high degree of purity. Attempts to obtain 1,8-dimethylthianthrene (2, R = Me) from 7-methyl-1,2,3-benzothiadiazole (1, R = Me) failed; in fact, 1 (R = Me) did not react at lower temperature (method A), while at higher temperature (method B) the products were unidentifiable. As for the reaction pathway leading to thianthrene 2, a mechanism analogous to that previously reported for the reaction of 1 with methyl, phenyl, and arylthio radicals,[9] aryl nitrenes,[10] and diphenylcarbenes[11] can be invoked also in this case; attack of *tert*-butoxy radical on the sulfur atom of 1 would in fact lead to decomposition of the heterocyclic nucleus with nitrogen loss and formation of the radical intermediate 3 (Scheme I). Reaction of 3 with a further molecule of 1 would afford 4 and then 2 by intramolecular homolytic substitution at the sulfur atom.

Experimental Section

1,2,3-Benzothiadiazole[7b] and 6-chloro-[13] and 5-methoxy-1,2,3-benzothiadiazole[14] were prepared as described in the literature. Reaction products, thianthrene and 2,7-dichloro-,[6] 2,7-dimethoxy-,[8] and 2,7-bis(carbomethoxy)thianthrene,[12] were identified by mixture melting points with authentic specimens. Di-*tert*-butyl peroxide[15] is commercially available.

7-Methyl-1,2,3-benzothiadiazole. To a solution of the bis(2-methyl-6-nitrophenyl) disulfide[16] (10 g) in hot acetic acid (50 mL) were added in small portions powdered zinc (20 g) and concentrated hydrochloric acid (40–50 mL). The mixture was refluxed for 1 h and then cooled; addition of a solution of sodium acetate (30 g) in water (400 mL) led to formation of a precipitate, which was filtered, washed with water and EtOH (10 mL), and then dried. The obtained zinc salt of 2-methyl-6-aminothiophenol was then dissolved in boiling concentrated hydrochloric acid; when the resulting solution was cooled, the 2-mercapto-3-methylaniline hydrochloride (6.3 g, 60% yield; mp 196–197 °C) was isolated. This crude product was suspended in water (10 mL) containing 7 mL of hydrochloric acid and diazotized with 2.7 g of sodium nitrite at 5–10 °C. Extraction of the reaction mixture and purification of the crude product on a silica gel column gave the title compound: 75% yield; mp 33–34 °C; bp 157 °C (17 mm); mass spectrum, *m/e* 150 ($M^{+\cdot}$), 122, 78, 77. Anal. Calcd for $C_7H_6N_2S$: C, 55.9; H, 4.02; N, 18.67; S, 21.37. Found: C, 55.8; H, 3.91; N, 18.55; S, 21.04.

5-(Carbomethoxy)-1,2,3-benzothiadiazole. A solution of 2-nitro-4-(carbomethoxy)chlorobenzene[17] (18.3 g) in EtOH (45 mL) was treated with a solution of sodium disulfide, obtained by dissolving 1.6 g of sulfur in a water solution of $Na_2S{\cdot}9H_2O$ (12 g). The mixture was refluxed for 3 h and then poured into water; filtration of the reaction mixture gave crude bis[2-nitro-4-(carbomethoxy)phenyl] disulfide: 17.6 g; mp 205–206 °C. This product was dissolved in methylene chloride (150 mL) and reduced by catalytic hydrogenation with 10% Pd/C as the catalyst. Filtration of the catalyst and evaporation of the solvent gave crude bis[2-amino-4-(carbomethoxy)phenyl] disulfide (13.6 g), which was suspended in 25 mL of water containing 19 mL of concentrated hydrochloric acid and diazotized with 5.7 g of sodium nitrite at 5–10 °C. Extraction of the reaction mixture and purification of the crude residue on a silica gel column gave the title product: 10 g (70% yield); mp 112–113 °C (lit.[18] mp 102–106 °C); mass spectrum, *m/e* 194 ($M^{+\cdot}$), 166, 135; IR 1725 (γ_{max}), 1290 cm^{-1}.

Synthesis of Thianthrenes. Method A. A solution of the appropriate benzothiadiazole (0.05 mol) and di-*tert*-butyl peroxide (10 mL) in benzene (20 mL) was refluxed for ca. 18 h. The thianthrene, which crystallized on cooling of the reaction mixture was collected and washed with *n*-pentane. With 6-methoxy-1,2,3-benzothiadiazole the reaction is very slow; chromatography of reaction mixture on a silica gel column with *n*-pentane/ether (90:10) as eluant gave 2,7-dimethoxythianthrene (35%) together with starting materials (60%). With the 5-(carbomethoxy) and 7-methyl derivatives the reaction failed; evaporation of the solvent gave unchanged starting product.

Method B. A solution of the appropriate benzothiadiazole (0.05 mol) in di-*tert*-butyl peroxide (25 mL) was refluxed for ca. 10 h. The thianthrene crystallized by cooling of the reaction mixture was filtered and washed with *n*-pentane. The reaction failed with the 7-methyl derivative; in this case a tarry, unidentified product was formed in 100% yield.

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Registry No. 1 (R = H), 273-77-8; 1 (R = Cl-6), 23644-01-1; 1 (R = CO_2Me-5), 23616-15-1; 1 (R = OMe-5), 31860-05-6; 2 (R = H), 92-85-3; 2 (R = Cl), 60420-80-6; 2 (R = CO_2Me), 65178-26-9; 2 (R = OMe), 54815-69-9; 7-methyl-1,2,3-benzothiadiazole, 78805-01-3; bis(2-methyl-6-nitrophenyl)disulfide, 56202-21-2; 2-methyl-6-aminothiophenol Zn, 78804-25-8; 2-mercapto-3-methylaniline hydrochloride, 78805-02-4; 2-nitro-4-(carbomethoxy)chlorobenzene, 14719-83-6; bis[2-nitro-4-(carbomethoxy)phenyl]disulfide, 35350-37-9; bis[2-amino-4-(carbomethoxy)phenyl]disulfide, 78822-61-4; di-*tert*-butyl peroxide, 110-05-4.

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Synthesis of Isoquinolines from Indenes

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The report by Miller and Frincke[1] of their synthesis of isoquinolines from indenes by ozonolysis followed by treatment of the intermediates with ammonia prompts us to report the results of a related investigation. Our rationale for seeking a route to isoquinolines via indenes was very similar to Miller and Frincke's. We chose to use osmium tetraoxide and sodium metaperiodate for the oxidation step, a procedure that also has precedent, having been used in a synthesis of illudine by Woodward and Hoye.[2] However, the latter authors met with limited success when they used the procedure with a catalytic amount of osmium tetraoxide[3] and found it necessary to use a stoichiometric quantity of this reagent. At the outset we had been aware that only catalytic amounts of osmium tetraoxide should be used if the method were to be of general utility. It had been our hope that we could find conditions under which the synthesis could be carried out in one operation by having all of the reactants, the indene, sodium metaperiodate, a catalytic amount of osmium tetraoxide, and ammonia, present together in solution. We did, indeed, succeed in converting indene to isoquinoline in 67% yield by this procedure, but the reaction proceeded very slowly, and several days were required for the con-

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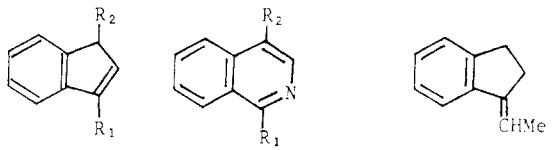
Table I. Conversion of Indenes to Isoquinolines

indene	isoquinoline	yield, %
1a	2a	73
1b	2b	57
1c	2c	56
1d + 3	2d	56[a] (80[b])
1e	2e	77

[a] Based on starting material (1d + 3). [b] Based on estimated amount of 1d in starting material.

version. Attempts to increase the rate of the process were not successful; the oxidation processes have a complex pH dependence, and ammonia deactivates osmium tetraoxide.[4]

We turned, therefore, to a two-step, "one-pot" procedure in which the oxidation step used 2 equiv of sodium metaperiodate and a catalytic amount of osmium tetraoxide in a 5:2 mixture of *tert*-butyl alcohol and a phosphate buffer of pH 8; the indene was normally oxidized within 5 h under these conditions. Ammonium acetate was then



1 2 3

a $R_1 = R_2 = H$

b $R_1 = Me$; $R_2 = H$

c $R_1 = Ph$; $R_2 = H$

d $R_1 = Et$; $R_2 = H$

e $R_1 = H$; $R_2 = Me$

added, and the isoquinoline produced could be isolated by standard procedures; isoquinoline itself was isolated in 73% yield by this method. Indenes carrying an alkyl or phenyl substituent on the olefinic double bond were also converted to isoquinolines in acceptable yields by this method. Under some of the reaction conditions we investigated initially, these compounds gave poor results, as might have been anticipated since it has been pointed out[5] that it is often difficult to dihydroxylate trisubstituted olefins under catalytic conditions.

One route to substituted indenes is by the dehydration of the Grignard product of the indanone, but this may produce a mixture of isomers; for example, when the ethyl Grignard reagent was used, a mixture of **1d** and **3** was obtained. As the fourth entry in Table I shows, it is unnecessary to separate the isomer with an exocyclic double bond before carrying out the conversion to the isoquinoline. Another route to substituted indenes is the alkylation of the indenyl anion, and the 1-alkylindene may be isolated from this reaction, but tautomerism to the 3-alkylindene can readily occur.[6] However, 1-methylindene (**1e**) was cleanly converted to 4-methylisoquinoline (**2e**) under the conditions described; no **2b** was detected in the product by ^1H NMR spectroscopy, showing that no appreciable tautomerism of **1e** had occurred during the reaction.

This procedure has proven to be a convenient method for the conversion of a range of simple indenes to isoquinolines, and its applicability to more complex examples will be investigated further.

Experimental Section

Isoquinoline Synthesis. A solution of indene (1.16 g, 10.0 mmol) in 50 mL of *tert*-butyl alcohol was prepared in a 250-mL flask equipped with a magnetic stirrer, and osmium tetraoxide (38 mg, 0.15 mmol) was added to the stirred solution. After 5 min, sodium metaperiodate (4.7 g, 22.0 mmol) and 30 mL of phosphate buffer (pH 8: 50 mL of 0.1 M KH_2PO_4 and 46.7 mL 0.1 M NaOH made up to 100 mL) were added. After 5 h (or when a flocculent, white precipitate appeared and the green color of the solution faded, signaling completion of the oxidation), ammonium acetate (7.7 g, 0.1 mol) was added, and stirring was continued for 30 min. The mixture was poured into 150 mL of dilute hydrochloric acid, and the resulting mixture was extracted with ether. The aqueous phase was made basic with concentrated aqueous ammonia and thoroughly extracted with ether. This ether extract afforded isoquinoline (0.95 g, 7.3 mmol) which was purified by vacuum distillation; picrate, mp 223–225 °C (lit.[7] mp 225–226 °C).

The same procedure with the same molar quantities of reactants was used in the preparation of substituted isoquinolines, and the results are listed in Table I. 3-Ethylindene was prepared from 1-indanone by Grignard reaction with ethylmagnesium bromide and dehydration of the alcohol produced with sulfuric acid in benzene. A 7:3 mixture of 3-ethylindene and 1-ethylideneindan (NMR integration) was obtained; this mixture of isomers (1.44 g, 10.0 mmol) was converted to 1-ethylisoquinoline (0.88g, 5.6 mmol). 1-Methylindene was prepared by treatment of indene sequentially with butyllithium and methyl sulfate.[6] The ^1H NMR spectra of all products were in accord with the structures assigned. Free bases were distilled under reduced pressure and converted to their crystalline picrates: 1-methylisoquinoline picrate, mp 226–227 °C (lit.[7] mp 225–226 °C); 1-phenylisoquinoline picrate, mp 165–166 °C (lit.[7] mp 165–166 °C); 1-ethylisoquinoline picrate, mp 208–210 °C (lit.[7] 209–210 °C); 4-methylisoquinoline picrate, mp 209–211 °C, with sublimation and remelting at 218 °C (lit.[8] mp 212–216 °C). Melting points were determined on a Thomas-Kofler micro hot stage.

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Registry No. **1a**, 95-13-6; **1b**, 767-60-2; **1c**, 1961-97-3; **1d**, 2294-91-9; **1e**, 767-59-9; **2a**, 119-65-3; **2a** picrate, 24171-66-2; **2b**, 1721-93-3; **2b** picrate, 21147-61-5; **2c**, 3297-72-1; **2c** picrate, 56947-88-7; **2d**, 7661-60-1; **2d** picrate, 79172-39-7; **2e**, 1196-39-0; **2e** picrate, 79172-40-0; **3**, 22495-79-0; 1-indanone, 480-90-0.

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Deamination of 6-Amino- and 6-(Alkylamino)-9-alkylpurines and Demethylation of Methylthiopurines by Sodium in Liquid Ammonia[1,2]

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Several reagents have been usefully applied for the reduction of a C=N bond in purines. With sodium borohydride reduction can occur at different positions.[3-6]

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(2) Part 84 on pyrimidines. For part 83 see: Gönczi, C.; Swistun, Z.; van der Plas, H. C. *J. Org. Chem.* **1981**, *46*, 608.

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