Synthesis of Heterocyclic Ketene *N,S*-Acetals and Their Reactions with Esters of α,β-Unsaturated Acids

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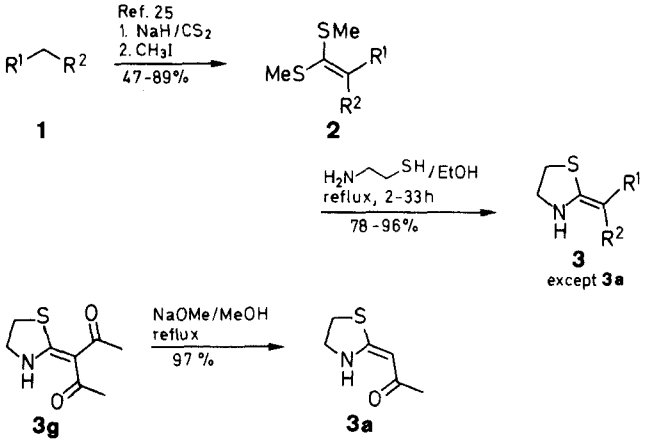
Ketene *S,S*-acetals **2** react with 2-amino-1-ethanethiol to afford the substituted 2-methylenethiazolidines **3**. The structure of these products as ketene *N,S*-acetals is confirmed by spectroscopic data. Compounds **3a–f** react with esters of α,β-unsaturated acids to give thiazolo[3,2-*a*]pyrid-5-one derivatives **4**, **6**, and **7** through an electrophilic addition and cyclocondensation sequences.

Heterocyclic ketene *N,N*-acetals are versatile starting materials for the synthesis of a wide variety of fused heterocycles. Thus, the synthesis and reactions of heterocyclic ketene *N,N*-acetals have attracted much attention.[1–18] However, their monosulfur analogs, heterocyclic ketene *N,S*-acetals, were studied only in a few cases.[3–7,19–22] Here, we describe the synthesis of heterocyclic ketene *N,S*-acetals and their reactions with esters of α,β-unsaturated acids. By the latter reactions, some 2,3-dihydrothiazolo[3,2-*a*]pyrid-5-one derivatives were synthesized.

Heterocyclic ketene *N,S*-acetals **3b–n** were synthesized by the reaction of ketene *S,S*-acetals **2b–n** with 2-aminoethanethiol in boiling absolute ethanol in good to excellent yields. The reaction time is dependent on the structure of **2**, in general, the stronger the electron-withdrawing effect of X and Y, the more rapid the reaction. The starting materials **2** were prepared by the reaction of active methylene compounds **1** with sodium

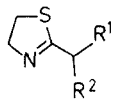


1–7	R^1	R^2	1–7	R^1	R^2
a	H	$COCH_3$	**h**	CO_2Me	$COCH_3$
b	H	COPh	**i**	CO_2Et	$COCH_3$
c	H	$COC_6H_4CH_3$-4	**j**	CO_2Et	CO_2Et
d	H	COC_6H_4OMe-4	**k**	CN	CN
e	H	COC_6H_4Cl-4	**l**	CN	CO_2Me
f	H	NO_2	**m**	CN	CO_2Et
g	$COCH_3$	$COCH_3$	**n**	CN	Ph

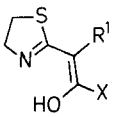
Scheme A

hydride and carbon disulfide, then alkylation with methyl iodide in a one-pot reaction. Ketene *N,S*-acetal **3a** was synthesized by the reaction of **3g** with sodium methoxide with elimination of one acetyl group (Scheme **A**)

The structure of the products **3** is confirmed by microanalytical data and mass spectra. There is only one set of signals in the ^{1}H- and ^{13}C-NMR spectra for **3**; this indicates that these compounds are not a mixture. The absence of a methine or methylene proton signal and the presence of a nitrogen proton signal in the ^{1}H-NMR spectra of **3** exclude the tautomer **A** and the presence of the ketone or ester carbonyl carbon signal in the ^{13}C-NMR spectra of **3a–e, 3g–j** and **3l,m** excludes also the tautomer **B**.



A



B X = CH_3, Ph, Ar, OEt, OMe

The *E* or *Z* structure can be assigned to **3** utilizing the intramolecular hydrogen bond formation in **3a–f, 3h,i** and **3l,m**. The intramolecular hydrogen bond formation is shown by the downfield shift (δ = 9.38–11.50, see Table 2) of the NH signal in the ^{1}H-NMR spectra. This suggests that **3a–f** and **3l,m** have *E*-configuration, and **3h,i** have *Z*-configuration. This method could not be used to determine the stereochemistry of **3n**.

The spectroscopic data listed in Tables 1–3 show the bathochromic shift of the carbonyl and double bond absorption in the IR spectra, and the upfield shift of the carbonyl carbon signal in the ^{13}C-NMR spectra, which are due to the conjugation of the carbonyl group with the double bond and nitrogen and sulfur atoms. Ketene *N,S*-acetals **3** show the chracteristic A_2B_2 pattern in the ^{1}H-NMR spectra, which is due to the $NHCH_2CH_2S$ structural segment.

The upfield shift of the signal of C-4 indicates that this atom possesses higher electron density, so that electrophilic attack may be expected to occur at this carbon atom. The formation of α-pyridone derivatives by way of reaction of enamines with acrylic acid has been reported.[23] Recently, we reported some reactions of heterocyclic ketene *N,N*-acetals with electrophilic reagents on this carbon atom. In the reaction with α,β-unsaturated esters, fused heterocyclic compounds with α-pyridone rings are formed by sequencial electrophilic addition and cyclocondensation.[12–17] The reactions of **3a–f** with α,β-unsaturated esters are similar and the products are biheterocycles with a thiazolidine ring fused to an α-pyridone.

Compounds **3a–e** reacted smoothly with methyl propiolate in boiling absolute ethanol to give crystalline products in good yields. The microanalytical data and mass spectra indicate that condensation of **3a–e** with methyl propiolate has taken place, with elimination of methanol.

Table 1. Compounds **3** Prepared

Product	Reaction Time (h)	Yield[a] (%)	mp (°C)	Molecular Formula[b] or Lit. mp (°C)	UV (EtOH) λ_{max} (nm) (log ε)	IR (KBr) ν (cm^{-1})	MS (M$^+$) *m/z* (%)
3a	–	97	97.5–98.5	C_6H_9NOS (143.2)	252 (2.98) 308 (4.53)	3152 (NH), 1593 (C=O), 1525 (C=C)	143 (50)
3b	24	88	172–173	$C_{11}H_{11}NOS$ (205.3)	246 (3.83) 340 (4.48)	3180 (NH), 1585, 1566 (C=O), 1500 (C=C)	205 (30)
3c	26	85	196–197.5	$C_{12}H_{13}NOS$ (219.3)	255 (3.85) 341 (4.60)	3155 (NH), 1585, 1560 (C=O), 1498 (C=C)	219 (36)
3d	33	79	153.5–154	$C_{12}H_{13}NO_2S$ (235.3)	267 (3.67) 341 (4.67)	3235 (NH), 1585, 1562 (C=O), 1500 (C=C)	235 (64)
3e	20	94	184–185	$C_{11}H_{10}ClNOS$ (239.7)	252 (3.90) 342 (4.39)	3155 (NH), 1588, 1560 (C=O), 1505 (C=C)	239 (79)
3f	20	86	137.5–139	141–143[22]	240 (3.00) 286 (sh) 344 (4.52)	3175 (NH), 1560 (C=C), 1435, 1317 (NO_2)	146 (36)
3g	12	92	124–125	126[20]	256 (4.10) 299 (4.09)	3150 (NH), 1615, 1552 (C=O), 1517 (C=C)	185 (35)
3h	12	85	102–103	$C_8H_{11}NO_3S$ (201.2)	241 (4.05) 294 (4.13)	3115 (NH), 1657 (ester C=O), 1580 (C=O), 1530 (C=C)	201 (30)
3i	12	84	79.5–80.5	$C_9H_{13}NO_3S$ (215.3)	241 (4.09) 294 (4.18)	3115 (NH), 1647 (ester C=O), 1575 (C=O), 1527 (C=C)	215 (30)
3j	12	82	66.5–67.5	$C_{10}H_{15}NO_4S$ (245.3)	228 (3.97) 282 (4.69)	3270 (NH), 1657, 1625 (ester C=O), 1527 (C=C)	245 (50)
3k	2	96	205–207	$C_6H_5N_3S$ (151.2)	248 (sh) 284 (4.06)	3190 (NH), 2215 (CN), 1568 (C=C)	151 (63)
3l	4	92	100.5–101	96–99[19]	249 (sh) 284 (4.25)	3260 (NH), 2197 (CN), 1660 (ester C=O), 1560 (C=C)	184 (42)
3m	5	91	128–129	125[20]	250 (sh) 285 (4.22)	3300 (NH), 2205 (CN), 1663 (ester C=O), 1570 (C=C)	198 (35)
3n	24	88	97–98	$C_{11}H_{10}N_2S$ (202.3)	232 (3.73) 304 (4.16)	3280 (NH), 2180 (CN), 1542 (C=C)	202 (60)

[a] Yield of isolated product based on **2**.
[b] Satisfactory microanalyses obtained: C ±0.25, H ±0.12, N ±0.27.

Table 2. NMR Data of Compounds **3**

Product	^{1}H-NMR ($CDCl_3$/TMS), δ, J(Hz)	^{13}C-NMR ($CDCl_3$/TMS), δ
3a	2.02 (s, 3H, CH_3), 3.19, 3.85 (A_2B_2, 2H each, CH_2CH_2, J = 7.2), 5.28 (s, 1H, =CH), 10.09 (s, 1H, NH)	–
3b	3.21, 3.88 (A_2B_2, 2H each, CH_2CH_2, J = 7.5), 5.93 (s, 1H, =CH), 7.30–7.90 (m, 5H_{arom}), 10.63 (s, 1H, NH)	28.4 (SCH_2), 48.5 (NCH_2), 85.8 (=CH), 126.2, 127.6, 129.9, 139.5 (C_{arom}), 168.8 (C=CH), 183.6 (C=O)[a]
3c	2.30 (s, 3H, CH_3), 3.17, 3.71 (A_2B_2, 2H each, CH_2CH_2, J = 7.5), 6.07 (s, 1H, =CH), 7.17 (d, 2H_{arom}, J = 8.4), 7.71 (d, 2H_{arom}, J = 8.4), 10.58 (s, 1H, NH)	20.4 (CH_3), 28.4 (SCH_2), 48.4 (NCH_2), 85.7 (=CH), 126.3, 128.3, 136.8, 139.9 (C_{arom}), 168.4 (C=CH), 183.5 (C=O)[a]
3d	3.17, 3.85 (A_2B_2, 2H each, CH_2CH_2, J = 7.5), 3.79 (s, 3H, OCH_3), 5.88 (s, 1H, =CH), 6.83 (d, 2H_{arom}, J = 8.8), 7.78 (d, 2H_{arom}, J = 8.8), 10.33 (s, 1H, NH)	28.9 (SCH_2), 49.3 (NCH_2), 55.0 (OCH_3), 86.2 (=CH), 113.1, 128.6, 131.9, 161.5 (C_{arom}), 168.8 (C=CH), 185.1 (C=O)
3e	3.22, 3.91 (A_2B_2, 2H each, CH_2CH_2, J = 7.5), 5.86 (s, 1H, =CH), 7.28 (d, 2H_{arom}, J = 8.5), 7.71 (d, 2H_{arom}, J = 8.5), 10.57 (s, 1H, NH)	29.4 (SCH_2), 49.5 (NCH_2), 86.6 (=CH), 128.6, 129.0, 135.9, 139.1 (C_{arom}), 170.3 (C=CH), 183.0 (C=O)[a]
3f	3.24, 3.82 (A_2B_2, 2H each, CH_2CH_2, J = 7.5), 6.98 (s, 1H, =CH), 9.38 (s, 1H, NH)[a]	29.2 (SCH_2), 48.5 (NCH_2), 94.8 (=CH), 170.5 (C=CH)[a]
3g	2.42 (s, 6H, CH_3), 3.01, 3.88 (A_2B_2, 2H each, CH_2CH_2, J = 8.5), 11.80 (s, 1H, NH)	28.4 (SCH_2), 30.9 (CH_3), 48.4 (NCH_2), 110.6 (=CH), 177.0 (C=CH), 194.4 (CO)
3h	2.40 (s, 3H, $COCH_3$), 3.07, 3.88 (A_2B_2, 2H each, CH_2CH_2, J = 8.5), 3.75 (s, 3H, OCH_3), 11.50 (s, 1H, NH)	28.5 (SCH_2), 30.6 ($COCH_3$), 48.8 (OCH_3), 50.5 (NCH_2), 97.7 (=CCH), 168.3 (CO_2CH_3), 177.0 (C=CH), 194.7 ($COCH_3$)
3i	1.33 (t, 3H, J = 7.0, CH_2CH_3), 2.43 (s, 3H, $COCH_3$), 3.07, 3.89 (A_2B_2, 2H each, CH_2CH_2, J = 8.2), 4.24 (q, 2H J = 7.0, CH_2CH_3), 11.43 (s, 1H, NH)	14.2 (CH_2CH_3), 28.7 (SCH_2), 31.0 ($COCH_3$), 49.0 (NCH_2), 59.8 (CH_2CH_3), 98.2 (=CCO), 168.2 (CO_2CH_2), 177.2 (C=CH), 195.1 ($COCH_3$)
3j	1.30 (t, 6H, J = 7.0, CH_2CH_3), 3.09, 3.86 (A_2B_2, 2H each, CH_2CH_2, J = 8.2), 4.18 (q, 4H, J = 7.0, CH_2CH_3), 9.97 (s, 1H, NH)	13.5 (CH_2CH_3), 28.5 (SCH_2), 48.3 (NCH_2), 59.0 (CH_2CH_3), 86.4 (=CCO_2), 166.8, 168.0 (CO_2CH_2)
3k	3.46, 3.87 (A_2B_2, 2H each, CH_2CH_2, J = 7.6), 9.82 (s, 1H, NH)	31.0 (SCH_2), 42.2 (=CCN), 51.3 (NCH_2), 114.9, 116.7 (CN), 176.6 (C=CCN)[a]
3l	3.43, 4.07 (A_2B_2, 2H each, CH_2CH_2, J = 7.6), 3.72 (s, 3H, CH_3), 9.16 (s, 1H, NH)	29.4 (SCH_2), 50.6 (NCH_2), 51.2 (OCH_3), 66.4 (=CCN), 118.0 (CN), 166.7 (CO_2CH_3), 175.4 (C=CCN)
3m	1.30 (t, 3H, J = 7.0, CH_2CH_3), 3.48, 4.15 (A_2B_2, 2H each, CH_2CH_2, J = 8.0), 4.26 (q, 2H, J = 7.0, CH_2CH_3), 9.30 (s, 1H, NH)	14.0 (CH_2CH_3), 29.6 (SCH_2), 50.6 (NCH_2), 60.2 (CH_2CH_3), 67.4 (=CCN), 117.8 (CN), 166.6 (CO_2CH_2), 175.5 (C=CCN)
3n	3.27, 3.77 (A_2B_2, 2H each, CH_2CH_2, J = 7.4), 6.00 (s, 1H, NH), 7.20, 7.42 (m, 5H_{arom})	31.5 (SCH_2), 51.5 (NCH_2), 95.3 (=CCN), 125.3 (CN), 126.9, 126.7, 129.0, 129.3 (C_{arom}), 163.5 (C=CCN)[a]

[a] Recorded in DMSO-d_6.

Table 3. Compounds **4**, **6** and **7** Prepared

Product	Reaction Time (h) (solvent)	Yield[a] (%)	mp (°C)	Molecular Formula[b]	UV (EtOH) λ_{max} (nm) (log ε)	IR (KBr) ν (cm^{-1})	MS (M^+) m/z (%)
4a	25 (EtOH)	90	174–174.5	$C_9H_9NO_2S$ (195.2)	250 (3.65) 303 (3.96)	1667, 1627 (C=O), 1565	195 (69)
4b	40 (EtOH)	76	176–177	$C_{14}H_{11}NO_2S$ (257.3)	255 (4.33) 313 (4.24)	1650, 1607 (C=O), 1568	257 (50)
4c	36 (EtOH)	81	213–214	$C_{15}H_{13}NO_2S$ (271.3)	258 (4.12) 324 (4.10)	1665, 1640, 1603 (C=O), 1568	271 (25)
4d	30 (EtOH)	87	173–174	$C_{15}H_{13}NO_3S$ (287.3)	260 (3.90) 316 (4.24)	1668, 1640, 1603 (C=O), 1570, 1560	287 (33)
4e	48 (EtOH)	65	164–165	$C_{14}H_{10}ClNO_2S$ (291.7)	258 (4.20) 324 (4.00)	1668, 1642, 1608 (C=O), 1583, 1568	291 (65)
6a	2 (MeOH)	93	153.5–154	$C_{11}H_{11}NO_4S$ (253.3)	248 (3.55) 306 (3.78)	1730, 1672, 1635 (C=O), 1480	253 (83)
6b	6 (MeOH)	87	194.5–195	$C_{16}H_{13}NO_4S$ (315.3)	251 (4.11) 324 (3.82)	1715, 1672, 1625 (C=O), 1483	315 (81)
6c	6 (MeOH)	90	203.5–204.5	$C_{17}H_{15}NO_4S$ (329.4)	256 (4.02) 324 (3.85)	1712, 1672, 1635 (C=O), 1594, 1480	329 (43)
6d	4 (MeOH)	91	173.5–174	$C_{17}H_{15}NO_5S$ (345.4)	244 (sh) 312 (3.96)	1720, 1660, 1627 (C=O), 1595, 1505	345 (30)
6e	8 (MeOH)	83	195.5–196.5	$C_{16}H_{12}ClNO_4S$ (349.8)	258 (4.26) 328 (3.82)	1710, 1672, 1625 (C=O), 1580, 1483	349 (67)
6f	10 (MeOH)	78	215–215.5	$C_9H_8N_2O_5S$ (256.2)	276 (3.71) 326 (sh) 354 (3.85)	1720, 1685, 1675 (C=O), 1520, 1330 (NO_2), 1520	256 (24)

Table 3. (continued)

Product	Reaction Time (h) (solvent)	Yield[a] (%)	mp (°C)	Molecular Formula[b]	UV (EtOH) λ_{max} (nm) (log ε)	IR (KBr) ν (cm^{-1})	MS (M^+) m/z (%)
7a	60 (EtOH)	46	107.5–108	$C_9H_{11}NO_2S$ (197.3)	260 (3.79) 326 (4.06)	1675, 1630 (C=O), 1520	197 (68)
7b	90 (EtOH)	34	174.5–175.5	$C_{14}H_{13}NO_2S$ (259.3)	261 (3.75) 341 (4.01)	1678, 1605 (C=O), 1570, 1500	259 (33)
7c	80 (EtOH)	39	147–148	$C_{15}H_{15}NO_2S$ (273.3)	262 (3.60) 340 (4.02)	1688, 1600 (C=O), 1560, 1490	273 (50)
7d	70 (EtOH)	44	129–130	$C_{15}H_{15}NO_3S$ (289.3)	270 (3.82) 344 (4.04)	1690, 1600 (C=O), 1566, 1494	289 (81)
7e	110 (EtOH)	29	123.5–125	$C_{14}H_{12}ClNO_2S$ (293.8)	262 (3.83) 345 (3.97)	1682, 1600 (C=O), 1500	293 (66)

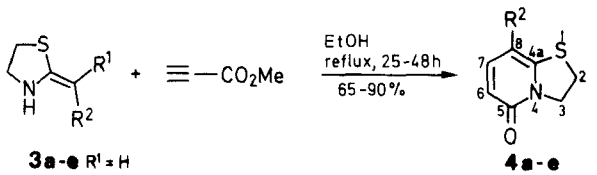
[a] Yield of isolated product based on **3**. [b] Satisfactory microanalyses obtained: C ±0.27, H ±0.13, N ±0.21.

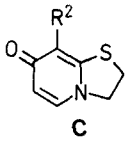
Table 4. NMR Data of Compounds **4**, **6** and **7** Prepared

Product	^{1}H-NMR ($CDCl_3$/TMS), δ, J(Hz)	^{13}C-NMR ($CDCl_3$/TMS), δ
4a	2.42 (s, 3H, CH_3), 3.27 (t, 2H, J = 8.0, H-2), 4.42 (t, 2H, J = 8.0, H-3), 6.19 (d, 1H, J = 9.4, H-6), 7.68 (d, 1H, J = 9.4, H-7)	25.9 (CH_3), 27.3 (C-2), 49.6 (C-3), 112.4 (C-8), 113.3 (C-6), 139.3 (C-7), 157.6 (C-4a), 161.3 (C-5), 192.7 (C=O)
4b	3.33 (t, 2H, J = 8.0, H-2), 4.49 (t, 2H, J = 8.0, H-3), 6.15 (d, 1H, J = 9.2, H-6), 7.42–7.57 (m, 5H_{arom}), 7.60 (d, 1H, J = 9.2, H-7)	27.7 (C-2), 50.3 (C-3), 111.4 (C-8), 112.6 (C-6), 128.3, 128.5, 131.7, 137.2 (C_{arom}), 141.5 (C-7), 159.6 (C-4a), 161.4 (C-5), 191.3 (C=O)
4c	2.39 (s, 3H, CH_3), 3.30 (t, 2H, J = 8.0, H-2), 4.47 (t, 2H, J = 8.0, H-3), 6.18 (d, 1H, J = 9.2, H-6), 7.16 (d, 2H_{arom}, J = 8.2), 7.43 (d, 2H_{arom}, J = 8.2), 7.56 (d, 1H, J = 8.0, H-7)	21.4 (CH_3), 27.6 (C-2), 50.0 (C-3), 111.9 (C-8), 112.9 (C-6), 128.7, 128.9, 134.6, 142.2 (C_{arom}), 141.1 (C-7), 159.2 (C-4a), 161.3 (C-5), 191.0 (C=O)
4d	3.32 (t, 2H, J = 8.0, H-2), 3.85 (s, 3H, OCH_3), 4.51 (t, 2H, J = 8.0, H-3), 6.25 (d, 1H, J = 9.4, H-6), 6.93 (d, 2H_{arom}, J = 8.8), 7.61 (d, 2H_{arom}, J = 8.8), 7.67 (d, 1H, J = 9.4, H-7)	27.9 (C-2), 50.4 (C-3), 55.6 (OCH_3), 112.3 (C-8), 113.1 (C-6), 113.8, 130.0, 131.2, 162.7 (C_{arom}), 141.3 (C-7), 159.2 (C-4a), 161.5 (C-5), 190.4 (CO)
4e	3.30 (t, 2H, J = 8.0, H-2), 4.47 (t, 2H, J = 8.0, H-3), 6.09 (d, 1H, J = 9.4, H-6), 7.38 (s, 4H_{arom}), 7.47 (d, 1H, J = 9.4, H-7)	27.8 (C-2), 50.3 (C-3), 111.6 (C-8), 113.0 (C-6), 128.7, 130.1, 135.7, 137.8 (C_{arom}), 140.9 (C-7), 160.0 (C-4a), 161.1 (C-5), 189.9 (C=O)
6a	2.28 (s, 3H, $COCH_3$), 3.28 (t, 2H, J = 8.0, H-2), 3.89 (s, 3H, OCH_3), 4.48 (t, 2H, J = 8.0, H-3), 6.38 (s, 1H, H-6)	27.6 ($CO\underline{C}H_3$), 28.2 (C-2), 50.2 (OCH_3), 53.0 (C-3), 111.4 (C-8), 114.6 (C-6), 143.4 (C-7), 157.9 (C-4a), 159.7 (C-5), 166.9 ($\underline{C}O_2CH_3$), 193.3 (C=O)
6b	3.18 (s, 3H, OCH_3), 3.30 (t, 2H, J = 8.0, H-2), 4.48 (t, 2H, J = 8.0, H-3), 6.48 (s, 1H, H-6), 7.29–7.58 (m, 5H_{arom})	27.6 (C-2), 50.4 (OCH_3), 51.7 (C-3), 109.3 (C-8), 114.4 (C-6), 128.1, 127.7, 132.1, 137.8 (C_{arom}), 142.6 (C-7), 156.5 (C-4a), 159.1 (C-5), 165.0 ($\underline{C}O_2CH_3$), 190.8 (CO)[a]
6c	2.35 (s, 3H, $ArC\underline{H}_3$), 3.22 (s, 3H, OCH_3), 3.29 (t, 2H, J = 7.8, H-2), 4.47 (t, 2H, J = 7.8, H-3), 6.50 (s, 1H, H-6), 7.10 (d, 2H_{arom}, J = 8.2), 7.42 (d, 2H_{arom}, J = 8.2)	20.5 ($Ar\underline{C}H_3$), 27.6 (C-2), 50.3 (OCH_3), 51.7 (C-3), 109.6 (C-8), 114.3 (C-6), 127.9, 128.6, 135.0, 142.6 (C_{arom}), 142.6 (C-7), 155.7 (C-4a), 159.1 (C-5), 164.9 ($\underline{C}O_2CH_3$), 190.8 (C=O)[a]
6d	3.30 (t, 2H, J = 7.8, H-2), 3.31 (s, 3H, OCH_3), 3.80 (s, 3H, $ArOC\underline{H}_3$); 4.49 (t, 2H, J = 7.8, H-3), 6.55 (s, 1H, H-6), 6.83 (d, 2H_{arom}, J = 8.6), 7.55 (d, 2H_{arom}, J = 8.6)	28.2 (C-2), 50.7 (OCH_3), 52.3 (C-3), 55.4 ($ArO\underline{C}H_3$), 110.8 (C-8), 113.8, 130.7, 130.9, 163.3 (C_{arom}), 115.8 (C-6), 143.5 (C-7), 155.5 (C-4a), 160.4 (C-5), 165.5 ($\underline{C}O_2CH_3$), 190.6 (C=O)
6e	3.30 (s, 3H, OCH_3), 3.32 (t, 2H, J = 8.0, H-2), 4.52 (t, 2H, J = 8.0, H-3), 6.56 (s, 1H, H-6), 7.33 (d, 2H_{arom}, J = 8.4), 7.53 (d, 2H_{arom}, J = 8.4)	27.7 (C-2), 50.4 (OCH_3), 51.9 (C-3), 112.2 (C-8), 114.7 (C-6), 128.3, 129.5, 136.5, 137.3 (C_{arom}), 142.3 (C-7), 156.8 (C-4a), 159.1 (C-5), 164.9 ($\underline{C}O_2CH_3$), 190.1 (C=O)[a]
6f	3.40 (t, 2H, J = 8.0, H-2), 3.88 (s, 3H, OCH_3), 4.56 (t, 2H, J = 8.0, H-3), 6.20 (s, 1H, H-6)	28.6 (C-2), 52.1 (OCH_3), 53.4 (C-3), 114.0 (C-6), 119.5 (C-8), 140.0 (C-7), 152.9 (C-4a), 159.0 (C-5), 164.2 ($\underline{C}O_2CH_3$)[a]
7a	2.23 (s, 3H, $COCH_3$), 2.71 (s, 4H, H-6, 7), 3.05 (t, 2H, J = 7.8, H-2), 4.07 (t, 2H, J = 7.8, H-3)	–
7b	2.57, 2.90 (A_2B_2, 2H each, J = 5.6, H-6, 7), 3.10 (t, 2H, J = 7.8, H-2), 4.10 (t, 2H, J = 7.8, H-3), 7.39 (s, 5H_{arom})	–
7c	2.35 (s, 3H, CH_3), 2.60, 2.77 (A_2B_2, 2H each, J = 5.6, H-6, 7), 3.09 (t, 2H, J = 7.8, H-2), 4.10 (t, 2H, J = 7.8, H-3), 7.14 (d, 2H_{arom}, J = 8.2), 7.37 (d, 2H_{arom}, J = 8.2)	–
7d	2.60, 2.83 (A_2B_2, 2H each, J = 5.6, H-6, 7), 3.10 (t, 2H, J = 7.8, H-2), 3.83 (s, 3H, CH_3), 4.13 (t, 2H, J = 7.8, H-3), 6.92 (d, 2H_{arom}, J = 8.6), 7.57 (d, 2H_{arom}, J = 8.6)	–
7e	2.59, 2.89 (A_2B_2, 2H each, J = 5.6, H-6, 7), 3.10 (t, 2H, J = 7.8, H-2), 4.13 (t, 2H, J = 7.8, H-3), 7.38 (s, 4H_{arom})	–

[a] Recorded in DMSO-d_6.

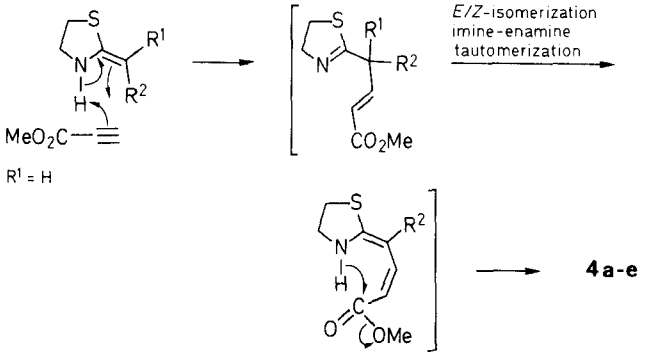
The two *cis* ethylenic proton signals (^{1}H-NMR) and amide carbonyl carbon signal (^{13}C-NMR) show the structure of the products to be **4a–e** and exclude the isomer **C** (Scheme **B**).





Scheme **B**

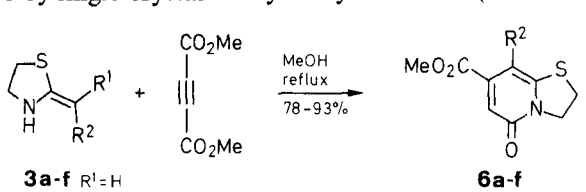
The reaction mechanism probably resembles the reaction of ketene *N,N*-acetals with methyl propiolate[15] (Scheme **C**).

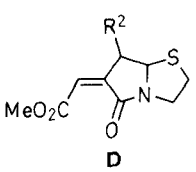


Scheme **C**

The intermediate **5d**, confirmed by the presence of two *trans* proton signals (^{1}H-NMR) and other spectral data, is isolated from the reaction of **3d** with methyl propiolate in dry dioxane at 40 °C, which was converted to **4d** upon refluxing in methanol. This provides further evidence in favor of the suggested mechanism.

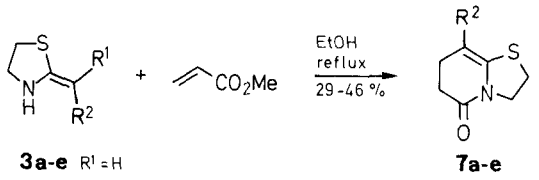
Compounds **3a–f** reacted readily with dimethyl acetylenedicarboxylate. The products were characterized as **6** or **D** by spectroscopic and microanalytical data, but it was not possible to distinguish between the two structures. The structure of products was established unambiguously as **6** by single-crystal X-ray analysis of **6a**[24] (Scheme **D**).





Scheme **D**

Compounds **3a–e** reacted also with methyl acrylate in boiling absolute ethanol, however the reaction time is longer and the yields of the products are lower. The structure of the products was established as **7** by spectroscopic and microanalytical data (Scheme **E**).



Scheme **E**

The analytical and spectral data of **4, 6** and **7** are listed in Tables 3 and 4.

Melting points are not corrected. Microanalytical data: Analytical Laboratory of the Institute. The following instruments were used for recording the spectra: MS, AEI MS-50, IR, Perkin-Elmer 782, UV, Hitachi 340, ^{1}H-NMR, Varian EM-360L, ^{13}C-NMR, Joel FX-100. Compounds **2** were prepared by the literature procedure.[25]

2-Methylenethiazolidine Derivatives 3; General Procedure:
A mixture of ketene *S,S*-acetal **2** (4.0 mmol) and 2-aminoethanethiol (0.32 g, 4.1 mmol) is refluxed in absolute EtOH (25 mL) for 2–33 h (see Table 1). On cooling, the product crystallizes and is filtered, and recrystallized from absolute EtOH.

(*E*)-2-(2-Oxopropylidene)thiazolidine (3a):
A mixture of **3g** (1.85 g, 10 mmol) and NaOMe (1 g of Na in 30 mL of MeOH) is refluxed for 4 h. Then water (20 mL) is added, and the mixture is extracted with $CHCl_3$ (3 × 50 mL). The organic extract is dried (Na_2SO_4), the solvent is removed, and the residue is recrystallized from EtOH.

8-Substituted 2,3-Dihydro-5*H*-thiazolo[3,2-*a*]pyridin-5-ones 4; General Procedure:
A mixture of **3a–e** (2 mmol) and methyl propiolate (0.18 g, 2.1 mmol) in absolute EtOH (20 mL) is refluxed for 25–48 h (see Table 4). The solvent is partially removed and the solid product obtained is filtered and recrystallized from absolute EtOH.

Methyl 4-(4'-Methoxybenzoyl)-4-(2-thiazolidinylidene)-(*E*)-2-butenoate (5d):
A mixture of **3d** (100 mg, 0.42 mmol) and methyl propiolate (168 mg, 2.0 mmol) in anhydrous dioxane (15 mL) is stirred at 40 °C for 3 d. After removal of solvent, the residue is recrystallized from EtOAc; yield: 84 mg (63 %); mp 130–131 °C.

$C_{16}H_{17}NO_4S$	calc.	C 60.17	H 5.37	N 4.39
(319.4)	found	60.15	5.37	4.35

IR (KBr): ν = 3185 (NH) 1695 (ester C=O), 1575 (C=O), 1530, 1505 cm^{-1}.

^{1}H-NMR ($CDCl_3$): δ = 3.53 (t, 2 H, J = 7.8 Hz), 4.21 (t, 2 H, J = 7.8 Hz), 3.84 (s, 3 H), 4.04 (s, 3 H), 5.82 (d, 1 H, J = 15 Hz), 7.84 (d, 1 H, J = 15 Hz), 7.14 (d, 2 H, J = 8.6 Hz), 7.62 (d, 2 H, J = 8.6 Hz), 11.71 (s, 1 H).

Conversion of 5d to 8-(4-Methoxybenzoyl)-2,3-dihydro-5*H*-thiazolo[3,2-*a*]pyridin-5-one(4d):
A methanolic solution of **5d** is heated at 40 °C for 4 h. After removal of solvent, the product is obtained in quantitative yield, its melting point and IR spectra are identical to **4d**.

Methyl 2,3-Dihydro-5-oxo-5*H*-thiazolo[3,2-*a*]pyridin-7-carboxylate 6; General Procedure:
A solution of dimethyl acetylenedicarboxylate (0.28 g, 2 mmol) in MeOH (2 mL) is added dropwise to a solution of **3a–f** (2 mmol) in MeOH (20 mL), and the mixture is stirred at room temperature for 2 h, then refluxed for 2–10 h (see Table 4). After partial removal of the solvent, the product crystallizes upon cooling and is recrystallized from MeOH/$CHCl_3$ (1:1) (**6b,c,e**), MeOH (**6a,d**), or DMSO (**6f**).

2,3,6,7-Tetrahydro-5*H*-thiazolo[3,2-*a*]pyrid-5-ones 7; General Procedure:

A mixture of **3a–e** (5 mmol) and methyl acrylate (0.65 g, 7.5 mmol) in absolute EtOH (30 mL) is refluxed for 60–110 h (see Table 4). The solvent is partially removed, the solid obtained on cooling is filtered and recrystallized from absolute EtOH.

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