The distilled materials were found to be at least 98% pure when analyzed by gas chromatography. Potassium *t*-butoxide was obtained from the Mine Safety Appliance Co. as the sublimed material and stored continuously in a nitrogen drybox equipped with a moisture conductivity cell.

Solvent Purification.—*t*-Butyl alcohol (commercial grade) and hexamethylphosphoramide (Eastman Organic Chemicals) were purified by distillation over Linde 13X Molecular Sieves to remove any adsorbed water. The sieves had previously been conditioned by calcination at 400° for 4 hr. The solvents were stored continuously in a moisture-free drybox.

Oxidation Experiments.—All base–solvent systems were made up to the appropriate molarity under nitrogen in a heavy-walled Pyrex flask equipped with a side arm. The reactant was added to the reaction flask; the flask was sealed under nitrogen, removed from the drybox, and transferred to the oxidation apparatus. Oxygen was stored in a polyethylene balloon under 1-atm. pressure and passed through a wet-test meter and into a calcium chloride drying tower and finally through a water-cooled Friedrichs condenser and into the reaction flask containing the reaction mixture. The system was flushed with oxygen through the flask side arm, the side arm was sealed, and an equilibrium pressure was established. The reaction was initiated by stirring at 1300 r.p.m. The volume of oxygen consumed as a function of time was determined from the wet-test meter which allows an estimation of the volume of gas consumed to within ±1 cc. With this method, a constant oxygen partial pressure of 1 atm. was maintained above the system. All reactions were allowed to proceed until no apparent oxygen consumption was observed. This oxidation technique was recently described in greater detail.[21]

Quantitative Determination of Products.—Quantitative analysis of all products and starting materials was carried out according to the method of Pobiner, Wallace, and Hofmann.[22] Two procedures were employed. One involves an extraction–ion-exchange–infrared procedure and the other an extraction–ultraviolet procedure. Both methods rely on initial homogenization with water and subsequent extraction with cyclohexane to remove the starting material. The latter removes any spectral interference during the determination of acidic products. The acidic products remain as their acid salts in the aqueous–HMPA phase and are subsequently liberated by acidification with hydrochloric acid. If the acid is aromatic, it can be quantitatively determined directly by ultraviolet spectroscopy from standard curves. If the acidic material is aliphatic or presents a weak ultraviolet absorption it is determined by the ion-exchange–infrared method. This involves treating the aqueous phase with Amberlite LA-2 anion-exchange resin. The free acid is extracted with CCl_4 and quantitatively determined by infrared spectroscopy. These methods were accurate to within 95–99% for all products isolated and identified.

Identification of Products.—The structure of the products reported have been confirmed by various methods following isolation by conventional techniques. These methods are summarized for each product. (a) Benzoic acid was identified by its characteristic infrared and ultraviolet spectra and its melting point (122–123°). (b) Stilbene was confirmed by its characteristic ultraviolet and infrared spectra and its melting point (124°). (c) Benzenesulfonic acid was confirmed by its characteristic ultraviolet and infrared spectra and the preparation of its phenylhydrazinium salt (m.p. 178–180°, lit.[23] m.p. 179°) according to the method of Latimer and Bost.[24] (d) Thiophenol was determined by its characteristic infrared and ultraviolet spectra. Quantitative data were obtained by potentiometric titration with standard silver nitrate solution. (e) Methanesulfonic acid was identified by its infrared spectrum and g.c. comparison to an authentic sample on the 2-ft. silicone rubber column described above. (f) Fluorenone was identified by infrared and ultraviolet comparison to an authentic sample of the ketone. (g) Carbon dioxide was determined by the infrared technique of Pobiner[25] which is both quantitative and qualitative. (h) 1-Butanesulfonic acid was identified by infrared comparison to an authentic sample and the preparation of its anilinium salt (m.p. 159–161°, lit.[26] m.p. 159–162°). (i) Butyric acid was determined by infrared comparison to an authentic sample. (j) Succinic acid was determined by infrared comparison to an authentic sample and its melting point (185°). In the oxidation of *n*-butyl sulfide and tetramethylene sulfide minor amounts of other products were formed but attempts to identify them were not successful. In many instances, attempts to detect sulfoxides and other reasonable intermediates were made. No evidence for the formation of such intermediates was found.

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A Convenient Method for the Preparation of Some Optically Active Allylic Alcohols[1]

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Reaction of cyclic olefins such as cyclopentene, cyclohexene, and cyclooctene with *t*-butyl hydroperoxide and a copper salt of an optically active acid yields allylic esters. The esters can be converted into allylic alcohols by saponification or reduction with lithium aluminum hydride. In some cases optically active allylic alcohols have been obtained. The total asymmetric induction is not high but because of the high rotation of the optically pure materials substantial rotations are found.

The copper ion catalyzed reactions of *t*-alkyl peresters and diacyl peroxides with olefins yields allylically substituted esters.[2] The general mechanism for this reaction involves reduction of the peroxide by cuprous ion to give a radical and an anion from the peroxide. For example, *t*-butyl perbenzoate yields *t*-butoxy radicals, benzoate ion, and cupric ion. In the presence of a good hydrogen donor, hydrogen transfer often occurs and a new radical is generated. In general this radical is oxidized by cupric ion. The product of this oxidation varies according to the structure of the radical.

One of the most valuable applications of this reaction is the allylic substitution process which is exemplified by the reaction of a terminal olefin with *t*-butyl

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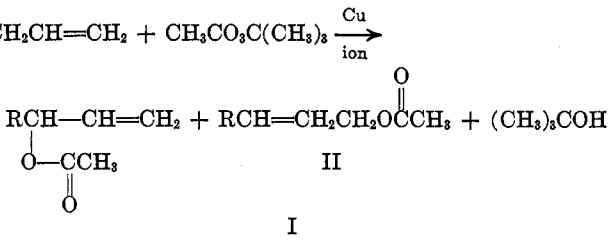
(2) For leading references, see J. K. Kochi, *Tetrahedron*, **18**, 482 (1962).

peracetate in the presence of copper ion. One of the most remarkable features of these reactions is that under most conditions the thermodynamically least stable isomer I is formed in considerable preference to the most stable isomer II.[3] The reasons for this are



not completely agreed upon; however, the general behavior is well established. It seemed possible that the transition state for the formation of ester might involve a reasonable amount of order of the various components. If this is the case and if an optically active carboxylate anion was used, then in the formation of esters I there is a chance for asymmetric induction. As part of a program aimed at learning more about the possibilities of asymmetric induction during complex metal ion reactions, a study of this reaction has been conducted.

After considerable experimentation it was found that the best yields of esters could be obtained if the olefin (10 moles), *t*-butyl hydroperoxide (1 mole), and cupric salt (0.1 mole) were allowed to react at room temperature or at slightly elevated temperatures. Completion of the reaction was often indicated by a color change from blue to brown. Although it is possible to consider a wide number of optically active carboxylates, attention has been focused in these experiments on two readily available materials, α-ethyl camphorate (III) and methyl diacetyltartarate (IV), with most of the work being done with III.[4] Some representative results of these experiments are collected in Table I.

TABLE I

PEROXIDE REACTIONS

Olefin	Carboxylate	Conditions	Rotation of allylic alcohol degrees
Cyclohexene	III	2 days, 25°	−10.1
Cyclohexene	IV	16 hr., 50°	+10.1
Cyclopentene	III	2 days, 25°	−13.8
Cyclooctene	III	1 week, 65°	+5.85
Bicyclo-3,2,1-octene-2	III	2 days, 25°	−5.21
2-Methyl-2-butene	III	1 week, 25°	0
1-Octene	III	1 week, 70°	0
Cyclododecene	III	1 week, 25°	0

It can be readily seen that most of the cyclic olefins gave optically active allylic alcohols. The total amount of asymmetric induction is probably small in these cases; however, the rotations of the optically pure materials are relatively high so that, even with small amounts of asymmetric induction, substantial rotations are observed.[5]

Unfortunately rotations of the alicyclic allylic alcohols are low and the amount of asymmetric induction, if any, was not sufficient to give observable rotations at the sodium D line.

It is clear that in those cases in which reasonable amounts of asymmetric induction are observed that this is a valuable method for the direct introduction of an optically active center.[6]

Experimental[7]

(+)-α-Ethyl Camphorate.—This material was prepared according to the procedure of Walker.[8]

Cupric Salt of α-Ethyl Camphorate.—A solution of 17.67 g. (0.18 mole) of potassium acetate in 110 ml. of water was added to a solution of 41.0 g. (0.18 mole) of (+)-α-ethyl camphorate in 110 ml. of methanol. A solution of 45.0 g. (0.18 mole) of cupric sulfate pentahydrate in 125 ml. of water was added with stirring over 1 hr. A heavy, blue liquid formed. It was taken up in ether which was washed with 10% sodium bicarbonate solution. The ether was evaporated to give 44 g. of a blue solid. The infrared spectrum of this material (potassium bromide pellet) exhibited a carbonyl band at 1720 and a carboxylate absorption at 1605 cm.$^{-1}$. It was found rather fortuitously that the material could be recrystallized from 1-octene. After two recrystallizations it had m.p. 250°.

Anal. Calcd. for $C_{24}H_{38}CuO_8$: C, 55.60; H, 7.35; Cu, 12.3. Found: C, 55.15; H, 7.32; Cu, 12.4.

Di-O-acetyltartaric Acid Half-Methyl Ester (IV).—This substance was prepared according to the procedure of Lucas and Baumgarten.[9]

Cupric Salt of IV.—To a solution of 24.8 g. (0.1 mole) of IV in 200 ml. of methanol was added 10.0 g. (0.05 mole) of cupric acetate monohydrate. The methanol was removed under reduced pressure and the residue was dissolved in 200 ml. of methanol which was evaporated. This procedure was repeated three times. There was obtained a blue-green solid which was washed with ether. This procedure gave 25.5 g. (91%) of material, m.p. 192–195°.

Δ²-Cyclopentenol.—The cupric salt of III, 12.0 g. (0.023 mole), was dissolved in 110 g. (1.61 mole) of cyclopentene containing 12.0 g. (0.133 mole) of *t*-butyl hydroperoxide. The solution was stirred for 40 hr. During this time a brown precipitate formed. Ether, 500 ml., was added and the solution was extracted with 10% aqueous sodium hydroxide. The organic phase was concentrated and dried over anhydrous magnesium sulfate. Evaporation afforded 14.2 g. of material which was distilled, b.p. 150° (12 mm). There was obtained 10.6 g. (78)% of α-ethyl-β-Δ²-cyclopentenyl camphorate, $[\alpha]^{28}D$ +23.04° (*c* 6.77, $CHCl_3$). The diester, 10.0 g. (0.039 mole), was reduced with 1.5 g. (0.04 mole) of lithium aluminum hydride in 50 ml. of dry ether. There was obtained 9.3 g. of a semisolid after treating the ether mixture with aqueous base and removing the ether. Evaporative distillation afforded 1.42 g. (43%) of Δ²-cyclopentenol, $[\alpha]^{26}D$ −13.8° (*c* 8.9, $CHCl_3$). The phenylurethan was prepared, m.p. 121–123° (lit.[10] m.p. 121.5°), $[\alpha]^{25}D$ −18.9° (*c* 3.92, $CHCl_3$). The yield of Δ²-cyclopentenol could be raised by forcing the distillation.

The solid residue after distillation was recrystallized three times from ether to give material, m.p. 136–138° (lit.[11] m.p. 135.5–137.5°) for 1,2,2,-trimethyl-1,3-dihydroxymethylenecyclopentane. A mixture melting point with an authentic sample[12] showed no depression.

(3) (a) M. S. Kharasch and G. Sosnovsky, *J. Am. Chem. Soc.*, **80**, 756 (1958); (b) M. S. Kharasch, G. Sosnovsky, and N. C. Yang, *ibid.*, **81**, 5819 (1959); (c) D. Z. Denney, A. Appelbaum, and D. B. Denney, *ibid.*, **84**, 4969 (1962).

(4) The choice of these substances may or may not be good and it is clear that others may be far superior.

(5) For comparison H. L. Goering and J. T. Doi [*J. Am. Chem. Soc.*, **82**, 5850 (1960)] reported a rotation of −265° for optically pure *trans*-5-methylcyclohexenol.

(6) For example, Professor R. K. Hill has recently used this method for the preparation of optically active cyclohexenol which was needed for a mechanism study.

(7) Rotations were taken in 1-dm. tubes using the conditions specified. The infrared and n.m.r. spectra of all of the allylic alcohols were commensurate with those expected.

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(9) H. J. Lucas and W. Baumgarten, *J. Am. Chem. Soc.*, **63**, 1653 (1941).

(10) R. Criegee, H. Pilz, and H. Flygare, *Ber.*, **72B**, 1799 (1939).

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(12) Kindly supplied by Professor Sauers.

Δ^2-Cyclohexenol.—This material was prepared as described for the preparation of Δ^2-cyclopentenol. The ester was obtained in 84% yield. The rotation of the cyclohexenol was $[\alpha]^{24}D$ −10.1° (*c* 5.54, $CHCl_3$). The phenylurethan had m.p. 107–108° (lit.[13] m.p. 107°), $[\alpha]^{26}D$ −13.4° (*c* 8.9, $CHCl_3$). The 3,5-dinitrobenzoate was prepared, m.p. 123–124°, $[\alpha]^{25}D$ −13.7° (*c* 5.24, $CHCl_3$).

Δ^2-Cyclooctenol.—A similar procedure was used except that the temperature was maintained at 65°. Under these conditions one week was required to complete the reaction. The ester was obtained in 36% yield. The alcohol had $[\alpha]^{26}D$ +5.85° (*c* 5.3, $CHCl_3$). The phenylurethan had m.p. 91–92° (lit.[14] m.p. 92.5–93°), $[\alpha]^{26}D$ +13.5° (*c* 3.02, $CHCl_3$).

Bicyclo[3.2.1]octen-2-ol-4.—Reaction of bicyclo[3.2.1]octene-2[15] according to the standard procedure afforded 90% of the ester. The *p*-nitrobenzoate of the alcohol had, m.p. 83–85° (lit.[16] m.p. 84–85°) $[\alpha]^{25}D$ −5.21° (*c* 11.8, $CHCl_3$). In another experiment the alcohol was oxidized with manganese dioxide to bicyclo[3.2.1]octen-2-one-4, b.p. 85° (35 mm.), $[\alpha]^{29}D$ −8.54° (*c* 9.6, $CHCl_3$). The 2,4-dinitrophenylhydrazone had m.p. 139–140° (lit.[17] m.p. 140.5–141.5°).

Δ^2-Cyclohexenol.—A solution of cupric di-O-acetyltartarate half-methyl ester, 24.0 g. (0.043 mole) in 700 ml. of warm benzene was heated to 50° and 150 ml. of cyclohexene was added, followed by the dropwise addition of 12.0 g. (0.133 mole) of *t*-butyl hydroperoxide in 75 ml. of benzene. The mixture was allowed to react at 50° for 16 hr. and then extracted with two 100-ml. portions of 5% sodium bicarbonate solution and two 100-ml. portions of water. The solution was dried over magnesium sulfate and concentrated to give 19.9 g. (61%) of crude ester. The ester was dissolved in 75 ml. of ether and added dropwise to a stirred suspension of 9.1 g. (0.23 mole) of lithium aluminum hydride in 250 ml. of ether. After stirring for 12 hr. the excess lithium aluminum hydride was decomposed with water, the mixture was filtered, and the ether was dried over sodium sulfate and evaporated. The residue was distilled to give 4.12 g. (72%) of Δ^2-cyclohexenol, b.p. 79–80° (28 mm.), $[\alpha]^{24}D$ +10.1° (*c* 7.26, $CHCl_3$). A portion of the alcohol was converted to the phenylurethan, m.p. 108–109°, $[\alpha]^{26}D$ +15.9° (*c* 2.69, $CHCl_3$).

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A New Synthesis of 5-Nitropyrimidines[1]

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A general procedure for the oxidation of 5-nitroso- to 5-nitropyrimidines with 30% hydrogen peroxide in trifluoroacetic acid is described.

To date more than 125 publications have dealt with the synthesis and use, as intermediates, of 5-nitropyrimidines.[2] The nitro group in the 5-position of a pyrimidine ring activates a 6-substituent toward nucleophilic displacement reactions, aldol-type condensations, or oxidation, and, upon reduction, conversion occurs to a 5-aminopyrimidine, a versatile intermediate for the synthesis of purines, pteridines, and other condensed pyrimidine heterocycles.[3] Furthermore, deoxygenation by the use of triethyl phosphite of 5-nitropyrimidines has afforded pyrrolopyrimidines by the generation of nitrene intermediates which insert into appropriate *ortho* substituents.[4] Novel condensed pyrimidines are also available through direct intramolecular interaction of the 5-nitro group with an adjacent guanidino substituent.[5]

These 5-nitropyrimidine intermediates have invariably been prepared either by nitration of a 5-unsubstituted pyrimidine[2] or by direct synthesis utilizing a nitro-substituted alicyclic moiety, such as nitroacetonitrile.[6] The former procedure is the more versatile of the two, but employs, of necessity, such vigorous acidic and oxidative conditions that sensitive groupings are often altered, either by oxidation or by hydrolysis. Typical examples are the hydrolytic desulfurization observed with nitric acid and 2-mercaptopyrimidines,[7] and the oxidation of aliphatic side chains to carboxylic acids.[8] Furthermore, aryl substituents can also undergo nitration,[8] and the procedure is thus inapplicable to systems where there is more than one possible site for nitration. The direct synthesis of 5-nitropyrimidines by ring-closure reactions is severely limited in scope because of the inaccessibility of a sufficient variety of nitro-containing acyclic precursors.

Among the most readily accessible of all 5-substituted pyrimidines are the 5-nitroso derivatives, of which a remarkable variety has been described.[2,9] We wish to report in this paper a facile, generally applicable method for the oxidation of 5-nitrosopyrimidines to 5-nitropyrimidines which mitigates or eliminates most of the disadvantages accompanying the previously employed procedures for the preparation of 5-nitropyrimidines.

We have found that a wide variety of 5-nitrosopyrimidines are oxidized directly and in high yield to 5-nitropyrimidines by treatment of a trifluoroacetic acid solution of the nitrosopyrimidine with 30% hydrogen peroxide at room temperature. The initial intensely colored solution rapidly fades to yellow, at which time the reaction is judged complete. The 5-nitropyrimidine is isolated either by filtration or by dilution of the pertrifluoroacetic acid solution with water. Typical conversions, reaction times required, and yields are summarized in Table I.

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(5) J. A. Carbon, *ibid.*, **26**, 455 (1961).
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