pentane and the extract dried over $MgSO_4$, the solvents were removed at atmospheric pressure. The hydrogenation products were obtained by distillation. *cis*-2- and *cis*-3-hexenes were obtained by distillation with a Nester-Faust NFT 50 spinning-band column.

In the case of functional alkynes, except the amino ones, the hydrogenation products were extracted with diethyl ether instead of pentane and then treated as above.

In the case of aminoalkynes, the filtrate was treated as for propylamine (vide supra). The crude hydrochloride was then purified by dissolving it in the minimum amount of acetone and then precipitating it with diethyl ether.

Isolated compounds were identified by comparison of their spectroscopic properties with those described in the literature. In some cases, direct comparison with authentic samples could be done. The purities were determined by GLC analysis.

Hydrogenation of Carbonyl Compounds (Table III). At the end of the reaction, the catalyst was filtered and rinsed with dichloromethane. After addition of water, the filtrate was acidified with 2 N HCl, extracted with dichloromethane, and dried over $MgSO_4$. After removal of the solvents, the hydrogenation products were separated by silica column chromatography. In the case of keto steroids (Scheme I), chloroform was used instead of dichloromethane.

Isolated compounds were identified by comparison of their physical and spectroscopic properties with those described in the literature. In most cases direct comparison with authentic samples was achieved.

Acknowledgment. The authors are indebted to the Centre National de la Recherche Scientifique, France, and the Société Francaise Hoechst for financial aid. Both referees are gratefully acknowledged for their constructive comments.

Registry No. Allylamine, 107-11-9; ethyl crotonate, 10544-63-5; *trans*-cinnamyl alcohol, 4407-36-7; *trans*-cinnamaldehyde, 14371-10-9; benzalacetone, 122-57-6; isophorone, 78-59-1; 6-methylhept-5-en-2-one, 110-93-0; cinnamic acid, 621-82-9; propylamine hydrochloride, 556-53-6; ethyl butyrate, 105-54-4; 3-phenylpropanol, 122-97-4; 3-phenylpropanal, 104-53-0; 1-phenyl-3-butanone, 2550-26-7; 3,3,5-trimethylcyclohexanone, 873-94-9; 6-methylheptan-2-one, 928-68-7; 6-methylhept-5-en-2-ol, 1569-60-4; 6-methylheptan-2-ol, 4730-22-7; 2-methylhept-2-en-6-ol, 1569-60-4; 3-phenylpropionic acid, 501-52-0; 2-hexyne, 764-35-2; 3-hexyne, 928-49-4; 1-propynylbenzene, 673-32-5; *N,N*-diethyl-2-butyn-1-amine, 73117-10-9; 2-butyne-1,4-diol, 110-65-6; ethynylbenzene, 536-74-3; *N,N*-diethyl-2-propyn-1-amine, 4079-68-9; 3-methyl-1-pentyn-3-ol, 77-75-8; 1-ethynylcyclohexyne, 931-49-7; *cis*-2-hexene, 7688-21-3; *cis*-3-hexene, 7642-09-3; *cis*-1-propenylbenzene, 766-90-5; *cis*-*N,N*-diethyl-2-penten-1-amine, 73117-11-0; *cis*-2-butene-1,4-diol, 6117-80-2; ethenylbenzene, 100-42-5; *N,N*-diethyl-2-propen-1-amine, 5666-17-1; 3-methyl-1-penten-3-ol, 918-85-4; 1-ethenylcyclohexene, 2622-21-1; 5-nonanone, 502-56-7; 1-phenylethanone, 98-86-2; cyclohexanone, 108-94-1; 2-methylcyclohexanone, 583-60-8; 3-methylcyclohexanone, 591-24-2; 4-methylcyclohexanone, 589-92-4; 2,6-dimethylcyclohexanone, 2816-57-1; 3,3,5,5-tetramethylcyclohexanone, 14376-79-5; 2-cyclohexylcyclohexanone, 90-42-6; 4-*tert*-butylcyclohexanone, 98-53-3; benzaldehyde, 100-52-7; heptanal, 111-71-7; 5-nonanol, 623-93-8; α-methylbenzenemethanol, 98-85-1; cyclohexanol, 108-93-0; *cis*-2-methylcyclohexanol, 7443-70-1; *trans*-2-methylcyclohexanol, 7443-52-9; *cis*-3-methylcyclohexanol, 5454-79-5; *trans*-3-methylcyclohexanol, 7443-55-2; *cis*-4-methylcyclohexanol, 7731-28-4; *trans*-4-methylcyclohexanol, 7731-29-5; *cis,cis*-2,6-dimethylcyclohexanol, 39170-84-8; *cis,trans*-2,6-dimethylcyclohexanol, 39170-83-7; *trans,trans*-2,6-dimethylcyclohexanol, 42846-29-7; *cis*-3,3,5-trimethylcyclohexanol, 933-48-2; *trans*-3,3,5-trimethylcyclohexanol, 767-54-4; 3,3,5,5-tetramethylcyclohexanol, 2650-40-0; *cis*-2-cyclohexylcyclohexanol, 51175-62-3; *trans*-2-cyclohexylcyclohexanol, 58879-21-3; *cis*-4-*tert*-butylcyclohexanol, 937-05-3; *trans*-4-*tert*-butylcyclohexanol, 21862-63-5; benzenemethanol, 100-51-6; 1-heptanol, 111-70-6; 5α-cholestan-3-one, 566-88-1; cholest-4-en-3-one, 601-57-0; cholest-5-en-3-one, 601-54-7; 5α-androstane-3,17-dione, 846-46-8; 3α,5α-cholestan-3-ol, 516-95-0; 3β,5α-cholestan-3-ol, 80-97-7; 5β-cholestan-3-one, 601-53-6; 3α,5α-3-hydroxyandrostan-17-one, 53-41-8; 3β,5α-3-hydroxyandrostan-17-one, 481-29-8; *tert*-amyl alcohol sodium salt, 14593-46-5; sodium hydride, 7646-69-7; nickel acetate, 373-02-4.

Facile Synthesis of Halo-Substituted Tetrahydroisoquinolines and Tetrahydro-2-benzazepines via *N*-Acetyl-1,2-dihydroisoquinolines

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A series of halo-substituted *N*-acetyl-1,2-dihydroisoquinolines (**3a–f**) has been prepared by a convenient and mild cyclization procedure. The synthetic utility of these compounds is demonstrated by their conversion to tetrahydroisoquinolines **5e** and **5f** and tetrahydro-2-benzazepines **10e** and **10f**, the latter via a cyclopropanation–ring expansion sequence.

1,2-Dihydroisoquinolines are interesting species due to both their chemical reactivity[1,2] and their potential as building blocks in the synthesis of alkaloids and medicinal agents. The most common method of generating these compounds involves the acid-catalyzed cyclization of (benzylamino)acetaldehyde dialkyl acetals, a procedure limited to those systems incorporating an election-rich aromatic ring.[1,3] Another route involves the reduction of isoquinolines[2] or their salts, which are usually obtained by a Pomeranz–Fritsch[4] or related reaction. Likewise, this approach is limited to electronically activated systems, and, furthermore, both methods involve the use of rather stringent reaction conditions.

We now report a mild and convenient method for the synthesis of a series of halo-substituted *N*-acetyl-1,2-dihydroisoquinolines (**3a–f**). We also describe the utilization of two of these (**3e,f**) in the preparation of the corresponding tetrahydroisoquinolines **5e,f**, as well as the 2-benzazepines **10e,f**, compounds that are only difficultly accessible by conventional procedures.

As illustrated in Scheme I, benzaldehydes **1** were converted to their Schiff bases with aminoacetaldehyde dimethyl acetal. Reductive acylation afforded **2** in good to excellent overall yields. Cyclization of **2** was effected by

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(3) A. J. Birch, A. H. Jackson, and P. V. R. Shannon, *J. Chem. Soc., Perkin Trans. 1*, 2185 (1974).

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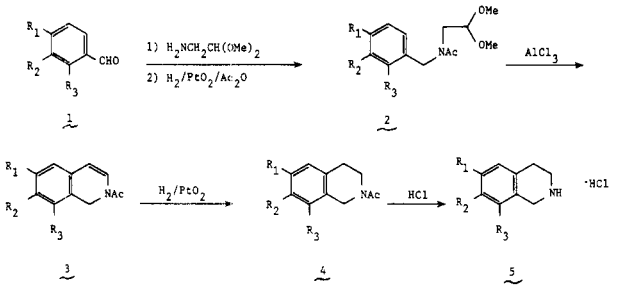
0022-3263/80/1945-1950$01.00/0

Scheme I



	R_1	R_2	R_3
a	H	H	Cl
b	H	Cl	H
c	H	F	H
d	Cl	H	H
e	H	Cl	Cl
f	Cl	Cl	H

addition to a slurry of $AlCl_3$ in 1,2-dichloroethane at *room temperature*. At least 4 equiv of $AlCl_3$ were necessary for optimum results; in practice, we utilized 4.6 equiv of $AlCl_3$. Workup shortly thereafter afforded the *N*-acetyldihydroisoquinolines **3**. The yields of monohalo products **3a–d** ranged from 35 to 55%, while the dichloro products **3e,f** were obtained consistently in 60–80% yield. The mildness of the cyclization conditions is noteworthy, and contrasts sharply with the harshness of other procedures.[1,3,4] **3e** and **3f** were then converted in high yield to **5e** and **5f** by sequential reduction and hydrolysis, completing a synthesis of halo-substituted tetrahydroisoquinolines that compares quite favorably with the Pomeranz–Fritsch route.

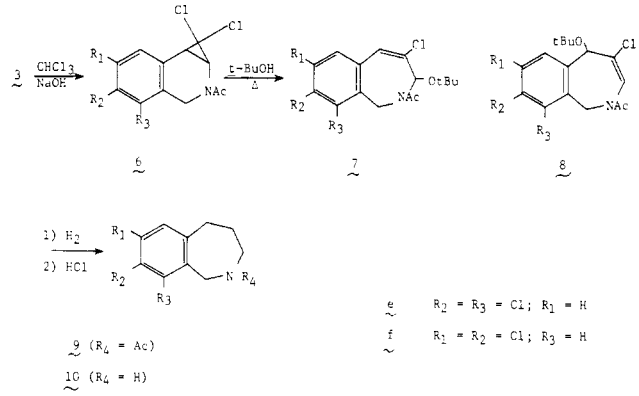
Attempts to extend the scope of this sequence to methyl-substituted derivatives were unsuccessful. Cyclization of **2** (R_1, R_2, R_3 = CH_3, H, H) derived from the three isomeric tolualdehydes gave initially small amounts of the desired products (TLC), but decomposition rapidly ensued, and much intractable material was obtained. Conducting the reaction at lower temperature or with other acid catalysts led to no improvement.

The synthetic utility of dihydroisoquinolines **3** was further illustrated by their conversion to 2,3,4,5-tetrahydro-1*H*-2-benzazepines **10** by the short and convenient reaction sequence shown in Scheme II. This cyclopropanation–ring enlargement approach is similar to the sequence of reactions carried out by Proctor[5] on *N*-tosyldihydroquinolines and also to the recently disclosed *N*-methylisoquinolone ring enlargement of Pandit.[6]

Addition of dichlorocarbene to enamides **3e** and **3f** readily afforded the desired dichlorocyclopropyl intermediates (**6**) in better than 85% yield. At room temperature they were stable, crystalline materials whose structural assignments were readily supported by the presence of characteristic AB quartets in their NMR spectra. The lower field signals at δ 5.45 and 3.80 in the spectrum of **6e** were assigned to the methylene protons from the large geminal splitting constants (J = 17 Hz), while the second AB quartet at δ 3.75 and 3.10 was assigned to the vicinal cyclopropyl protons. By a $Eu(fod)_3$-induced shift experiment, we could deduce that the signals at δ 3.75 originate from the proton proximal to the nitrogen, and the doublet at δ 3.10 is due to the proton in the benzylic position (see Experimental Section).

Thermal cleavage of the cyclopropyl moiety was best carried out in refluxing *tert*-butyl alcohol. The reaction

Scheme II



resulted in a major product, isolated in about 35–40% yield by chromatography, in addition to other minor, presumably regioisomeric, materials. Either structure **7** or **8** would satisfy the NMR spectrum of the principal product of this reaction. We assign **7**, on the basis of the strong ultraviolet absorption bands at 220 and 270 nm, characteristic of conjugation of the double bond with the aromatic nucleus. Lack of a double absorption peak at 5.95 and 6.10 μm in the IR, as appears in the spectra of **3**, further indicates the absence of the enamide structural unit of **8**.

Catalytic reduction of dihydro-2-benzazepines **7** with PtO_2 at atmospheric pressure resulted in the uptake of 3 molar equiv of hydrogen and the formation of *N*-acetyl-2,3,4,5-tetrahydro-1*H*-2-benzazepines **9**. The finding that this reduction proceeded under such mild conditions to the highest level of saturation is noteworthy and raises the possibility that the hydrogenolysis of the chlorine atom receives neighboring-group assistance from the amide moiety.

Removal of the acetyl group from **9** was readily accomplished by acid hydrolysis in 3 N HCl, and the resultant tetrahydro-2-benzazepines **10** were isolated by crystallization from the acidic medium. Structural support for these final products was unequivocally established from their spectral characteristics and furthermore from their identity with authentic materials that were synthesized by an independent sequence.[7,8]

Experimental Section

Melting points were taken in open capillaries (except where noted) on a Thomas-Hoover apparatus and are uncorrected. Boiling points are uncorrected. Infrared spectra were determined on Nujol mulls (except where noted) on a Perkin-Elmer Infracord spectrometer and are reported in micrometers. NMR spectra were obtained on $CDCl_3$ solutions (except where noted) on a Perkin-Elmer R24 spectrometer and are reported in parts per million downfield from internal Me_4Si. Combustion analyses and high-resolution mass measurements were determined by the Analytical and Physical Chemistry Section of Smith Kline & French Laboratories.

Preparation of *N*-Benzyl-*N*-(2,2-dimethoxyethyl)acetamides 2. A solution of 50 mmol of the appropriate aldehyde 1 and 50 mmol of aminoacetaldehyde dimethyl acetal in 100 mL of toluene was refluxed for 1.5 h under N_2, with azeotropic removal of water. Evaporation of solvent and Kugelrohr distillation of the residue produced the Schiff base in near quantitative yield. A mixture of 45 mmol of the Schiff base, 90 mmol of Ac_2O, 100 mg of PtO_2, and 100 mL of EtOAc was shaken under 20 psi of H_2 for ca. 1 h. The catalyst was filtered, and the filtrate was washed with $NaHCO_3$ and brine, dried over $MgSO_4$, and evaporated. Kugelrohr distillation of the residue then afforded **2**.

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(6) H.-P. Soetens and U. K. Pandit, *Heterocyles*, 11, 75 (1978).
(7) W. E. Bondinell et al., to be submitted for publication.
(8) C. Razgaitis and I. Lantos, Smith Kline & French Laboratories, unpublished results.

***N*-(2-Chlorobenzyl)-*N*-(2,2-dimethoxyethyl)acetamide (2a)**: 77%; bp 140–143 °C (0.025 mmHg). Anal. Calcd for $C_{13}H_{18}ClNO_3$: C, 57.46; H, 6.68; N, 5.15; Cl, 13.05. Found: C, 57.75; H, 6.71; N, 5.24; Cl, 12.91.

***N*-(3-Chlorobenzyl)-*N*-(2,2-dimethoxyethyl)acetamide (2b)**: 87%; bp 120–130 °C (0.003 mmHg). Anal. Calcd for $C_{13}H_{18}ClNO_3$: C, 57.46; H, 6.68; N, 5.15; Cl, 13.05. Found: C, 57.25; H, 6.70; N, 4.98; Cl, 13.03.

***N*-(3-Fluorobenzyl)-*N*-(2,2-dimethoxyethyl)acetamide (2c)**: 89%; bp 120–124 °C (0.005 mmHg). Anal. Calcd for $C_{13}H_{18}FNO_3$: C, 61.16; H, 7.11; N, 5.49; F, 7.44. Found: C, 61.44; H, 6.93; N, 5.16; F, 6.98.

***N*-(4-Chlorobenzyl)-*N*-(2,2-dimethoxyethyl)acetamide (2d)**: 85%; bp 134–137 °C (0.025 mmHg). Anal. Calcd for $C_{13}H_{18}ClNO_3$: C, 57.46; H, 6.68; N, 5.15; Cl, 13.05. Found: C, 57.43; H, 6.53; N, 5.20; Cl, 12.68.

***N*-(2,3-Dichlorobenzyl)-*N*-(2,2-dimethoxyethyl)acetamide (2e)**: 59%; mp 68–69 °C (after trituration with Et_2O). Anal. Calcd for $C_{13}H_{17}Cl_2NO_3$: C, 51.00; H, 5.60; N, 4.57; Cl, 23.16. Found: C, 50.91; H, 5.53; N, 4.54; Cl, 22.87.

***N*-(3,4-Dichlorobenzyl)-*N*-(2,2-dimethoxyethyl)acetamide (2f)**: 91%; bp 125–135 °C (0.005 mmHg). Anal. Calcd for $C_{13}H_{17}Cl_2NO_3$: C, 51.00; H, 5.60; N, 4.57; Cl, 23.16. Found: C, 50.71; H, 5.28; N, 4.56; Cl, 23.52.

Preparation of 2-Acetyl-1,2-dihydroisoquinolines 3. A solution of 10 mmol of the appropriate compound **2** in 25 mL of 1,2-dichloroethane was added at ambient temperature under N_2 to a suspension of 46 mmol of $AlCl_3$ in 100 mL of the same solvent. About 10 min later, the resulting solution was cooled in ice, and 100 mL of 40% aqueous NaOH was added gradually. The aqueous phase was separated and extracted with 100 mL of 1,2-dichloroethane. The combined organic fractions were washed with brine, dried over $MgSO_4$, and evaporated. **3a–d** were purified by chromatography on silica gel (EtOAc–CH_2Cl_2). **3e** and **3f** were obtained by trituration with Et_2O.

2-Acetyl-8-chloro-1,2-dihydroisoquinoline (3a): 37%; IR (neat) 5.95, 6.13, 12.58; NMR 7.4–6.7 (m, 3, aromatic), 6.63 (d, 1, J = 8 Hz, C_3 H), 5.68 (d, 1, J = 8 Hz, C_4 H), 4.96 (s, 2, C_1 H), 2.20 (s, 3, $COCH_3$); mass spectrum, m/e 207.044 (M^+, calcd for $C_{11}H_{10}ClNO$, 207.045).

2-Acetyl-7-chloro-1,2-dihydroisoquinoline (3b): 55%; mp 73–74.5 °C (EtOH); IR (neat) 5.96, 6.13, 12.03; NMR 7.4–6.8 (ABC pattern, 3, J_{AB} = 8 Hz, J_{BC} = 2 Hz, J_{AC} = 0, aromatic), 6.62 (d, 1, J = 8 Hz, C_3 H), 5.75 (d, 1, J = 8 Hz, C_4 H), 4.87 (s, 2, C_1 H), 2.18 (s, 3, $COCH_3$). Anal. Calcd for $C_{11}H_{10}ClNO$: C, 63.62; H, 4.85; N, 6.74; Cl, 17.07. Found: C, 63.43; H, 4.82; N, 6.82; Cl, 17.23.

2-Acetyl-7-fluoro-1,2-dihydroisoquinoline (3c): 36%; IR (neat) 5.97, 6.14; NMR 7.2–6.6 (m, 3, aromatic), 6.43 (d, 1, J = 8 Hz, C_3 H), 5.60 (d, 1, J = 8 Hz, C_4 H), 4.74 (s, 2, C_1 H), 2.13 (s, 3, $COCH_3$); mass spectrum, m/e 191.078 (M^+, calcd for $C_{11}H_{10}FNO$, 191.075).

2-Acetyl-6-chloro-1,2-dihydroisoquinoline (3d): 35%; IR (neat) 5.97, 6.13, 11.62; NMR 7.4–6.8 (m, 3, aromatic), 6.67 (d, 1, J = 8 Hz, C_3 H), 5.70 (d, 1, J = 8 Hz, C_4 H), 4.87 (s, 2, C_1 H), 2.19 (s, 3, $COCH_3$); mass spectrum, m/e 207.044 (M^+, calcd for $C_{11}H_{10}ClNO$, 207.045).

2-Acetyl-7,8-dichloro-1,2-dihydroisoquinoline (3e): 79%; mp (sealed tube) 142–143.5 °C (EtOAc); IR 5.98, 6.14, 11.95; NMR 7.28 and 6.84 (AB q, 2, J = 8 Hz, aromatic), 6.71 (d, 1, J = 8 Hz, C_3 H), 5.67 (d, 1, J = 8 Hz, C_4 H), 5.00 (s, 2, C_1 H), 2.23 (s, 3, $COCH_3$). Anal. Calcd for $C_{11}H_9Cl_2NO$: C, 54.57; H, 3.75; N, 5.79; Cl, 29.29. Found: C, 54.71; H, 3.73; N, 5.94; Cl, 29.23.

2-Acetyl-6,7-dichloro-1,2-dihydroisoquinoline (3f): 62%; mp (sealed tube) 127–128 °C (EtOAc); IR 5.97, 6.11, 11.13; NMR 7.19 (s, 1, aromatic), 7.12 (s, 1, aromatic), 6.76 (d, 1, J = 8 Hz, C_3 H), 5.73 (d, 1, J = 8 Hz, C_4 H), 4.87 (s, 2, C_1 H), 2.24 (s, 3, $COCH_3$); NMR (18 mol % Eu(fod)$_3$) 7.79 (d, 1, J = 8 Hz, C_3H), 7.37 (s, 1, aromatic), 7.32 (s, 1, aromatic), 7.06 (s, 2, C_1 H), 6.23 (d, 1, J = 8 Hz, C_4 H), 4.10 (s, 3, $COCH_3$). Anal. Calcd for $C_{11}H_9Cl_2NO$: C, 54.57; H, 3.75; N, 5.79; Cl, 29.29. Found: C, 54.52; H, 3.77; N, 5.79; Cl, 28.95.

Preparation of 2-Acetyl-1,2,3,4-tetrahydroisoquinolines 4. A mixture of 10 mmol of the appropriate compound **3**, 100 mg of PtO_2, and 60 mL of THF was shaken under 20 psi of H_2 for 3 h. It was then treated with charcoal and filtered. Evaporation of the solvent and trituration with Et_2O afforded **4**.

2-Acetyl-7,8-dichloro-1,2,3,4-tetrahydroisoquinoline (4e): 86%; mp 98–100 °C (*i*-PrOH–Et_2O); IR 6.13, 12.22; NMR 7.24 and 6.95 (AB q, 2, J = 8 Hz, aromatic), 4.66 and 4.58 (2 s, 2, C_1 H, syn and anti to carbonyl), 3.7 (m, 2, C_3 H), 2.8 (m, 2, C_4 H), 2.17 (s, 3, $COCH_3$). Anal. Calcd for $C_{11}H_{11}Cl_2NO$: C, 54.12; H, 4.54; N, 5.74; Cl, 29.05. Found: C, 54.08; H, 4.54; N, 5.92; Cl, 29.19.

2-Acetyl-6,7-dichloro-1,2,3,4-tetrahydroisoquinoline (4f): 89%; mp 174.5–175.5 °C (EtOH); IR 6.10, 11.34; NMR 7.23 (br s, 2, aromatic), 4.67 and 4.58 (2 s, 2, C_1 H, syn and anti to carbonyl), 3.7 (m, 2, C_3 H), 2.8 (m, 2, C_4 H), 2.17 (s, 3, $COCH_3$). Anal. Calcd for $C_{11}H_{11}Cl_2NO$: C, 54.12; H, 4.54; N, 5.74; Cl, 29.05. Found: C, 54.42; H, 4.39; N, 5.84; Cl, 29.37.

Preparation of 1,2,3,4-Tetrahydroisoquinolines 5. A mixture of 10 mmol of the appropriate compound **4** and 50 mL of 12 N HCl was refluxed for ca. 4 h. The cooled reaction mixture was then treated with charcoal, filtered, and evaporated. The last traces of water were azeotropically removed with EtOH, and the produce was isolated by trituration with EtOH–Et_2O.

7,8-Dichloro-1,2,3,4-tetrahydroisoquinoline hydrochloride (5e): 85%; mp 222.5–225 °C (lit.[9] 223–225 °C); IR 3.7–4.1, 6.27, 12.09; NMR (D_2O) 7.26 and 7.05 (AB q, 2, J = 8 Hz, aromatic), 4.36 (s, 2, C_1 H), 3.50 (t, 2, J = 7 Hz, C_3 H), 3.10 (t, 2, J = 7 Hz, C_4 H). Anal. Calcd for $C_9H_9Cl_2N$·HCl: C, 45.32; H, 4.23; N, 5.87. Found: C, 45.56; H, 4.39; N, 5.97.

6,7-Dichloro-1,2,3,4-tetrahydroisoquinoline hydrochloride (5f): 88%; mp 271–273 °C; IR 3.6–4.2, 6.23, 11.35; NMR (D_2O–Me_2SO–d_6) 7.41 (s, 2, aromatic), 4.40 (s, 2, C_1 H), 3.53 (t, 2, J = 6 Hz, C_3 H), 3.13 (t, 2, J = 6 Hz, C_4 H). Anal. Calcd for $C_9H_9Cl_2N$·HCl: C, 45.32; H, 4.23; N, 5.87. Found: C, 45.47; H, 4.31; N, 6.16.

Preparation of 2-Acetyl-1a,2,3,7b-tetrahydro-1*H*-cyclopropa[*c*]isoquinolines 6. A solution of 10 mmol of the appropriate dihydroisoquinoline **3** and 4 mmol of benzyltriethylammonium chloride was stirred in 40 mL of $CHCl_3$ with 40 mL of 40% NaOH at room temperature for 6 h. The organic phase was separated from the aqueous solution and was washed with 5 N HCl, 5% Na_2CO_3, and saturated brine solutions. Concentration of the chloroform extract at reduced pressure furnished an oil, which was chromatographed on SiO_2 with EtOAc–petroleum ether (1:1). The resulting solids were recrystallized from $CHCl_3$–petroleum ether.

1,1,4,5-Tetrachloro compound 6e: 85%; mp 135–136 °C; IR 6.06, 9.60, 10.20, 11.75; NMR 7.4 (br s, 2, aromatic), 5.45 and 3.80 (AB q, 2, J = 18 Hz, CH_2), 3.75 and 3.10 (AB q, 2, J = 10 Hz, cyclopropyl), 2.30 (s, 3, CH_3CO); NMR (26 mol % Eu(fod)$_3$) 7.49 (s, 2, aromatic), 7.28 and 4.64 (AB q, 2, J = 18 Hz, CH_2), 4.35 and 3.40 (AB q, 2, J = 10 Hz, cyclopropyl), 3.58 (s, 3, CH_3CO). Anal. Calcd for $C_{12}H_9Cl_4NO$: C, 44.35; H, 2.79; N, 4.31. Found: C, 44.18; H, 3.06; N, 4.24.

1,1,5,6-Tetrachloro compound 6f: 80%; mp 123.5–124.5 °C; IR 6.0, 8.85, 9.62, 12.0; NMR 7.47 and 7.18 (2 s, 2, aromatic), 5.10 and 3.80 (AB q, 2, J = 18 Hz, CH_2), 3.70 and 3.05 (AB q, 2, J = 10 Hz, cyclopropyl), 2.28 (s, 3, CH_3CO). Anal. Calcd for $C_{12}H_9Cl_4NO$: C, 44.35; H, 2.79; N, 4.31. Found: C, 44.27; H, 2.75; N, 4.42.

Preparation of Trichloro-2-acetyl-3-(1,1-dimethylethoxy)-2,3-dihydro-1*H*-2-benzazepines 7. Dichlorocyclopropyl compounds **6** (4.5 mmol) were refluxed in 50 mL of *tert*-butyl alcohol for ca. 6 h. Evaporation of the solvent yielded an oil which was chromatographed on SiO_2.

4,8,9-Trichloro compound 7e was obtained in 30% yield by using chloroform for the chromatography (R_f 0.62). The compound was crystallized from the eluent by the addition of petroleum ether: mp 133–134 °C; IR 6.07, 6.15, 9.27, 9.40, 11.05, 11.15; NMR 7.42 and 7.07 (AB q, 2, J = 8 Hz, aromatic), 6.7 (s, 1, C_3 H), 6.45 (s, 1, C_5 H), 5.1 and 4.6 (AB q, 2, J = 17 Hz, C_1 H), 2.0 (s, 3, CH_3CO), 1.35 (s, 9, $(CH_3)_3C$); UV max (EtOH) 218 nm (ϵ 26 400), 268 (25 700). Anal. Calcd for $C_{16}H_{18}Cl_3NO_2$: C, 52.99; H, 5.00; N, 3.86. Found: C, 53.07; H, 4.91; N, 3.98.

4,7,8-Trichloro compound (7f) was obtained in 35% yield by using cyclohexane–ether (2:1) for the chromatography, and the desired fraction (R_f 0.36) was crystallized from an ether–petroleum ether mixture: mp 176–179 °C; IR 6.12, 6.17, 9.20, 9.40,

(9) U.S. Patent 3 988 339 (1976); *Chem. Abstr.*, **86**, 55299 (1977).

11.32, 11.50; NMR 7.25 (br s, 2, aromatic), 6.6 (s, 1, C_3 H), 6.4 (s, 1, C_5 H), 4.80 and 4.10 (AB q, 2, J = 17 Hz, C_1 H), 1.95 (s, 3, CH_3CO), 1.3 (s, 9, $(CH_3)_3C$); UV max (EtOH) 220 nm (ϵ 28 700), 270 (25 700). Anal. Calcd for $C_{16}H_{18}Cl_3NO_2$: C, 52.99; H, 5.00; N, 3.86. Found: C, 52.88; H, 5.02; N, 3.79.

Preparation of Dichloro-2,3,4,5-tetrahydro-1*H*-2-benzazepines 10. A solution of the dihydro-2-benzazepines **7** (1.0 g, 2.7 mmol) in 80 mL of MeOH was hydrogenated at atmospheric pressure and room temperature with 200 mg of PtO_2. When uptake of hydrogen ceased, the solution was filtered, and the filtrate was concentrated to an oil. The crude 2-acetyltetrahydro-2-benzazepines thus obtained were covered with 50 mL of 4 M aqueous HCl and were refluxed overnight. This acidic hydrolysate was filtered and cooled overnight in the refrigerator, whereupon it deposited white crystalline hydrochlorides of the desired 2-benzazepines.

8,9-Dichloro-2,3,4,5-tetrahydro-1*H*-2-benzazepine hydrochloride (10e): 80%; mp 268–270 °C (MeOH–Et_2O). The product was identical spectroscopically with a sample prepared by an independent sequence (mp 268–271.5 °C):[7] IR 6.4, 7.25, 8.4, 8.8, 11.7, 12.1; NMR (Me_2SO-d_6) 9.8 (br s, 2, NH_2, D_2O exchanged), 7.64 and 7.30 (AB q, 2, J = 8 Hz, aromatic), 4.58 (s, 2, C_1 H), 3.2 (m, 4, C_3 H and C_5 H), 1.9 (m, 2, C_4 H).

7,8-Dichloro-2,3,4,5-tetrahydro-1*H*-2-benzazepine hydrochloride (10f): 70%; mp 308–310 °C (MeOH–Et_2O). Spectroscopically, the product was identical with a sample prepared by an independent sequence (mp 315–317 °C):[8] IR 6.15, 8.8, 10.1, 10.35; NMR (free base) 7.2 (m, 2, aromatic), 3.85 (s, 2, C_1 H), 3.05 (m, 4, C_3 H and C_5 H), 1.7 (m, 3, NH (D_2O exchanged) and C_4 H). Anal. Calcd for $C_{10}H_{11}Cl_2N$·HCl: C, 47.55; H, 4.79; N, 5.55. Found: C, 47.24; H, 4.86; N, 5.58.

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Registry No. **1a**, 89-98-5; **1b**, 587-04-2; **1c**, 456-48-4; **1d**, 104-88-1; **1e**, 6334-18-5; **1f**, 6287-38-3; **2a**, 73261-75-3; **2b**, 73261-76-4; **2c**, 73261-77-5; **2d**, 73261-78-6; **2e**, 73261-79-7; **2f**, 73261-80-0; **3a**, 73261-81-1; **3b**, 73261-82-2; **3c**, 73261-83-3; **3d**, 73261-84-4; **3e**, 73261-85-5; **3f**, 73261-86-6; **4e**, 61563-45-9; **4f**, 73261-87-7; **5e**, 57987-77-6; **5f**, 73075-49-7; **6e**, 73261-88-8; **6f**, 73261-89-9; **7e**, 73261-90-2; **7f**, 73261-91-3; **9e**, 73261-92-4; **9f**, 73261-93-5; **10e**, 69739-51-1; **10f**, 69239-59-4; aminoacetaldehyde dimethyl acetal, 22483-09-6; *N*-[(2-chlorophenyl)methylene]-2,2-dimethoxyethanamine, 62882-12-6; *N*-[(3-chlorophenyl)methylene]-2,2-dimethoxyethanamine, 62882-13-7; *N*-[(3-fluorophenyl)methylene]-2,2-dimethoxyethanamine, 73261-94-6; *N*-[(4-chlorophenyl)methylene]-2,2-dimethoxyethanamine, 54879-73-1; *N*-[(2,3-dichlorophenyl)methylene]-2,2-dimethoxyethanamine, 57987-75-4; *N*-[(3,4-dichlorophenyl)methylene]-2,2-dimethoxyethanamine, 73274-27-8.

Facile Oxyselenation of Olefins in the Presence of Copper(II) or Copper(I) Chloride as Catalyst

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Treatment of olefinic hydrocarbons with phenyl selenocyanate in alcohol in the presence of copper(II) or copper(I) chloride affords β-alkoxyalkyl phenyl selenide in good yield. Similar reactions in aqueous tetrahydrofuran or acetic acid–chloroform give the corresponding selenide. The reaction is trans stereospecific in the cases of *trans*-2-butene, *cis*-2-butene, and cyclohexene and regiospecific in the cases of styrene, acrylaldehyde, crotonaldehyde, and vinyl acetate, respectively. The reaction proceeds even with a catalytic amount of copper(II) chloride. Of the various transition-metal salts examined, nickel(II) halides are similar to copper(II) or copper(I) halides as catalyst; the chlorides of Cr(III) and Co(II) are moderately effective, while the chlorides of Mn(II), Fe(III), Fe(II), Zn(II), Ag(I), Cd(II), Hg(II), Hg(I), Tl(III), and Tl(I) are almost ineffective. The use of the pyridine complex of copper or nickel halides suppresses the reaction. The reaction is presumed to proceed via (i) the polarization of the Se–CN bond by coordination of the effective metal salt to the cyano group and (ii) a nucleophilic attack of olefin on the polarized selenium. The substituent parameters of phenylseleno and selenocyanato groups for ^{13}C NMR have been found to be +13 and +15 to ~16 ppm for the α carbon and +6 and +6 to ~7 ppm for the β carbon, respectively.

The chemistry of organoselenium compounds is of current interest from the viewpoint of organic synthesis.[1] One of the key reactions in this chemistry is the introduction of selenium into organic compounds. Oxyselenation of olefins is an effective method for this purpose, and so far several methods have been described in the literature[2] which use aryl- or alkylselenenyl carboxylate or halide or dimethyl selenoxide. We have now found a new facile oxyselenation reaction of olefins by aryl or alkyl selenocyanate with various metal halides, especially copper or nickel chloride and bromide, in alcohol, acetic acid, or water.[3] This provides another method for organic synthesis using the easily accessible aryl[4,5] or alkyl selenocyanates.[6,7a] We describe here the details of this reaction,

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