles, m.p. 88–89° (Litt.[12] 88–89°). Found: C, 47.82; H, 5.03. Calc.: C, 48.15; H, 4.97%. ^{1}H NMR: 10.93, s (NH); 9.02, d ($J_{H\text{-}3,H\text{-}5}$ = 2.5 Hz) (arom. H-3); 8.23, d of d ($J_{H\text{-}3,H\text{-}5}$ = 2.5 Hz; $J_{H\text{-}5,H\text{-}6}$ = 9 Hz) (arom. H-5); 7.87, d ($J_{H\text{-}5,H\text{-}6}$ = 9 Hz) (arom. H-6); 3.68, s (CH_3O); 2.70–1.50, m (3 CH_2); 2.10, s (CH_3C=N).

2,4-DNPH of cetoester **11**: $C_{17}H_{22}N_4O_8$ (M = 410.38). Yellow plates, m.p. 78° (litt.[12] 74–77°). Found: C, 49.63; H, 5.42. Calc.: C, 49.75; H, 5.40%. ^{1}H NMR: 10.98, s (NH); 9.07, d ($J_{H\text{-}3,H\text{-}5}$ = 2.5 Hz) (arom. H-3); 8.28, d of d ($J_{H\text{-}3,H\text{-}5}$ = 2.5 Hz; $J_{H\text{-}5,H\text{-}6}$ = 9 Hz (arom. H-5); 7.90, d ($J_{H\text{-}5,H\text{-}6}$ = 9 Hz) (arom. H-6); 3.68, s (2 CH_3O); 2.75–1.60, m (4 CH_2, CH); 2.08, s (CH_3C=N). Litt.[12] in agreement.

Reactions (3) *and* (4) (*Scheme* 2)

(1) A 0.8 M benzene solution of imine **1b** was refluxed 1 hr. Vpc showed cyclohexylamine (5%), imine **8** (5%) and imine **1b** (90%).

(2) A benzene soln of cyclohexylamine and imine **8**, both 0.2 M, was refluxed 14 hr. Vpc showed cyclohexylamine (33%), imine **8** (10%), imine **1b** (47%) and unidentified compounds (10%).

(3) A benzene soln of cyclohexylamine and methyl acrylate, both 0.8 M was refluxed 4 hr. Vpc showed cyclohexylamine (35%), methyl acrylate (34%) and β-aminoester 9 (31%).

(4) After a 24 hr reflux of a 0.8 M soln of 9 in benzene, the vpc remained unchanged.

Enaminoketone 12. To 1.74 g (0.03 mole) of acetone and 1.85 g (0.01 mole) of secondary amine 9 was added 4 g of a mixture of molecular sieves—SiO_2/Al_2O_3[f] and 12.5 ml of benzene. The mixture was heated (bath 60°) under N_2 with magnetic stirring in a well closed flask, during 2 weeks. Vpc showed that conversion of 9 was *ca.* 30% and that besides acetone excess, cyclohexylamine (1%), imines 1b (8%) and 8 (17%), enaminoketone 12 (64%), tertiary amine 13 (5%) and unidentified compounds (5%) were present. After evaporation of the soln, 12 and 13 were isolated by preparative vpc.

1-Cyclohexyl-2,3-dihydro-6-methyl-4-pyridone (12): $C_{12}H_{19}NO$ (M = 193.29). Mass *m/e*: 193 (60%), M^+; 150 (100%), $(M-C_3H_7)^+$; 83 (35%), $(C_6H_{11})^+$; 55 (50%), $(C_6H_{11}-C_2H_4)^+$. IR (neat): 1620 and 1541 cm^{-1}. UV (MeOH): λ_{max} 328 nm (ϵ = 18,000). IR and UV values are similar to those reported for model compounds.[18e-g,22] ^1H NMR (C_6D_6): 5.17, s (HC=C); 3.07, part. m and 2.85, t, J = 7 Hz (CHN and CH_2N); 2.18, t, J = 7 Hz (CH_2CO); 1.50, s and 0.67–1.80, m (CH_3 and 5 CH_2).

Reaction of aminoester 9 with methyl acrylate. A 0.8 M benzene soln of both products was heated (bath 60°) for 15 hr. Conversion of aminoester 9 was 18% and the only compound formed was the tertiary amine 13.

Alkylation of imine 1b by methyl acrylate in presence of molecular sieves—SiO_2/Al_2O_3 catalyst. 0.01 mole (1.39 g) of imine 1b and 0.01 mole (0.86 g) of methyl acrylate were mixed in 12.5 ml of benzene (0.8 M soln). 4 g of molecular sieves SiO_2/Al_2O_3 catalyst[f] was added and the mixture was refluxed for 14h30. *ca.* 50% conversion of reactants was observed. Compounds 3b (22%), 5 (6%), 9 (29%), 7 (11%) and 8 (32%) were obtained but no trace of enaminoketone 12 was detected.

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[f]Prepared by mixing 32 g of 3 Å powder molecular sieves with 8 g SiO_2/Al_2O_3 catalyst[15] and heating 3 h in an oven at 400° under a vacuum of 0.1 Torr.