Preparation of New Nitrogen-Bridged Heterocycles. 34. Synthesis and Reaction of 2,3-Dihydrooxepino[2,3-*b*]-indolizines[1)]

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The reactions of 2(3*H*)-indolizinones, generated *in situ* from the alkaline treatment of 1-(ethoxycarbonylmethyl)pyridinium bromides having an 2-ethyl, 2-propyl, and 2-benzyl group, with ethoxymethyleneacetylacetone and some phenacyl bromides gave novel heterocyclic compounds, 4-acetyl-2-aroyl-3-methyl-2,3-dihydrooxepino[2,3-*b*]indolizin-3-ols, in low to moderate yields together with considerable amounts of 2-aroylfuro[2,3-*b*]indolizines. The dehydration of these dihydrooxepinoindolizines on the exposure with methanesulfonic acid did not give the initially expected full conjugated oxepino[2,3-*b*]indolizines, but afforded 3-methylene-2,3-dihydrooxepino[2,3-*b*]indolizine derivatives.

1. Introduction

Previously, we reported the ready preparation of 2-aroylmethoxy-3-(2,2-disubstituted vinyl)indolizines from the reactions of 2(3*H*)-indolizinones with various activated ethoxymethlene compounds and phenacyl halides in the presence of a base and their transformation to 2-aroylfuro[2,3-*b*]indolizine derivatives *via* the intramolecular Michael addition followed by the aromatization with the elimination of an active methylene compound.[2)] In our recent reinvestigation on these reactions, we noticed that the product from the reaction of 1-methyl-2(3*H*)-indolizinone, ethoxymethyleneacetylacetone, and phenacyl bromide in the presence of a base is not the corresponding 3-(2,2-diacetylvinyl)-1-methyl-2-phenacyloxyindolizine, and is its intramolecular nucleophilic cycloadduct, 4-acetyl-2-benzoyl-3,11-dimethyl-2,3-di-

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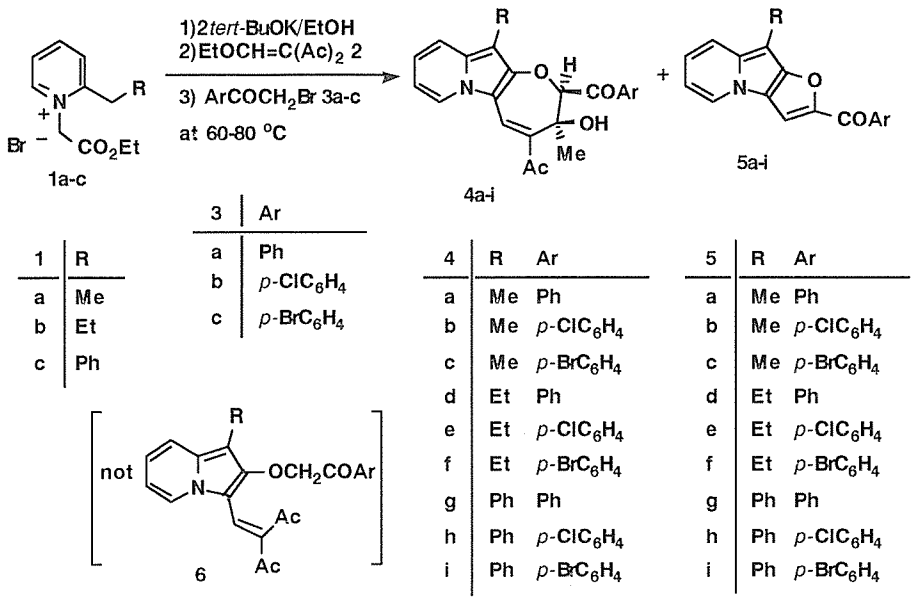
hydrooxepino[2,3-*b*]indolizin-3-ol. This fact prompted us to investigate further the reactions of 2(3*H*)-indolizinones with the same vinylating agent and some phenacyl bromides, because this is the reaction leading to novel indolizine derivatives with an oxygen-containing seven-membered ring which are not obtainable by other methods. In this paper we wish to report the first preparation of title compounds from the alkaline treatment of the corresponding pyridinium salts, ethoxymethleneacetylacetone, and phenacyl bromides and their acid-catalyzed dehydration.

2. Results and Discussion

2.1 Preparation of 2,3-Dihydrooxepino[2,3-*b*]indolizin-2-ols

The reactions of 1-(ethoxycarbonylmethyl)pyridinium bromides **1a-c**, ethoxymethyleneacetylacetone **2**, and phenacyl bromide **3a** were carried out initially by using sodium ethoxide as a base,[2] but, though the reason was still unclear, the reappearance for the yields of the desired 2,3-dihydrooxepino-[2,3-*b*]indolizin-3-ols **4a-c** in these reactions was extremely difficult. Hence, potassium *tert*-butoxide as a base was employed in these reactions. When an ethanolic solution of 1-ethoxycarbonylmethyl-2-ethylpyridinium bromide **1a** was treated with two equivalents of potassium *tert*-butoxide and then with ethoxymethyleneacetylacetone **2** and phenacyl bromide **3a** at 60-80 °C in a water bath, the corresponding 2-benzoylfuro[2,3-*b*]indolizine **5a** was obtained as a main product (68%) together with considerable amounts of 4-acetyl-2-benzoyl-3,11-dimethyl-2,3-dihydrooxepino[2,3-*b*]indolizin-3-ol **4a** (27%). Similar reactions of **1a** with **2** and *p*-chlorophenacyl bromide **3b** and *p*-bromophenacyl bromide **3c** gave 2-aroyl-2,3-dihydrooxepino[2,3-*b*]indolizin-3-ols **4b,c** and 2-aroylfuro[2,3-*b*]indolizines **5b,c**, respectively. Furthermore, the alkaline treatment of other pyridinium salts **1b,c**, a vinylating agent **2**, and phenacyl bromides **3a-c** afforded the same types of compounds **4d-i** and **5d-i** respectively, but the yields of the title compounds **4d-i** were very low (3-11%). (Scheme 1)

The structures of these 2,3-dihydrooxepino[2,3-*b*]indolizin-3-ols **4a-i** were determined mainly by the physical and spectral means, and those of furo-[2,3-*b*]indolizines **5a-i** were concluded by the comparisons with authentic samples prepared earlier by us.[2,3] For example, the proton nuclear magnetic resonance (^{1}H-NMR) spectra (Table 1) of compounds **4a-i** exhibited each characteristic singlet signals at near δ 1.5 (3H), 2.5 (3H), 5.4 (1H), and 7.8 (1H,



1	R
a	Me
b	Et
c	Ph

3	Ar
a	Ph
b	*p*-ClC$_6$H$_4$
c	*p*-BrC$_6$H$_4$

4	R	Ar
a	Me	Ph
b	Me	*p*-ClC$_6$H$_4$
c	Me	*p*-BrC$_6$H$_4$
d	Et	Ph
e	Et	*p*-ClC$_6$H$_4$
f	Et	*p*-BrC$_6$H$_4$
g	Ph	Ph
h	Ph	*p*-ClC$_6$H$_4$
i	Ph	*p*-BrC$_6$H$_4$

5	R	Ar
a	Me	Ph
b	Me	*p*-ClC$_6$H$_4$
c	Me	*p*-BrC$_6$H$_4$
d	Et	Ph
e	Et	*p*-ClC$_6$H$_4$
f	Et	*p*-BrC$_6$H$_4$
g	Ph	Ph
h	Ph	*p*-ClC$_6$H$_4$
i	Ph	*p*-BrC$_6$H$_4$

Scheme 1.

exchangeable with deuterium oxide) attributable to a methyl attached to a sp^3 carbon, an acetyl, a methine at the 2-position, and a hydroxyl group, respectively, together with four proton signals (δ 6.5-8.2) coupled with each other due to the pyridine moiety and multiplet signals (δ 7.1-8.3) due to the 2-aroyl group. The infrared (IR) spectra showed a hydroxyl absorption band at 3230-3440 cm^{-1} and two carbonyl absorption bands at 1584-1593 and 1699-1705 cm^{-1}. In particular, the presences of the 2-methine (δ near 5.4), only one acetyl, and a hydroxyl group and the absence of the *O*-methylene group in these spectra refused completely the structures of our previously proposed 2-aroylmethoxy-3-(2,2-diacetylvinyl)indolizine derivative **6**, and suggested strongly that compounds **4a-i** are formed *via* the intramolecular addition of the active methylene group on an acetyl group in this intermediate **6**. From the ^{1}H-NMR spectral inspection, it was also showed that all of products **4a-i** are each only one diastereomer and there is not any isomeric compounds in them.[4] Finally, the structure, 4-acetyl-2-aroyl-3-methyl-2,3-dihydrooxepino[2,3-*b*]indolizin-3-ol, including its stereochemistry was determined by the single crystal X-ray analysis of one compound **4a**.[5] Main products **5a-i**, of course, were completely in accord with authentic samples in all respects.[2,3]

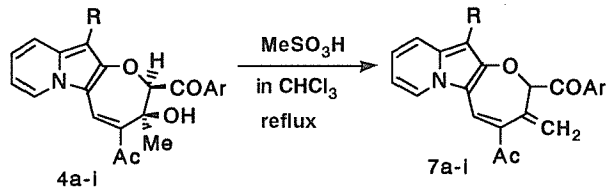
2.2 Dehydration of 2,3-Dihydrooxepino[2,3-*b*]indolizin-3-ols

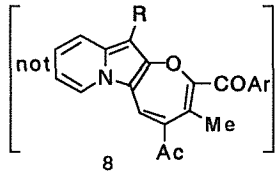
Table 1. ^{1}H-NMR Spectral Data for Oxepino[2,3-*b*]indolizines in $CDCl_3$

Compd[a]	C-2	C-5	C-7	C-8	C-9	C-10	OH	Ac	2-Me[b]	R		Ar
4a	5.43	7.69	c)	6.59	6.89	7.16	7.58	2.58	1.42	1.97		7.3-8.2
	s	s		dt	br t	br d	s	s	s	s		m
4b	5.38	7.64	8.09	6.64	6.96	7.21	7.64	2.56	1.44	2.00		7.3-8.1
	s	s	br d	dt	br t	br d	s	s	s	s		m
4c	5.39	7.69	8.08	6.64	6.92	7.21	7.64	2.57	1.45	2.02		7.4-8.0
	s	s	br d	dt	br t	br d	s	s	s	s		m
4d	5.46	7.69	c)	6.63	6.91	c)	7.63	2.58	1.46	0.95	2.49	7.1-8.3
	s	s		dt	br t		s	s	s	t	q	m
4e	5.42	7.68	8.08	6.67	6.94	7.23	7.68	2.56	1.42	0.99	2.49	7.2-8.1
	s	s	br d	dt	br t	br d	s	s	s	t	q	m
4f	5.33	7.70	8.11	6.63	6.93	7.25	c)	2.50	1.40	0.97	2.46	7.3-8.1
	s	s	br d	dt	br t	br d		s	s	t	q	m
4g	5.43	7.76	8.17	6.70	6.99	c)	7.76	2.62	1.53	-----6.9-8.1-----		
	s	s	br d	dt	br t		s	s	s	m		
4h	5.34	7.73	8.15	6.77	c)	c)	c)	2.61	1.54	-----6.8-7.8-----		
	s	s	br d	dt				s	s	m		
4i	5.33	7.71	8.16	6.75	7.02	c)	c)	2.59	1.51	-----7.0-7.8-----		
	s	s	br d	dt	br t			s	s	m		
7a	5.94	7.90	8.18	6.61	6.95	7.25	-----	2.28	5.64	2.22		7.3-8.1
	s	s	br d	dt	br t	br d		s	s	s		m
7b	5.86	7.86	8.16	6.64	6.97	7.26	-----	2.35	5.63	2.19		7.3-8.1
	s	s	br d	dt	br t	br d		s	d[d]	s		m
7c	5.90	7.88	8.19	6.61	6.96	7.26	-----	2.37	5.67	2.22		7.4-8.0
	s	s	br d	dt	br t	br d		s	d[d]	s		m
7d	6.01	7.92	8.19	6.62	6.97	c)	-----	2.29	5.67	1.22	2.45	7.1-8.1
	s	s	br d	dt	br t			s	s	t	q	m
7e	5.90	7.86	8.18	6.63	6.96	c)	-----	2.34	5.68	1.24	2.72	7.1-8.1
	s	s	br d	dt	br t			s	d[d]	t	q	m
7f	5.86	7.84	8.15	6.61	6.94	7.29	-----	2.34	5.64	1.22	2.72	7.4-8.0
	s	s	br d	dt	br t	br d		s	s	t	q	m
7g	6.02	7.87	8.20	6.66	6.98	c)	-----	2.24	5.67	-----7.1-8.1-----		
	s	s	br d	dt	br t			s	s	m		
7h	5.94	7.84	8.20	6.69	7.00	c)	-----	2.38	5.70	-----7.1-8.1-----		
	s	s	br d	dt	br t			s	d[d]	m		
7i	5.95	7.86	8.26	6.68	7.01	c)	-----	2.39	5.71	-----7.1-8.1-----		
	s	s	br d	dt	br t			s	d[d]	m		

a) The coupling constants are as follows: $J_{7,8}=J_{8,9}=7.0$, $J_{9,10}=9.0$, $J_{8,10}=2.0$, and $J_{Et}=7.0$ Hz. b) Or the 3-methylene protons in compounds **7a-i**. c) Overlapped with the phenyl proton signals. d) Though this signal pattern should be theoretically an AB quartet, its side signals could not be recognized in the measurement with the considerable concentration because of the small difference between their chemical shifts and of the small coupling constant of them.

Since there are an acidic methine proton at the 2-position and the 3-hydroxyl group in compounds **4a-i**, it was easily anticipated that the full conjugated oxepino[2,3-*b*]indolizines such as **8** (see Scheme 2) should be formed by the dehydration between these two groups. The treatment of **4a** with methanesulfonic acid as an acid catalyst, however, did not give any such type of compound **8**, but afforded alternative dehydrated products, 4-acetyl-2-aroyl-3-methylene-2,3-dihydrooxepino[2,3-*b*]indolizines **7a-i**, in 20-58% yields, respectively.





7	R	Ar
a	Me	Ph
b	Me	*p*-ClC$_6$H$_4$
c	Me	*p*-BrC$_6$H$_4$
d	Et	Ph
e	Et	*p*-ClC$_6$H$_4$
f	Et	*p*-BrC$_6$H$_4$
g	Ph	Ph
h	Ph	*p*-ClC$_6$H$_4$
i	Ph	*p*-BrC$_6$H$_4$

Scheme 2.

The fact that these products are 4-acetyl-2-aroyl-3-methylene-2,3-dihydro-oxepino[2,3-*b*]indolizines **7a-i** and not the full conjugated 4-acetyl-2-aroyl-3-methyloxepino[2,3-*b*]indolizine derivatives **8** could be concluded with ease by the indications of the presences of the 2-methine proton (δ near 5.9) and the terminal 3-methylene protons (δ near 5.7) and of the disappearances of the 3-hydroxyl and the 3-methyl group in ^{1}H-NMR (Table 1) and IR spectra. The structural data from the single crystal X-ray analysis of one compound, 4-acetyl-2-benzoyl-11-ethyl-3-methylene-2,3-dihydrooxepino[2,3-*b*]indolizine **7d**, confirmed also our proposed structure. Some crystal data and the ORTEP drawing[6] of **7d** are shown in Tables 2 and 3 and Fig. 1.

Table 2. Crystal and Structure Analysis Data of Compound **7d**

Formula		$C_{24}H_{21}NO_3$
Formula weight		371.43
Crystal system		Monoclinic
Spece group		$P2_1/a$; Z=4
Lattice parameter	*a*/Å	12.437(2)
	b/Å	12.310(2)
	c/Å	12.891(2)
	ß/°C	98.08(1)
V/Å^3		1954.1(5)
D_{calcd}/gcm^{-1}		1.262
Crystal size/mm^3		0.34x0.64x0.86
Diffractometer		Rigaku AFC5S
Radiation		Mo*Kα*(λ=0.71069 A)
Monochromator		Graphite
Scan type		ω–2θ
2θ Max		54.9 °
Computer program		TEXSAN System[a]
Structure Solution		Direct method; MITHRIL[b]
Hydrogen atom treatment		Calcd, not refined
Refinement		Full-matrix, anisotropic
Least-squares weight		$4F_o^2/\sigma^2(F_o^2)$
No. of measurement reflection		Total: 4896 Unique: 4690
No. of observation[c]		2194
No. of Variables		253
Residuals *R*; *R*w		0.052; 0.058
Max Shift/Error		0.14
$\Delta\rho_{max}$/e$^-$/A^3; $\Delta\sigma_{min}$/e$^-$/A^3		0.30; -0.22

a) See Ref. 7). b) See Ref 8). c) $I>3.00\sigma(I)$

Table 3. Selected Bond Lengths and Bond Angles of Compound **7d**
(esd's, where given, are in parentheses)

Bond Lengths[a]			
O1-C1	1.448(3)	C3-C4	1.356(3)
O1-C12	1.369(3)	C3-C21	1.480(4)
O2-C13	1.220(3)	C4-C5	1.403(4)
O3-C21	1.228(3)	C5-C12	1.406(4)
N1-C5	1.406(3)	C6-C7	1.355(4)
N1-C6	1.376(3)	C7-C8	1.407(4)
N1-C10	1.398(4)	C8-C9	1.363(5)
C1-C2	1.502(4)	C9-C10	1.406(5)

Continued

Continued

C1-C13	1.533(4)	C10-C11	1.394(4)
C2-C3	1.478(4)	C11-C12	1.383(4)
C2-C20	1.330(4)	C11-C23	1.498(4)

Bond Angles

C1-O1-C12	117.3(2)	C6-C7-C8	120.9(3)
C5-N1-C6	129.4(2)	C7-C8-C9	119.9(3)
C5-N1-C10	109.5(2)	C8-C9-C10	120.1(3)
C6-N1-C10	121.1(2)	N1-C10-C9	118.5(3)
O1-C1-C2	112.7(2)	N1-C10-C11	108.5(2)
O1-C1-C13	112.9(2)	C9-C10-C11	133.0(3)
C2-C1-C13	113.9(2)	C10-C11-C12	106.0(3)
C1-C2-C3	118.0(2)	C10-C11-C23	125.8(3)
C1-C2-C20	118.5(3)	C12-C11-C23	128.2(3)
C3-C2-C20	123.5(3)	O1-C12-C5	126.3(2)
C2-C3-C4	121.1(3)	O1-C12-C11	121.8(3)
C2-C3-C21	121.8(2)	C5-C12-C11	111.8(3)
C4-C3-C21	114.0(2)	O2-C13-C1	117.2(3)
C3-C4-C5	128.9(3)	O2-C13-C14	120.6(3)
N1-C5-C4	122.8(2)	C1-C13-C14	122.0(3)
N1-C5-C12	104.2(2)	O3-C21-C3	121.1(3)
C4-C5-C12	132.9(2)	O3-C21-C22	118.4(3)
N1-C6-C7	119.6(3)	C11-C23-C24	113.0(3)

a) For the numberings of compound **7d** shown here, see its ORTEP drawing in Fig. 1.

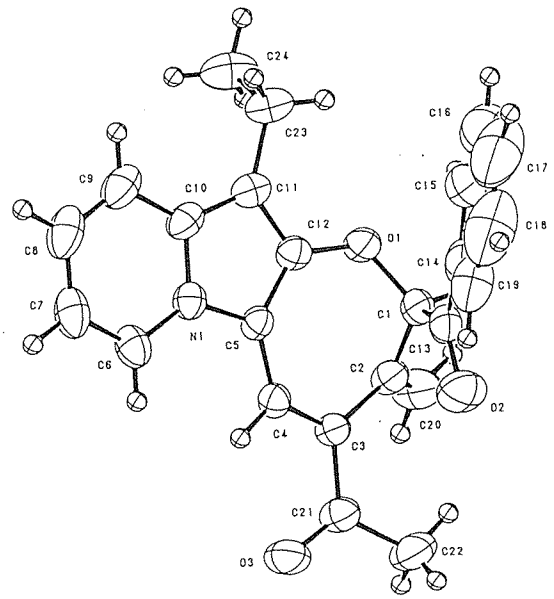
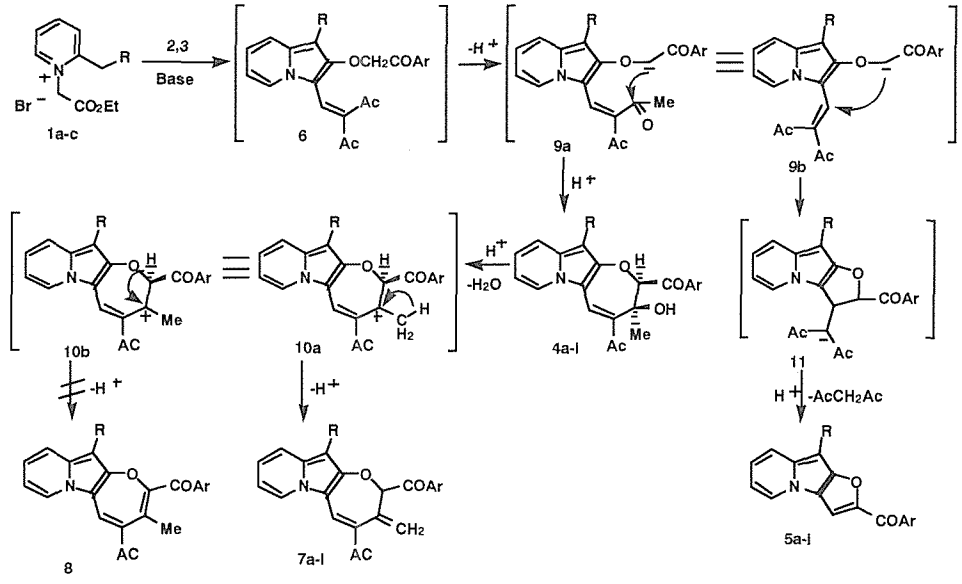


Fig. 1. ORTEP Drawing of Compound **7d**

2.3 Reaction Mechanisms

Possible mechanisms for the formation and the dehydration of 2,3-dihydrooxepino[2,3-*b*]indolizin-3-ols **4a-i** are summarized in Scheme 3. The formation of title compounds **4a-i** must proceed *via* the intermediate genaration of 3-(2,2-diacetylvinyl)-2-phenacyloxyindolizines **6** from the reactions of pyridinium salts **1a-c**, a vinylating agent **2**, and phenacyl bromides **3a-c** in the presence of a base, the proton abstraction from the active methylene group in **6**, followed by the nucleophilic addition of the resulting carbanion **9a** to an acetyl carbonyl group on the 3-vinyl substituent. Furthermore, the alternative ion **9b** different from only the spacial conformation of the 3-vinyl group should leat to the principal products, 3-aroylfuro[2,3-*b*]indolizines **5a-i**, by the intramolecular Michael addition of the carbanion on the 3-vinyl substituent followed by the aromatization of the resulting 2,3-dihydrofuro[2,3-*b*]indolizine **11** accompanied by the elimination of acetylacetone. In some reactions,[2,3] the corresponding 2-acylmethoxy-3-(2,2-disubstituted vinyl)indolizine derivatives were actually isolated and their smooth transformation to furo[2,3-*b*]indolizines and an active methylene compound were also observed. More recently, we have seen first application of this procedure for the synthesis of thieno[3,2-*a*]indolizine derivatives.[1] On the other hand, the reason for the formation of sole isomer of 2,3-dihydro-



Scheme 3.

oxepino[2,3-*b*]indolizin-3-ols **4a-i** is still unclear, but it may be explained by the sterically favorable approach of a conformer **12a** of the carbanion **9a** (see Fig. 2, an alternative approach of the less favorable comformer **12b** should lead to other isomer with a trans configuration between the 2-aroyl and the 3-hydroxyl group), or by the smooth transformation of the trans isomer once formed to thermodynamically stable cis isomer **4** through the keto-enol tautomerism under the alkaline conditions employed here.

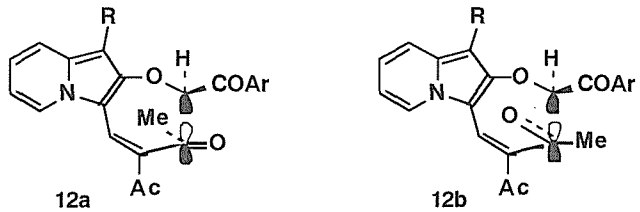


Fig. 2.

The explicit explanation for the fact that the product in the acid-catalyzed dehydration of 2,3-dihydrooxepino[2,3-*b*]indolizin-3-ols **4a-i** were not full conjugated oxepino[2,3-*b*]indolizines **8** and were the 3-methylene derivatives **7a-i** can not be also explained reasonably. However, the instability of the full conjugated oxepino[2,3-*b*]indolizines **8** with the 16π-electronic system expected by Huckel rule may be considered as a reason.

Although its mechanistic ambiguity is still remaining to some extent, the construction method for a novel nitrogen-bridged heterocycles was developed from the reactions in which polyfunctionalized 3-vinylindolizine derivatives intervene.

3. Experimental

Melting points were measured with a Yanagimoto micromelting point apparatus and are uncorrected. The microanalyses were carried out on a Perkin-Elmer 2400 elemental analyzer. The ^{1}H-NMR spectra were determined with a Varian EM360 spectrometer in deuteriochloroform with tetramethylsilane as an internal standard and the chemical shifts are expressed in δ values. The IR spectra were taken with a JASCO FT/IR-5300 infrared spectrophotometer.

3.1 preparation of 2,3-dihydrooxepino[2,3-b]indolizin-3-ols

General Method: To an ethanolic solution (30 ml) of pyridinium salt (**1**,

3 mmol) potassium *tert*-butoxide (0.672g, 6 mmol) was added under heating (60-80 °C) in a water bath and, after 5 min, ethoxymethyleneacetylacetone (**2**, 3 mmol) and phenacyl bromide (**3**, 3 mmol) were added to the resulting solution. The reaction mixture was allowed to react further 2 h at that temperature. The solvent was then removed at reduced pressure and the residue was separated twice by column chromatography on alumina using chloroform as an eluent. The chloroform layer was concentrated at reduced pressure. The residues were recrystallized from ethanol to afford the corresponding pure products **4a-i** and **5a-i**, respectively.

The use of sodium ethoxide as a base in these reactions caused the large changes (0-29%) for the yields of title compounds **4a-i** and the reappearance of the reaction was extremely poor.

Some Physical and spectral data of new compounds **4a-i** were summarized in Tables 1 and 4.

Table 4. Some Data for 2,3-Dihydrooxepino[2,3-*b*]indolizin-3-ols

Prod. $4^{a,b)}$	React. **1**	**3**[c]	Yield (%)	M.P. °C	IR (KBr) cm^{-1} ν_{OH}	ν_{CO}	Formula	Calcd% (Found%)
a	**a**	**a**	27	199-201	3232	1698 1582	$C_{23}H_{21}NO_4$	73.58 5.64 3.73 (73.36 5.63 3.59)
b	**a**	**b**	20	199-201	3304	1699 1584	$C_{23}H_{20}ClNO_4$	67.40 4.92 3.42 (67.32 4.87 3.55)
c	**a**	**c**	20	194-196	3424	1705 1584	$C_{23}H_{20}BrNO_4$	60.81 4.44 3.08 (60.54 4.41 2.83)
d	**b**	**a**	5	209-211	3412	1699 1582	$C_{24}H_{23}NO_4$	74.02 5.95 3.60 (73.73 5.95 3.33)
e	**b**	**b**	5	215-217	3393	1699 1584	$C_{24}H_{22}ClNO_4$	68.00 5.23 3.33 (67.99 5.19 3.35)
f	**b**	**c**	3	209-211	3436	1699 1586	$C_{24}H_{22}BrNO_4$	61.55 4.73 2.99 (61.47 4.70 3.10)
g	**c**	**a**	5	224-227	3272	1699 1593	$C_{28}H_{23}NO_4$	76.87 5.30 3.20 (76.74 5.32 3.31)
h	**c**	**b**	11	218-220	3436	1705 1586	$C_{28}H_{22}ClNO_4$	71.26 4.70 2.97 (71.22 4.72 2.99)
i	**c**	**c**	5	222-224	3436	1705 1584	$C_{28}H_{22}BrNO_4$	65.13 4.29 2.71 (65.05 4.37 2.71)

a) Compounds **4a-c,e-i** were obtained as orange prisms, and **4d** as orange flakes. b) The corresponding 2-aroylfuro[2,3-*b*]indolizines **5a-i** in these reactions were also obtained in 63, 37, 46, 66, 56, 58, 95, 89, and 91% yields, respectively, and their physical and spectral data were in accord with authentic samples in all respects. (See ref. 2 and 3) c) Plus ethoxymethleneacetylacetone.

3.2 Dehydration of 2,3-Dihydrooxepino[2,3-b]indolizin-3-ols

General Method: A chloroform solution (10 ml) of compound (**4**, 1 mmol) and methanesulfonic acid (3 ml) was allowed to react at the reflux temperature in a water bath for 30 min. After the evaporation of the solvent at reduced pressure, the residual oil was separated by column chromatography on alumina using chloroform. After evaporation of the solvent, recrystallization of the residue from ethanol gave the corresponding 3-methylene-2,3-dihydro- oxepino[2,3-*b*]indolizines **7a-i**.

The same dehydration product **7a** could be also obtained in 36% yield by direct treatment of compound **4a** with hydrobromic acid as an acidic catalyst at room temperature for 1 h.

Some data for these products **7a-i** are listed in Tables 1 and 5.

Table 5. Some Data for 3-Methylene-2,3-dihydrooxepino[2,3-*b*]indolizines

Prod. 7[a)]	React. 4	Yield (%)	M.P. °C	IR (KBr) cm^{-1} ν_{CO}	$\nu_{=CH2}$	Formula	Calcd%(Found%)
a	**a**	37	190-192	1680	1649 858	$C_{23}H_{19}NO_3$	77.29 5.36 3.76 (77.32 5.43 3.76)
b	**b**	36	178-181	1682	1649 868	$C_{23}H_{18}ClNO_3$	70.50 4.63 3.57 (70.79 4.69 3.41)
c	**c**	26	186-188	1682	1645 868	$C_{23}H_{18}BrNO_3$	63.32 4.16 3.21 (63.52 4.30 3.04)
d	**d**	31	82-85	1680	1649 851	$C_{24}H_{21}NO_3$	77.61 5.70 3.77 (77.40 5.74 3.94)
e	**e**	32	130-133	1674	1647 856	$C_{24}H_{20}ClNO_3$	71.02 4.97 3.45 (71.31 4.96 3.75)
f	**f**	20	123-125	1698	1649 860	$C_{24}H_{20}BrNO_3$	64.01 4.48 3.11 (64.03 4.48 3.26)
g	**g**	43	198-200	1682	1645 868	$C_{28}H_{21}NO_3$	80.17 5.05 3.34 (80.44 5.07 3.26)
h	**h**	48	193-194	1694	1649 860	$C_{28}H_{20}ClNO_3$	74.09 4.44 3.09 (73.90 4.56 3.16)
i	**i**	58	188-190	1694	1649 858	$C_{28}H_{20}BrNO_3$	67.48 4.05 2.81 (67.28 4.19 2.87)

a) Compounds **7a-i** were obtained as orange prisms.

References

1) For part 33 of this series, see A. Kakehi, S. Ito, T. Ueda, and S. Takano, *Chem. Pharm. Bull.*, **41**, 1753 (1993).

2) A. Kakehi, S. Ito, H. Furuta, and K. Todoroki, *J. Fac. Eng. Shinshu Univ.*, No

58, 1 (1985).
3) A. Kakehi, S. Ito, T. Ohizumi, and M. Ito, *Bull. Chem. Soc. Jpn.*, **56**, 1219 (1983).
4) The structure for compounds **4a-i** shown here is not absolute structure, and is the relative one which exhibits only the relation of the cis configuration between the 2-aroyl and the 3-hydroxyl group.
5) For the structural results of compound **4a**, see A. kakehi, K. kitajima, S. Ito, and N. Takusagawa, *Acta. Cryst.*, in press.
6) C. K. Johnson, "ORTEPII, Report ORNL-5138," Oak Ridge National Laboratory, Oak Ridge, Tennessee, 1976.
7) TEXSAN TEXRAY, Structure Analysis Package, Molecular Structure Corporation (1985).
8) C. J. Gilmore, *J. Appl. Crystallogr.*, **17**, 42 (1984).