often unavoidable in other tertiary butylation procedures.

Basic catalytic hydrogenolysis of the chlorine substituent in **4a** was unexceptional, leading to one further 2-*t*-butylaminobenzophenone, **4d**.

Further chemical transformations of the intermediate benzisoxazolium salts are under study.

Experimental Section

Melting points were determined on a Thomas-Hoover capillary melting point apparatus and are not corrected. Infrared spectra were measured on a Model 457 Perkin-Elmer spectrophotometer in methylene chloride; nmr spectra in deuteriochloroform solution with tetramethylsilane as an internal standard, on a Varian A-60 instrument. Microanalyses were carried out in our analytical unit.[10]

1-*t*-Butyl-5-chloro-6-methyl-3-phenyl-2,1-benzisoxazolium Perchlorate (2a).—To a solution of 9 g (0.037 mol) of **1a** in 350 ml of nitromethane were added 3.2 g (0.042 mol) of *t*-butyl alcohol and 7 g (0.042 mol) of a 60% aqueous solution of perchloric acid. The resulting solution was left at room temperature for 60 hr and then diluted with 1000 ml of anhydrous ether. The crystalline precipitate so obtained was filtered off, dissolved in 50 ml of acetone, and reprecipitated by the addition of 250 ml of ether. There resulted 13 g (88%) of **2a**, mp 183–185°. Similarly prepared were **2b**, mp 142–145°, and **2c**, mp 132–134° dec.

1-*t*-Butyl-5-chloro-6-methyl-3-phenyl-2,1-benzisoxazoline (3a).—To a stirred suspension of 13.3 g (0.033 mol) of **2a** in 100 ml of ethanol at room temperature was added in several portions 1.5 g (0.04 mol) of sodium borohydride. After the addition was complete, the stirring was continued for a further 30 min by which time only a little fine crystalline precipitate was present in the reaction mixture. Water was then added slowly to give initially a clear solution followed by precipitation of the product. Isolation by filtration and recrystallization from aqueous ethanol gave 7.5 g (75%) of **3a**: mp 115–117°; nmr δ 1.32 (9 H, s, *t*-butyl), 2.34 (3 H, s, Ar-CH_3), 6.32 (1 H, s, >CH), 6.81, 6.90 (2 H, 2 s, aromatic), 7.36 (5 H, s, phenyl). Similarly prepared were **3b** [mp 69–73°; nmr δ 1.32 (9 H, s, *t*-butyl), 6.41 (1 H, s, >CH), 6.85–7.25 (4 H, m, aromatic), 7.38 (5 H, s, phenyl)] and **3c** [oil, distilled (Kugelrohr; 0.2 mm, 90–100°); nmr δ 1.24 (9 H, s, *t*-butyl), 5.14 (2 H, s, $-CH_2-$), 6.80–7.20 (4 H, m, aromatic)].

2-*t*-Butylamino-5-chloro-4-methylbenzophenone (4a).—Under an atmosphere of nitrogen, the melt from 11 g of **3a** was maintained at a temperature of 160° for 4 hr. The resulting liquid was cooled, diluted with 50 ml of CH_2Cl_2, and filtered through a short column of aluminum oxide. Further elution with CH_2Cl_2 and evaporation of the yellow solution gave 9 g (82%) of **4a**: crystallized from pentane, mp 76–78°; ir 3.02 (NH), 6.18 μ (C=O); nmr δ 1.48 (9 H, s, *t*-butyl), 2.36 (3 H, s, Ar-CH_3), 6.90 (1 H, s, aromatic), 7.32–7.70 (6 H, aromatic), 8.89 (1 H, D_2O exchangeable, NH). Similarly prepared were **4b** [oil, distilled (Kugelrohr, 0.2 mm, 140–160°); nmr δ 1.50 (9 H, s, *t*-butyl), 6.49 (1 H, t, aromatic), 6.90–7.75 (8 H, aromatic), 8.85 (1 H, D_2O exchangeable, NH)] and **4c** [oil, distilled (Kugelrohr, 0.2 mm, 100–130°) ir 3.05 (NH), 6.07 μ (C=O); nmr δ 1.43 (9 H, s, *t*-butyl), 6.45–7.50 (4 H, aromatic), 8.70 (1 H, D_2O exchangeable, NH), 9.85 (1 H, s, -CHO)].

2-*t*-Butylamino-4-methylbenzophenone (4d).—A solution of 1.7 g of **4a** in 100 ml of methanol containing 200 mg of KOH and 200 mg of 5% palladium on carbon was shaken under an atmosphere of hydrogen until 1 equiv had been taken up (*ca.* 12 hr). After filtration, evaporation of the solvent, and isolation of the organic material, there was obtained 1.3 g (87%) of **4d**: oil, distilled (Kugelrohr, 0.2 mm, 140–160°); nmr δ 1.48 (9 H, s, *t*-butyl), 2.28 (3 H, s, Ar-CH_3), 6.26 (1 H, s, aromatic), 6.83 (1 H, s, aromatic), 7.27–7.70 (6 H, aromatic), 8.98 (1 H, D_2O exchangeable, NH).

Registry No.—**2a**, 24806-54-0; **2b**, 24766-86-7; **2c**, 24766-87-8; **3a**, 24766-64-1; **3b**, 24766-65-2; **3c**, 24766-66-3; **4a**, 24766-67-4; **4b**, 24766-68-5; **4c**, 24766-69-6; **4d**, 24766-70-9.

(10) Satisfactory elemental analyses (±0.3% for C, H, and N or Cl) were reported for all compounds.

Reaction of Electrophiles with Enolizable N-Hydrogen Ketimines

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Recent investigations[1] have shown that electrophiles such as acyl chlorides, isocyanates, and isothiocyanates can react with N-substituted imines containing an enolizable proton to form, among other products, acylenamides, enureas, and enthioureas, respectively. The amount of enamide or urea obtained was shown to depend on both the electrophile and imine employed, as well as conditions of reaction.

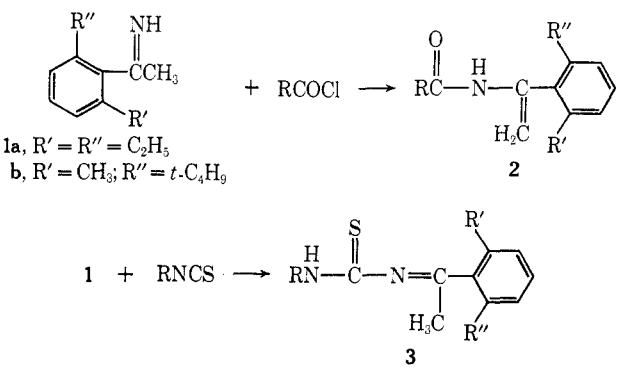
In addition to the above products, it should be possible for N-hydrogen imines to alternatively react substitutively at nitrogen to form acylimine compounds. Earlier literature references[2] disclose the acylation of enolizable ketimine derivatives (Grignard complexes from acetophenone ketimines) to give such compounds. However, the structural assignments were shown to be incorrect, as later investigations[3,4] proved the materials to be enamides.

It is therefore a principal object of the present report to demonstrate that enolizable N-hydrogen ketimines can, in fact, under certain conditions, give acylimine derivatives with electrophiles such as acyl chlorides, isocyanates, and isothiocyanates.

Several representative N-hydrogen ketimines were prepared for investigation. Material **1** is derived from reaction of 2,6-dialkylbenzonitriles with an organometallic reagent, while **4**, **8**, and **9** are available by reaction of the respective ketone with ammonia in the presence of suitable reagents[5] or through an ammonolysis of the nitramine derivative.[6]

Reaction of **1** with acid chlorides invariably gave only **2**, while **3** was the product on reaction with isothiocyanates (Scheme I). In similar manner, **4** with acid

SCHEME I[a]



1a, $R' = R'' = C_2H_5$
b, $R' = CH_3$; $R'' = t\text{-}C_4H_9$

2

3

[a] See Table I for specific examples of **2** and **3**.

(1) (a) J. P. Chupp and E. R. Weiss, *J. Org. Chem.*, **33**, 2357 (1968); (b) S. J. Love and J. A. Moore, *ibid.*, **33**, 2361 (1968).

(2) C. Moureu and G. Mignonac, *Ann. Chim. Phys.*, **13**, 340 (1920).

(3) J. E. Benfield, G. M. Brown, F. H. Davey, W. Davies, and T. H. Ramsey, *Aust. J. Sci. Res., Ser. A*, **1**, 330 (1948).

(4) (a) Y. Heng Suen, A. Horeau, and H. B. Kagan, *Bull. Soc. Chim.*, 1454 (1965); (b) H. B. Kagan, A. Horeau, and Y. Heng Suen, *ibid.*, 1457 (1965).

(5) H. Weingarten, J. P. Chupp, and W. A. White, *J. Org. Chem.*, **32** 3246 (1967).

(6) J. Houben and E. Pfankuch, *Ber.*, **60**, 586 (1927).

TABLE I

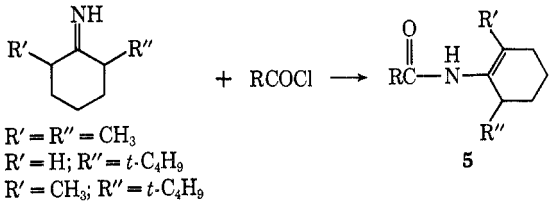
PRODUCTS FROM REACTION OF ELECTROPHILES WITH ENOLIZABLE N-HYDROGEN KETIMINES

Compd	R	R′	R″	X	Yield, %	Mp or bp (mm), °C	Calcd, % Cl	Calcd, % N	Calcd, % S	Found, % Cl	Found, % N	Found, % S	Pertinent spectra, nmr (CCl_4), δ [ir, μ]
2a	$ClCH_3$	C_2H_5	C_2H_5	O	70	149–150	14.08	5.56		14.34	5.95		4.8 (d, 1, J = 1 Hz, =CH), 6.3 (s, 1, =CH)
2b	$ClCH_3$	CH_3	$(CH_3)_3C$	O	66	103–104	13.34	5.27		13.35	5.80		4.8 (d, 1, J = 1 Hz, =CH), 6.3 (s, 1, =CH)
3	3,4-$(Cl)_2C_6H_3$	C_2H_5	C_2H_5	S	57	83–84	18.69	7.38	8.45	19.02	7.22	8.24	2.3 (s, 3, N=CCH_3) [6.1 (C=N)]
5a	$ClCH_2$	CH_3	CH_3	O	67	114–115	17.67	6.98		17.86	7.02		0.98 (d, 3, J = 7 Hz, >$CHCH_3$), 1.6 (s, 3, =CCH_3), 7.67 (broad s, 1, NH)
5b[a]	$ClCH_2$	$(CH_3)_3C$	H	O	58	103–105	15.43	6.10		15.80	6.20		6.3 (m, 0.35, =CH), 7.4 (broad s, 1, NH)
5c	$ClCH_2$	CH_3	$(CH_3)_3C$	O	50	121–123	14.54	5.75		15.10	5.87		1.6 (s, 3, =CH_3), 7.3 (broad s, 1, NH)
6a	3,4-$(Cl)_2C_6H_3$	CH_3	CH_3	S	93	150–151	21.53	8.51		21.31	8.70		1.11 (d, 3, J = 7 Hz, >$CHCH_3$), 1.7 (s, 3, =CCH_3)
6b	CH_3	H	$(CH_3)_3C$	O		137–139		13.32			13.26		(m, 1, =CH)
7a	3,4-$(Cl)_2C_6H_3$	CH_3	CH_3	O		128–131	22.79	9.00		22.60	9.07		1.3 (d, 6, J = 7 Hz, 2 >$CHCH_3$)
7b	3,4-$(Cl)_2C_6H_3$	H	$(CH_3)_3C$	O	81	124–126	21.41	8.46		21.13	7.86		
7c	3,4-$(Cl)_2C_6H_3$	H	$(CH_3)_3C$	S	58	106–108	19.84	7.84	8.97	19.57	7.87	8.80	[6.0 (C=N)]
7d	3,4-$(Cl)_2C_6H_3$	CH_3	$(CH_3)_3C$	O		130–132	20.01	7.91			7.57		1.2 (d, 3, J = 7 Hz, >$CHCH_3$)
10					74	Oil	15.57	6.15		14.81	5.89		
11					37	140–150 (1 mm)	11.82	4.67		11.94	4.87		5.8 (d, 1, J = 3 Hz, =CH)

[a] A mixture of isomers where R′ = $(CH_3)_3C$ (65%); R′ = H (35%).

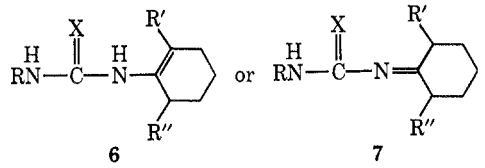
chlorides gave only enamide (**5**), while, with isocyanates or isothiocyanates, **4** could give either **6** or the acylimine compound **7**. When **6** was the product, mixtures of isomers were possible, depending upon the 1 or 5 position of the double bond (Scheme II).

SCHEME II[a]



4a, R′ = R″ = CH_3
b, R′ = H; R″ = t-C_4H_9
c, R′ = CH_3; R″ = t-C_4H_9

4 + RNCX →

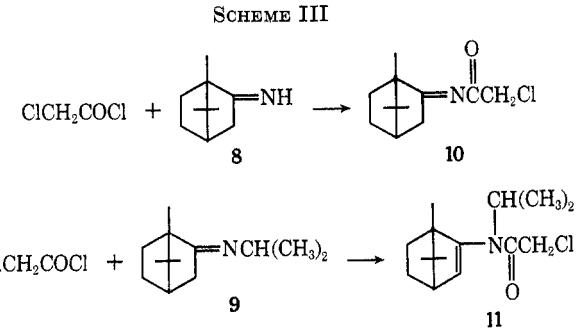


6 **7**

[a] See Table I for specific examples of **5**, **6**, and **7**.

Acyl chlorides do not invariably give enamide, however, as witnessed by the contrast in products from camphorimine (**8**) (acylimine **10**) and N-isopropylcamphorimine (**9**) (enamide **11**) (Scheme III).

SCHEME III



8 **10**

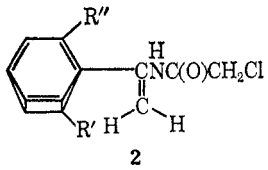
9 **11**

Structure proofs of the various products isolated were verified by nmr and ir spectral analyses. The enamide structure for **2a** or **2b**, is easily discerned by the presence of two different olefinic proton absorptions at δ 4.8 and 6.3.[7] The thionoacylimine **3** shows no olefinic proton absorption, but does clearly display a downfield methyl singlet, typical of methylimino or methylcarbonyl moieties.

There are several criteria for analyses of the cyclohexyl derivatives **5**, **6**, and **7**. *endo*-1,2-Cyclohexenyl rings generally show a characteristic "double hump," or two multiplets of three or four protons each centered at *ca.* δ 1.7 and 2.1–2.3. The downfield resonance is presumably due to the protons vicinal to the *endo* double bond. In contrast, cyclohexyl rings possessing an *exo* double bond display a continuous broad absorption between *ca.* δ 1.3 and 2.4. This difference is useful in assigning the enamide and enurea structure to **5** and **6**, and the imine structure to **7**. In addition, where R′ = H, the olefinic proton is quite prominent as a multiplet at *ca.* δ 5.8, while olefinic methyl (R′ = CH_3) gives a characteristic singlet at *ca.* δ 1.6. Where NH is not obscured by aromatic or additional amidic protons, the presence of this absorption is useful in eliminating acylimine as a possible structure.

The ir spectra are also useful in verifying structure; the presence of an acylimine (**7a**, **7b**, or **10**) shows only a broad, intense absorption between 5.9 and 6.1 μ for both C=O and C=N. However, there is a strong band at 6.1 μ for C=N in the thionoacylimine (**3**, **7c**), absent in the enthiourea (**6a**).

(7) The two olefinic protons have unexpectedly large differences in absorption. The abnormally high field resonance is assigned to the proton



2

cis, and nearly orthogonal, to the aromatic ring, while the more downfield absorption is assigned to the *trans* proton.

Compelling rationales for product formation must await detailed examination on whether materials arise from kinetics or thermodynamic control. Nevertheless the α-chloroacetamides would appear to arise from the latter, as they can be formed after prolonged heating. Nor would it be difficult to accept the thesis that **10** is formed because of resistance to *endo* camphene formation, whereas there is no alternative to such formation in **11**. Assuming **5** to be products of thermodynamic control, it would appear that the more substituted olefinic bond in cyclohexene is favored, unless the substituent is large (*i.e.*, *t*-butyl), where steric interactions of this group, planar to the group on nitrogen, might favor the imino or less substituted cyclohexene structure.

Experimental Section

Preparation of Enolizable Imines.—The preparation of imines **1a** and **1b**[8] is similar to the method of Heng Suen.[4]

1-(2,6-Diethylphenyl)ethylidenimine (1a).—To 100 g (0.629 mol) of 2,6-diethylbenzonitrile in 500 ml of ether was added under a nitrogen atmosphere, 0.688 mol of methyllithium. The reaction mixture was stirred 21 hr at room temperature, when 500 ml water was cautiously added. The ether layer was separated, washed with two 250-ml portions of water, dried over sodium sulfate, and then concentrated to give 108 g of an oil: ir (CCl_4) 3.05 (NH), 6.15 μ (C=N), no absorption for C≡N or C=O; pertinent nmr ($CDCl_3$) δ 2.29 (s, 3, N=CC**H**$_3$), 8.87 (broad s, 1, N**H**).

1-(2-*t*-Butyl-6-methylphenyl)ethylidenimine (1b).—In analogous fashion to the procedure above for **1a**, **1b** was prepared as an oil (bp 255–258°) in 98% yield from 2-*t*-butyl-6-methylbenzonitrile (mp 61–62°): ir (film) 2.9–3.15 (NH), 6.15 μ (C=N), no C≡N or C=O; pertinent nmr ($CDCl_3$) δ 2.21, 2.35 (2 s, 3 H each, ArC**H**$_3$ and N=CC**H**$_3$), 9.03 (broad s, 1, N**H**).

Imines **4a**, **4c**, and **9** have been previously described[5] as has **8**.[6] Imine **4b** was made in similar fashion to **7**, through the nitramine.

2-*t*-Butylcyclohexylidenamine. (4b).—2-*t*-Butylcyclohexanone (0.3 mol) was allowed to react with 51 g of hydroxylamine hydrochloride and 86 g of pyridine in 300 ml of absolute ethanol. After heating 3.5 hr, the material was permitted to stand 12 hr, the solvent was then evaporated, and the residue was washed with water. The oil was taken up in ether, washed with 5% HCl and once with water, and then dried over $MgSO_4$. The residue (48.4 g), upon removal of ether, showed only oxime (no C=O absorption by ir). The crude oxime (20 g) was dissolved in 200 ml of ether and mixed with 20 g of $NaNO_2$. Then 12 g of sulfuric acid diluted with water to 70 ml was added dropwise at 0–5°. After addition of acid, the material was allowed to warm to room temperature; the ether layer was separated and dried. Evaporation of solvent gave 22 g of oil: ir 6.15 (C=N), 6.4 and 7.62 μ (NO_2).

The nitramine (17.5 g) was placed in 50 ml of 28% ammonia with 100 ml of ether in a sealed pressure bottle. The material was shaken and then permitted to stand for 2 hr. The bottle was opened, the ether layer was separated and dried, and solvent was removed to give 12.5 g of an oil as **4b**, n^{25}D 1.4727.

Acylenamides.—With the exception of **10**, the preparation of chloroacetamides is illustrated by the specific procedure for **2a**.

2-Chloro-N-(2,6-diethyl-α-methylenebenzyl)acetamide (2a).—The imine of 2,6-diethylacetophenone (5.8 g, 0.033 mol) was added in 50 ml of chlorobenzene to 3.8 g of chloroacetyl chloride. The mixture was refluxed for *ca.* 2 hr, during which time hydrogen chloride was evolved. The solvent was removed and the resulting crystals were recrystallized twice (charcoal) from aqueous methanol to give a 5.8-g yield.

N-(1,7,7-Trimethylnorborn-2-ylidene)-2-chloroacetamide (10).—Camphorimine (**8**, 0.053 mol, 8.0 g) was dissolved in benzene and added to a solution of 0.05 mol of chloroacetyl chloride contained in 50 ml of benzene. A white precipitate formed during this addition. After imine had been allowed to react, 0.05 mol of pyridine (5.0 g) was added at 0.5°, and the reaction was stirred further for 0.5 hr at room temperature. The pyridine hydrochloride was filtered off, and the filtrate was washed twice with water, dried over $MgSO_4$, and then stripped of solvent. The residue consisted of an oil and some crystals (the latter was shown to be α-chloroacetamide). The oil was taken up in pentane, the solution was filtered, and oily **9** was obtained afters olvent evaporation and filtration through clay.

The en- and iminoureas and thio analogs were all prepared from the respective isocyanate or isothiocyanate and imine at room temperature, contained in an inert solvent such as benzene. A specific example is as follows.

1-(2-*t*-Butylcyclohexylidene)-3-(3,4-dichlorophenyl)-2-thiourea (7c).—3,4-Dichlorophenyl isothiocyanate (0.027 mol, 5.5 g) was mixed in benzene with 4.0 g (0.026 mol) of 2-*t*-butylcyclohexylidenamine. After standing 12 hr the solution was vacuum treated to remove solvent. The residue was a semisolid (ketone and some unreacted isothiocyanate present). The material was triturated with pentane and then filtered to give 5.4 g of **6c**, mp 103–106°. This material was recrystallized from methylcyclohexane.

Registry No.—**1a**, 24766-71-0; **1b**, 24766-72-1; **2a**, 24766-73-2; **2b**, 24766-74-3; **3**, 24766-75-4; **4b**, 24766-76-5; **5a**, 24766-77-6; **5b**, 24766-78-7; **5c**, 24766-79-8; **6a**, 24766-80-1; **6b**, 24766-81-2; **7a**, 24766-82-3; **7b**, 24766-83-4; **7c**, 24766-84-5; **7d**, 24766-85-6; **10**, 24744-55-6; **11**, 24744-56-7.

(8) Kindly supplied by Dr. R. K. Howe.

Chlorosulfonyl Isocyanate Addition to Bicyclo[2.1.0]pentane[1]

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The reactions of mercuric,[3a] lead,[3b] and thallium acetate,[3b,c] *p*-toluenesulfonic acid in acetic acid,[3d] hydrobromic acid,[3b] and halogens[3e] with the title compound have all proceeded *via* exclusive cleavage of the internal cyclopropane σ bond. The dominant influence in these bicyclopentane ring scissions is the relief of strain which accompanies cleavage or partial cleavage of the bent bridgehead bond in the transition state. This relief of strain energy overrides any electronic, steric, and/or statistical factors which determine the course of cleavage in less strained bicyclo[*n*.1.0]alkanes.

The general response of **1** to these electrophiles has been formation of *trans*-1,3-disubstitution products,[3a-d] although bromination and chlorination of **1** in the dark afforded *trans*-1,2-dihalocyclopentanes predominantly.[3e] With electron-deficient acetylenes[3f] and olefins,[3g] **1** underwent competitive reactions leading to both *cis*-fused 1,3 cycloadducts and ene-type products. On the basis of very careful kinetic, product ratio, and solvent polarity studies, Gassman, Mansfield, and Mur-

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(2) Postdoctoral Research Assistant (1968–1969) on a grant[1] supported by the NIH.

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