α-Isocyanatoacrylonitriles from Alkylidene- or Arylidenecyanoacetic Acids; Synthesis and Reactions

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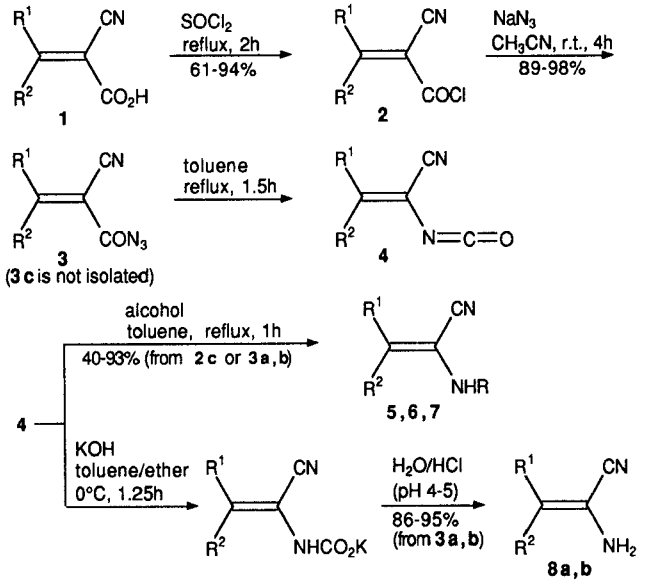
The Curtius reaction converts alkylidene- or arylidenecyanoacetic acids to α-isocyanatoacrylonitriles in a stereospecific way. These versatile intermediates allow an easy access to arylacetic acids and various amino acid derivatives, as well as β-lactams or 2-azabutadienes.

Alkylidene- or arylidenecyanoacetic acids are versatile synthetic intermediates, readily obtained by Knoevenagel condensation.[1,2] In this paper, we describe a further application of these compounds. By Curtius reaction, they afford a stereospecific access to α-isocyanatoacrylonitriles. We report here some aspects of the usefulness of this functional group interconversion.

Curtius reaction has been extensively used for amino acid synthesis from malonic derivatives[3] and Stammer has reported the conversion of methyl benzylidenemalonate to didehydrophenylalaninate.[4] The lack of stereoselectivity precluded a further use of the reaction. The choice of α-cyanoacrylic acids **1** for starting materials allowed us to overcome this difficulty (Scheme 1).



Product	R^1	R^2
1-8 a	C_6H_5	H
1-8 b	*p* $MeOC_6H_4$	H
1-6 c	cyclohexyl	

Product	R
5a,b,c	CO_2Me
6a,b,c	CO_2tBu
7a,b	CO_2Et

Scheme 1

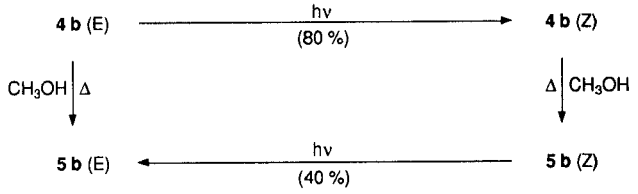
Compounds **1**, obtained as pure *E*-isomers for **1a** and **1b**,[5] were converted to acid chlorides **2** with thionyl chloride and then to acylazides **3** with sodium azide in dry acetonitrile. Aromatic acylazides **3a,b** are stable crystalline compounds, while the aliphatic derivative **3c** gives rise to a slow extrusion of nitrogen at room temperature and was not isolated.

Thermolysis of acylazides **3** was performed in anhydrous boiling toluene. As isocyanates **4** slowly polymerise upon exposure to air, they are best characterized after conversion into carbamates **5,6** or **7** by treatment with the appropriate alcohol.

The Curtius reaction was also performed with isopropylidenecyanoacetic acid (**1**, $R^1 = R^2 = CH_3$). The corresponding methyl carbamate $Me_2C{=}C(CN)NHCO_2Me$, obtained as nice white crystals, promoted a severe allergy to one of us and we have avoided further studies with aliphatic derivatives.

The very sensitive, unprotected α-aminoacrylonitriles **8a** and **8b** have also been synthesized (Scheme 1). Addition of concentrated aqueous potassium hydroxide to isocyanates **4a,b** promotes the crystallization of the corresponding potassium carbamates. A careful treatment at pH 4–5 with immediate extraction allows isolation of the free amines **8a,b**.

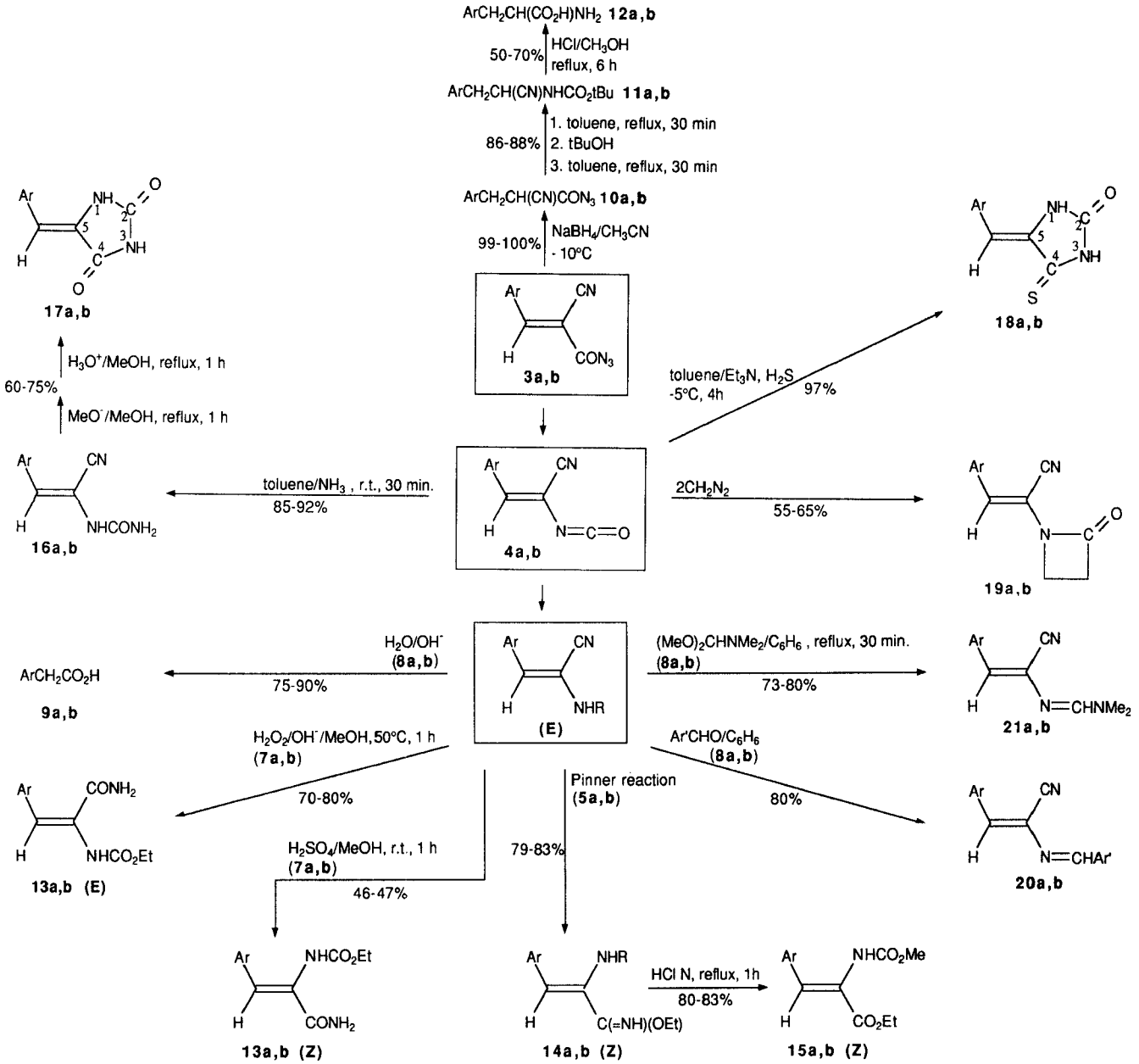
As expected, the Curtius reaction occurs with retention of configuration.[6] Vinylic isocyanates **4a,b** and the corresponding carbamates **5a,b** or **6a,b** were obtained as pure *E*-isomers. The assignment of configuration was performed by NMR spectroscopy, by comparison of the data of both stereoisomers of **4b** and **5b**, obtained by photoisomerisation:



In the ^1H NMR spectra, vinylic hydrogens of the *E*-isomers are deshielded by at least 0.4 ppm, compared with those of the *Z*-isomers. In ^{13}C NMR spectra, the $^3J_{CH}$ coupling constant between the cyano carbon and the vinylic hydrogen is 13 Hz for (*E*)-**5b** and 6 Hz for (*Z*)-**5b**, in good agreement with the literature[4] (Table 1).

For synthetic applications, preferentially aryl derivatives have been investigated. α-Isocyanato- or α-aminoacrylonitriles allow an efficient access to a variety of compounds (Scheme 2).

Reaction of α-aminoacrylonitriles **8** with base followed by treatment with acid gives the corresponding arylacetic acids **9a** or **9b**. The net result of this reaction, that proceeds probably through a carbonyl cyanide intermediate, is a one-carbon homologation of the aldehyde used in the Knoevenagel condensation.



Ar : C_6H_5	*p* $MeOC_6H_4$	R : CO_2Me	CO_2Et	H
a	b	5a,b	7a,b	8a,b

Scheme 2

The synthesis of racemic α-amino acids **12** implies a reduction that is best conducted on acylazides **3** (Scheme 2). With sodium borohydride in anhydrous acetonitrile, a selective hydrogenation of the double bond occured and amino acids **12a** and **12b** were then obtained, according to the Curtius procedure,[3] in 50% and 70% overall yield.

Selective hydrolysis of the cyano group has been performed in several ways with carbamates **5a,b** or **7a,b**. According to experimental procedures, both stereoisomers of α-aminoacrylamides **13a,b** were isolated in good yields. Hydrolysis with hydrogen peroxide in alkaline media afforded *E*-isomers with retention of configuration, while sulfuric acid promoted an isomerisation to the more stable *Z*-isomers.[4] Pinner reaction, with ethanolic hydrogen chloride, led to *Z*-imidates **14a,b**, readily converted to (*Z*)-α-aminoacrylates **15a,b** with dilute hydrochloric acid. When the reaction was performed with methanolic hydrogen chloride and methyl carbamates **5a,b**, amides (*Z*)-**13** (R = CO_2Me) were isolated (Scheme 2). Assignments of configuration were performed by NMR spectroscopy and are in good agreement with several studies on the isomerisation of related compounds.[4,7,8]

Heterocyclic derivatives of didehydroamino acids are readily available by treatment of isocyanates **4** with appropriate nucleophiles. Intramolecular attack of the cyano group allowed very clean and nearly quantitative reac-

Table 1. Compounds **3** to **8** Prepared

Product[a]	Yield (%)	mp (°C)	IR (Nujol) ν (cm^{-1})	^1H NMR ($CDCl_3$/TMS, 80 MHz)[b] δ, J (Hz)
(*E*)-**3a**	89	120	2218, 2150, 1650	8.30 (s, 1H)
(*E*)-**3b**	98	138	2216, 2150, 1650	3.87 (s, 3H), 8.20 (s, 1H)
3c[c]	–	–	–	1.70–1.80 (m, 6H), 2.85–2.70 (m, 4H)
(*E*)-**4a**	–	–	2220, 1670	6.87 (s, 1H)
(*E*)-**4b**	–	–	2220, 1665	3.78 (s, 3H), 6.75 (s, 1H)
(*Z*)-**4b**[d]	–	–	–	3.78 (s, 3H), 6.37 (s, 1H)
(*E*)-**5a**	74	86	3270, 2225, 1710, 1635	3.73 (s, 3H), 6.88 (br s, 1H)[e]
(*E*)-**5b**	70	127	3290, 2230, 1700, 1650	3.82 (s, 3H), 3.86 (s, 3H), 6.55 (br s, 1H), 7.19 (s, 1H)[f]
(*Z*)-**5b**	–	127	3270, 2200, 1700, 1635	3.82 (s, 3H), 3.84 (s, 3H), 6.42 (br s, 1H), 6.67 (s, 1H)[g]
5c	72	78	3290, 2220, 1710, 1640	1.30–1.70 (m, 6H), 2.25–2.62 (m, 4H), 3.68 (s, 3H), 6.40 (br s, 1H)
(*E*)-**6a**	65	100	3240, 2220, 1680, 1615	1.43 (s, 9H), 6.85 (br s, 1H), 7.05 (s, 1H)
(*E*)-**6b**	89	70	3240, 2215, 1685, 1605	1.55 (s, 9H), 3.85 (s, 3H), 6.55 (br s, 1H), 7.10 (s, 1H)
6c	40	100	3240, 2210, 1721, 1632	1.58 (s, 9H), 1.62–1.95 (m, 6H), 2.06–2.62 (m, 4H), 6.50 (br s, 1H)
(*E*)-**7a**	91	100	3305, 2230, 1735, 1625	1.31 (t, 3H, J = 7.0), 4.23 (q, 2H, J = 7.0), 6.84 (br s, 1H)[e]
(*E*)-**7b**	93	92	3270, 2230, 1700, 1615	1.32 (t, 3H, J = 7.0), 3.80 (s, 3H), 4.24 (q, 2H, J = 7.0), 6.95 (br s, 1H), 7.15 (s, 1H)
(*E*)-**8a**	86	85	3250, 3150, 2220, 1660	3.40 (br s, 2H), 6.20 (s, 1H)
(*E*)-**8b**	95	96	3260, 3160, 2220, 1665	3.40 (br s, 2H), 3.79 (s, 3H), 6.25 (s, 1H)

[a] Satisfactory microanalyses obtained C ± 0.23, H ± 0.07, N ± 0.15.
[b] Aromatic signals are not reported.
[c] Compounds **3c** and **4a,b,c** are unstable and not isolated.
[d] Obtained as a mixture with *E*-isomer.
[e] Signal of vinylic proton masked by those of aromatic protons.
[f] ^{13}C NMR (20.115 MHz): δ = 53.1 (q, ^1J = 147 Hz), 55.4 (q, ^1J = 143 Hz), 104.5, 116.0 ($^3J_{CN,=CH}$ = 13 Hz), 135.8 (d, ^1J = 157 Hz), 154.5.
[g] ^{13}C NMR (20.115 MHz): δ = 53.3 (q, ^1J = 148 Hz), 55.5 (q, ^1J = 144 Hz), 106.3, 116.8 ($^3J_{CN,=CH}$ = 6 Hz), 134.8 (^1J = 151 Hz), 154.1.

tions. Ammonia afforded the ureido derivatives **16**, readily converted to arylidenehydantoins **17**. Hydrogen sulfide, with a catalytic amount of triethylamine, led directly to thiohydantoins **18**. Structural assignments depend mainly on ^{13}C NMR spectroscopy. Chemical shifts of carbonyl or thiocarbonyl groups are indicative. Moreover, $^3J_{CH}$ coupling constants between the vinylic hydrogen and the C-4 carbonyl or thiocarbonyl carbon, are in the range 6–7 Hz, in agreement with a *Z*-configuration.

A further aspect of the reactivity of α-isocyanatoacrylonitriles **4** was exemplified by cycloaddition reactions. Diazomethane led to β-lactams **19a,b** with two consecutive methylene insertions. Such a reaction has been reported with phenylisocyanate.[9]

Azeotropic distillation of α-aminoacrylonitriles **8a,b** with *p*-chlorobenzaldehyde or dimethylformamide dimethyl acetal afforded 3-cyano-2-azabutadienes **20** or **21**, which are currently used as substrates for cycloaddition reactions.

^1H NMR and ^{13}C NMR spectra were recorded on Bruker WP 80 CW and WP 80 DS spectrometers ($CDCl_3$/TMS). IR spectra were obtained on a Perkin–Elmer 157G or 1420 spectrophotometer. Microanalyses were performed by the Laboratoire Central de microanalyse du CNRS (Lyon). Mass spectra were recorded on a Varian MAT 311 spectrometer. Melting points were measured using a Köfler apparatus and were uncorrected.

Alkylidene- or arylidenecyanoacetic acids **1** were obtained according to the literature procedure.[10]

Cyanoacryloyl chlorides **2a** and **2b** were prepared by refluxing the acids **1** (20 g, 100–120 mmol) for 2 h with excess $SOCl_2$ (60 mL) and crystallization from CCl_4. For **2c**, a solution of acid (20 g, 120 mmol) and $SOCl_2$ (60 mL) in $CHCl_3$ (100 mL) was refluxed 4 h before distillation.

2a, mp: 65 °C, yield: 78%. **2b**, mp: 100 °C, yield: 94%. **2c**, bp: 120 °C/0.5 Torr, yield: 61%.

α-Cyanoacryloyl Azides 3; General Procedure:
NaN_3 (1.3 g, 20 mmol) was added to a solution of chloride **2** (10 mmol) in MeCN (30 mL). The mixture was stirred for 4 h at r.t. under N_2. CH_2Cl_2 (100 ml) was added and the mixture was washed with cold H_2O and dried ($MgSO_4$) before removal of solvents under reduced pressure. Compounds **3a** and **3b** were crystallized from EtOH. **3c** was immediately submitted to thermolysis (Table 1).

Solutions of α-Isocyanatoacrylonitriles 4; General Procedure:
A solution of α-cyanoacryloyl azide **3** (10 mmol) in anhydr. toluene (100 mL) was refluxed for 1.5 h **(4a, 4b)** or 0.5 h **(4c)** (Table 1). Further reactions with isocyanates **4** were best conducted using these toluene solutions.

Photoisomerisation of (*E*)-**4b** was performed with a Philips HPK 125 Watt lamp for 5.5 h at r.t. in toluene.

(*N*-Alkoxycarbonyl)-α-aminoacrylonitriles 5, 6, 7; General Procedure:
The appropriate alcohol (10 mL) was added to a solution of isocyanate **4** (10 mmol) in toluene (100 mL). The mixture was refluxed for 1 h and the solvent was removed in vacuo. Carbamates **5, 6, 7** were crystallized from EtOH (Table 1).

Mixture of (*E*/*Z*)-**4b** (20:80) obtained by photoisomerisation of (*E*)-**4b** led to a mixture of (*E*/*Z*)-**5b** (20:80). (*Z*)-**5b** was crystallized from MeOH before photoisomerisation.

α-Aminoacrylonitriles 8; General Procedure:
KOH (1.12 g, 20 mmol) in H_2O (1 mL) was added at 0 °C under vigorous stirring to isocyanate **4** (10 mmol) in toluene (100 mL). After 15 min Et_2O (50 mL) was added to promote the crystallization of potassium carbamates, which were filtered, washed with Et_2O, and poured into H_2O (25 mL). By careful addition of 1 N HCl

(~ 40 mL), the pH was adjusted to 5 and the mixture was immediately extracted with CH_2Cl_2 when the emission of CO_2 subsided. After drying, the solvent was evaporated, and aminoacrylonitriles **8** were recrystallized from Et_2O/hexane (Table 1). The products can be stored for a few days.

Arylacetic Acids 9; General Procedure:
1 N NaOH (25 mL) was added to α-aminoacrylonitriles **8a** or **8b** (0.2 g) in MeOH (25 mL). After 1.5 h at r.t., 1 N HCl was added and arylacetic acids **9** extracted with CH_2Cl_2. The acids **9** obtained were similar to the commercially available samples.

9a, mp: 77 °C, yield: 75%. **9b**, mp: 83 °C, yield: 90%.

***rac*-Phenylalanine (12a) and *rac*-*O*-Methyltyrosine (12b):**
A solution of $NaBH_4$ (0.16 g, 4.2 mmol) in MeCN (20 mL) was cooled to – 20 °C. α-Cyanoacryloyl azides **3a** or **3b** (4.2 mmol) were added under good stirring. After 5 min, the mixture was poured into 2 N HCl and extracted with Et_2O. The intermediate azides **10** obtained in almost quantitative yields were characterized only by NMR spectroscopy (Table 2).

The crude azides **10** were then converted to the corresponding *tert*-butyl carbamates by boiling in toluene (100 mL) for 0.5 h followed by addition of *tert*-butanol (10 mL), and boiling again for a further 0.5 h Solvents were distilled under reduced pressure and the residual carbamates **11** were recrystallized from H_2O/EtOH (Table 2).

Hydrolysis of carbamates **11** was performed by refluxing for 6 h a mixture of carbamate (1 g, ~ 4 mmol), MeOH (5 mL) and concentrated HCl (25 mL). Hydrochlorides were isolated by evaporation to dryness and dissolved in H_2O (10 mL). 1 N ammonia solution was added until pH 5 was obtained and the amino acids were allowed to crystallize for 24 h (Table 2). The products were similar to the commercially available samples.

(*N*-Ethoxycarbonyl)-α-aminoacrylamides 13; General Procedure:
(E)-Isomers: A solution of ethyl carbamate **7** (4 mmol) in MeOH (20 mL) was added to a mixture of 30% H_2O_2 (10 mL) and 1 N NaOH (4 mL). After 1 h at 50 °C, the mixture was made acidic with 1 N HCl and extracted with CH_2Cl_2. After elimination of solvent, amides were recrystallized from toluene (Table 2).

Table 2. Compounds **10** to **21** Prepared

Product[a]	Yield (%)	mp (°C)	IR (Nujol) ν (cm^{-1})	^{1}H NMR ($CDCl_3$/TMS, 80 MHz)[b] δ, J (Hz)
10a	99–100	oil	2240, 2140, 1725	3.10–3.30 (m, 2H), 3.60–3.80 (m, 1H)
10b	99–100	71	2250, 2150, 1730	3.15–3.25 (m, 2H), 3.60–3.75 (m, 1H), 3.80 (s, 3H)
11a	86	76	3355, 2240, 1690	1.48 (s, 9H), 3.00 (d, 2H, J = 7.0), 4.50–4.87 (m, 1H, CH), 5.37 (d, 1H, J = 8.0, NH)
11b	77	88	3360, 2240, 1690	1.50 (s, 9H), 3.00 (d, 2H, J = 6.0), 3.80 (s, 3H), 4.50–4.87 (m, 1H, CH), 5.00 (d, 1H, J = 8.0, NH)
12a	50	260–265 (dec)	–	3.30–3.60 (m, 2H), 4.50–5.30 (m, 1H)[c]
12b	70	255–260 (dec)	–	3.30–3.60 (m, 2H), 4.00 (s, 3H), 4.50–4.70 (m, 1H)[c]
(*E*)-**13a**	80	130	3470, 3320, 3180, 1720, 1660, 1640	1.15 (t, 3H, J = 7.0), 4.17 (q, 2H, J = 7.0), 7.40 (s, 1H)
(*E*)-**13b**	70	128	3480, 3350, 3240, 1730, 1675, 1630	1.05 (t, 3H, J = 7.0), 3.55 (s, 3H), 4.10 (q, 2H, J = 7.0), 7.61 (s, 1H)
(*Z*)-**13a**	46	130	3470, 3330, 3180, 1720, 1660, 1640	1.06 (t, 3H, J = 7.0), 4.06 (q, 2H, J = 7.0), 7.26 (s, 1H)
(*Z*)-**13b**	47	128	3440, 3340, 3260, 1690, 1650, 1610	1.15 (t, 3H, J = 7.0), 3.61 (s, 3H), 4.17 (q, 2H, J = 7.0), 7.35 (s, 1H)
(*Z*)-**14a**	79	130	3340, 3170, 1745, 1650, 1610	1.34 (t, 3H, J = 7.0), 3.70 (s, 3H), 4.25 (q, 2H, J = 7.0), 6.50 (s, 2H, 2NH), 6.98 (s, 1H)
(*Z*)-**14b**	83	146	3320, 3150, 1725, 1638, 1595	1.38 (t, 3H, J = 7.0), 3.68 (s, 3H), 3.78 (s, 3H), 4.25 (q, 2H, J = 7.0), 6.58 (s, 2H, 2NH), 7.02 (s, 1H)
(*Z*)-**15a**	80	95	3300, 1740, 1690, 1650	1.30 (t, 3H, J = 7.0), 3.65 (s, 3H), 4.26 (q, 2H, J = 7.0), 6.38 (s, 1H, NH)[d]
(*Z*)-**15b**	83	107	3300, 1740, 1695, 1650	1.35 (t, 3H, J = 7.0), 3.68 (s, 3H), 3.82 (s, 3H), 4.26 (q, 2H, J = 7.0), 6.30 (s, 1H, NH), 7.30 (s, 1H, CH)
16a	85	170	3480, 3360, 3280, 3220, 2230, 1715, 1680, 1650	6.12 (s, 2H), 7.18 (s, 1H, CH), 8.75 (s, 1H, NH)[e]
16b	92	204	3450, 3340, 3260, 3200, 2210, 1705, 1665 (br.)	3.80 (s, 3H), 5.60 (s, 2H), 7.17 (s, 1H, CH), 7.90 (s, 1H, NH)[f]
17a	75	223[g]	3540, 3460, 3290, 1735, 1710, 1650	6.43 (s, 1H, CH), 10.50 (s, 1H, NH), 11.23 (s, 1H, NH)[e]
17b	60	247[h]	3250, 3170, 3030, 1755, 1710, 1650	3.80 (s, 3H), 6.40 (s, 1H, CH), 10.38 (s, 1H, NH), 11.12 (s, 1H, NH)[e]
18a	97	232[i]	3210, 3120, 1740, 1635	6.85 (s, 1H, CH), 10.67 (s, 1H, NH), 12.55 (s, 1H, NH)[e]
18b	97	260[j]	3230 (br), 1715, 1635	3.80 (s, 3H), 6.84 (s, 1H, CH), 10.65 (s, 1H, NH), 12.50 (s, 1H, NH)[e]
19a	65	129	2207, 1735, 1620	3.00 (t, 2H, J = 4.5), 3.65 (t, 2H, J = 4.5)[d]
19b	55	123	2205, 1732, 1607	2.90 (t, 2H, J = 4.5), 3.50 (t, 2H, J = 4.5), 3.75 (s, 3H), 7.25 (s, 1H)
20a	80	72	2200, 1615, 1590	7.58 (s, 1H, CH=C), 8.63 (s, 1H, CH=N)
20b	80	98	2205, 1615, 1590	3.85 (s, 3H), 7.55 (s, 1H, CH=C), 8.60 (s, 1H, CH=N)
21a	73	–[k]	2210, 1635, 1590	2.95 (s, 6H), 6.87 (s, 1H, CH=C), 7.78 (s, 1H, CH=N)
21b	80	59	2200, 1635, 1600	2.96 (s, 6H), 3.75 (s, 3H), 6.84 (s, 1H, CH=C), 7.78 (s, 1H, CH=N)

[a] Satisfactory microanalyses obtained: C ± 0.38, H ± 0.38, N ± 0.41.
[b] Aromatic signals are not reported.
[c] Solvent: CF_3CO_2H.
[d] Signal of vinylic proton masked by those of aromatic protons.
[e] Solvent: DMSO-d_6.
[f] Solvent: acetone-d_6.
[g] Lit.[11] mp 220 °C.
[h] Lit.[12] mp 243–244 °C.
[i] Lit.[13] mp 228 °C.
[j] Lit.[13] mp 266 °C.
[k] bp = 190 °C/0.2 Torr.

Table 3. ^{13}C NMR Data of Selected Compounds (20.115 MHz)

Product	DMSO-d_6/TMS δ, J (Hz)
(*Z*)-**15a**	14.3 (q, $^1J_{C,H}$ = 127), 52.8 (q, $^1J_{C,H}$ = 148), 61.8 (t, $^1J_{C,H}$ = 147), 125.1 (C-2), 131.4 (d, $^1J_{C,H}$ = 157, C-3), 154.8 ($NHCO_2Me$), 165.5 ($^3J_{C,=CH}$ = 5, C-1)[a]
(*Z*)-**15b**	14.3 (q, $^1J_{C,H}$ = 127), 52.8 (q, $^1J_{C,H}$ = 147), 55.3 (q, $^1J_{C,H}$ = 144), 61.6 (t, $^1J_{C,H}$ = 148), 122.5 (C-2), 132.1 (d, $^1J_{C,H}$ = 158, C-3), 154.8 ($NHCO_2Me$), 165.6 ($^3J_{C,=CH}$ = 4, C-1)[a]
17a	108.6 (d, $^1J_{C,H}$ = 159), 133.1 (C-5), 155.8 (C-2), 165.7 ($^3J_{C,=CH}$ = 7, C-4)
17b	55.3 (q, $^1J_{C,H}$ = 144), 108.8 (d, $^1J_{C,H}$ = 157), 126.3 (C-5), 155.8 (C-2), 165.8 ($^3J_{C,=CH}$ = 6, C-4)
18a	113.2 (d, $^1J_{C,H}$ = 159), 134.6 (C-5), 156.6 (C-2), 191.8 ($^3J_{C,=CH}$ = 7, C-4)
18b	55.4 (q, $^1J_{C,H}$ = 145), 114.0 (d, $^1J_{C,H}$ = 159), 133.3 (C-5), 156.5 (C-2), 191.4 ($^3J_{C,=CH}$ = 6, C-4)

[a] Solvent: $CDCl_3$.

(*Z*)-*Isomers:* Ethyl carbamate **7** (0.5 g) were dissolved in a mixture of MeOH (1 mL) and 95% H_2SO_4 (1 mL). After 1 h at r.t., the mixture was poured on ice and extracted with CH_2Cl_2. α-Aminoacrylamides were isolated as described above (Table 2).

Ethyl (*N*-Methoxycarbonyl)-α-aminoacrylates 15; General Procedure:

A solution of methyl carbamate **5** (10 mmol) in EtOH (50 mL) was saturated with dry HCl at −40°C. After 1 h, the cooling was removed and the mixture was kept 15 h at r.t. and then poured onto ice (100 g). After neutralisation with sat. $NaHCO_3$, imidates **14** were extracted with CH_2Cl_2. After drying and removal of the solvent, they were recrystallized from MeOH. After treatment of these imidates (2 mmol) with 1 N HCl (50 mL) 1 h at reflux and neutralisation with $NaHCO_3$, the mixture was extracted with CH_2Cl_2. The α-aminoacrylates **15** obtained after drying and removal of the solvent were recrystallized from MeOH (Tables 2 and 3).

5-Arylidenehydantoins 17; General Procedure:

NH_3 (28%, 20 mL) was added to isocyanate **4** (10 mmol) in toluene (100 mL). After stirring for 0.5 h at r.t., 2-ureidoacrylonitriles **16** were filtered and recrystallized from MeOH (Table 2).

A solution of urea **16** (5 mmol) and NaOMe (10 mmol) in MeOH (100 mL) was refluxed for 1 h. Then 6 M HCl (40 mL) were added and the mixture refluxed for an additional 1 h. The major part of the MeOH was eliminated in vacuo and hydantoin **17** was filtered and recrystallized from MeOH (Tables 2 and 3).

5-Arylidenethiohydantoins 18; General Procedure:

One drop of Et_3N was added to a solution of isocyanate **4** (10 mmol) in toluene (100 mL). The mixture was saturated at −5°C with H_2S for 3 min and kept at −5°C for 4 h. Thiohydantoins were filtered and crystallized from MeOH (Tables 2 and 3).

1-(1-Cyanovinyl)-2-azetidinones 19; General Procedure:

A solution of isocyanate **4** (10 mmol) in toluene (100 mL) was added to an ethereal solution of CH_2N_2 (20 mmol) at −20°C. After 0.5 h, solvent and excess CH_2N_2 were eliminated under reduced pressure and the residue recrystallized from MeOH (Table 2).

2-Aza-3-cyanobutadienes 20; General Procedure:

A solution of α-aminoacrylonitrile **8** (10 mmol) and benzaldehyde (10 mmol) in benzene (50 mL) was refluxed 6 h using a Dean-Stark apparatus. After removal of the solvent, the crude azadienes were recrystallized from benzene (Table 2).

2-Aza-3-cyano-1-(dimethylamino)butadienes 21; General Procedure:

A solution of α-aminoacrylonitrile **8** (10 mmol) and DMF dimethyl acetal (10 mmol) in benzene (50 mL) was refluxed for 0.5 h. The solvent was removed and azadienes **21** were recrystallized from Et_2O/hexane (Table 2).

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