

Owing to the effects of cis-trans isomerism on the value of  $\Delta_\gamma$ , carbon atoms in hydroxylic environments of a given configuration give rise to characteristic multiplet features. Thus, molecular fragments along with their stereochemistry can be readily identified. In favorable cases, there may be only one possible way to join these fragments into a complete molecular structure. In more complex molecules, e.g., oligosaccharides, the presence of a molecular fragment may reveal the identity of a whole monosaccharide residue. Furthermore, the absence of certain multiplet features can serve to identify the substitution pattern of a monosaccharide residue within an oligosaccharide. Thus, isotopic multiplets should be useful in the sequencing of oligosaccharides.

**Acknowledgment.** The excellent technical assistance of David S. Rice is gratefully acknowledged.

### Production of Arene Oxides by the Caroate-Acetone System (Dimethyldioxirane)

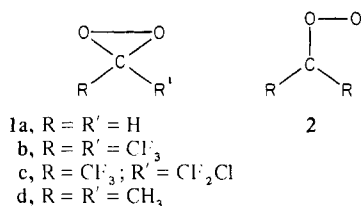
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Received November 21, 1983

Revised Manuscript Received January 24, 1984

Dioxiranes (**1**) are isomeric with the better known carbonyl oxides (**2**) one of the peroxidic intermediates involved in the

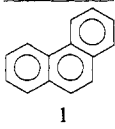
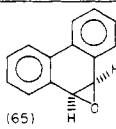
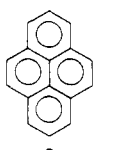
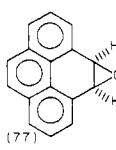
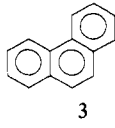
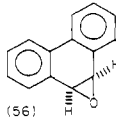
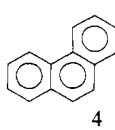
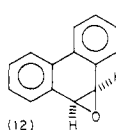
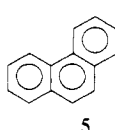
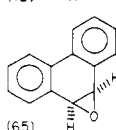
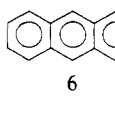
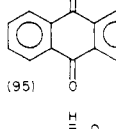
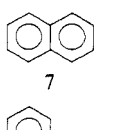
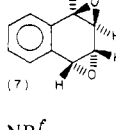



ozonolysis process. Dioxirane (**1a**), produced via ozonolysis of ethylene, has been characterized by both mass spectral and microwave methods.<sup>1-3</sup> In two cases, **1b** and **1c**, it has been reported<sup>4</sup> that dioxiranes have been isolated and characterized by physical and chemical methods. In these cases the dioxiranes were synthesized by oxidation of the corresponding dilithio alkoxides.

Dioxiranes have been postulated as intermediates in two cases involving peracids. In one of these Edwards, Curci, and co-workers<sup>5-9</sup> have provided kinetic, stereochemical, and <sup>18</sup>O-labeling evidence that the peroxymonosulfate (caroate)-acetone system generates dimethyldioxirane (**1d**) as a reactive intermediate. This intermediate undergoes facile one oxygen atom transfer reactions including one<sup>5</sup> that produces epoxides in a high yield, stereospecific manner. A second possible source of **1d** has been described<sup>10</sup> by us and uses peracetic acid and acetone to produce an epoxidizing intermediate.

We now report that the caroate-acetone system can be used to convert arenes to arene oxides. In many cases the yields ob-

Table I. Reaction of Arenes with Caroate-Acetone (Dimethyldioxirane)<sup>a</sup>

arene	T, °C	reaction time, min	product (% conversion) <sup>b</sup>	isolated yield, % <sup>c</sup>
	0-10	5.5	 (65)	60
	0-5	1.5	 (77)	45
	25	6.5	 (56)	29.5 <sup>d</sup>
	25	8	 (12)	8
	25	6	 (65)	<sup>e</sup>
	25	1.5	 (95)	85
	0-5	2	 (7)	5
	25	6	NR <sup>f</sup>	

<sup>a</sup> Reactions used excess acetone and potassium peroxymonosulfate (Du Pont oxone: 2KHSO<sub>5</sub>·KHSO<sub>4</sub>·K<sub>2</sub>SO<sub>4</sub>) in H<sub>2</sub>O and CH<sub>2</sub>Cl<sub>2</sub> with phosphate buffer and PTC (tetra-*n*-butylammonium hydrogen sulfate). <sup>b</sup> Percent conversions are based on NMR integration data for the crude reaction mixtures. <sup>c</sup> Products isolated using preparative TLC. <sup>d</sup> Product was 96% pure after three recrystallizations. <sup>e</sup> The arene oxide consistently rearranged during workup. <sup>f</sup> NR = no reaction.

tained suggest that this procedure may be synthetically useful (Table I). Observation of arene oxide formation under these conditions is highly significant in view of the suggestion<sup>1</sup> that gas-phase ozonolyses are likely dioxirane sources and the relationship of arene oxides to mutagenesis/carcinogenesis in polycyclic aromatic hydrocarbons (PAH).<sup>11-14</sup>

In a typical reaction a mixture of acetone (250 mL), phosphate buffer (50 mL), methylene chloride (100 mL), tetra-*n*-butylammonium hydrogen sulfate (200 mg), and phenanthrene (900 mg) was stirred vigorously at 0-10 °C while a solution of potassium peroxymonosulfate (Oxone (Du Pont): 2KHSO<sub>5</sub>·

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KHSO<sub>4</sub>-K<sub>2</sub>SO<sub>4</sub>, 46.0 g) in 225 mL of water was added dropwise over a period of 1.5 h. The pH was maintained at 7.5-8.5 by monitoring with a pH electrode and dropwise addition of an aqueous solution of KOH (2-3%). The reaction mixture was stirred for an additional 4 h and then mixed with an equal volume of ice cold water. The reaction mixture was then extracted with methylene chloride and the extract washed three times with ice-cold water. The methylene chloride layer was dried (K<sub>2</sub>CO<sub>3</sub>) and the solvent removed on the rotary evaporator. TLC analysis of the solid residue indicated that it contained only phenanthrene and phenanthrene oxide. The arene oxide was isolated by preparative TLC with methylene chloride/hexane (1:1) as the eluent. The product was recrystallized from methylene chloride/hexane (1:1) to give shining white flakes of the oxide. Oxide obtained in this manner gave two separate melting points, 127-128 °C and 145-147 °C. Similar melting point behavior has been reported in the literature, i.e., 124-125<sup>15</sup> and 148 °C.<sup>16</sup> The results obtained with a series of arenes are shown in Table I. All of the oxides listed in Table I had melting point and spectral data that were identical with those given in the literature or with those of samples prepared locally<sup>17</sup> by using literature methods. Control reactions using caroate alone showed that no oxide is obtained in the absence of acetone except in the cases of **3** and **4** where traces of oxide were observed. Similarly when the procedure is attempted with methanol or dioxane instead of acetone no oxide is formed in the phenanthrene case.

Arene oxides have been successfully synthesized by several routes.<sup>18-34</sup> The simplest of these appears to be the use of hypochlorite as described by Hamilton.<sup>18</sup> Use of the caroate-acetone system may be a competitive synthetic method. Work in progress is aimed at determining the requirements, particularly the electronic requirements, for O atom transfer by dioxiranes. It should be noted that the yield data for arenes **3** and **4** contain a hint that the transfer reaction may be electrophilic in nature.

We find the evidence<sup>5-9</sup> to be convincing that the caroate-acetone system involves the formation of dioxiranes. In earlier studies we<sup>35-38</sup> and Jerina et al.<sup>39,40</sup> have described cases where

O atom transfer to arenes has been attributed to carbonyl oxides. The present results which we believe are best interpreted as involving O atom transfer from dimethyldioxirane, raise questions about the involvement of dioxiranes in a range of organic oxidations involving peroxides including those in which a carbonyl oxide is the presumed oxidant.<sup>41</sup>

It has been demonstrated<sup>1-3</sup> that gas-phase ozonolyses can produce dioxiranes. Urban atmospheres frequently contain relatively high concentrations of ozone, olefins, and PAH. Such atmospheres thus contain the essential elements for the production of dioxiranes and/or carbonyl oxides and it seems likely that these reactive intermediates would undergo subsequent reactions with PAH to give arene oxides. Indeed we have been able to show<sup>43</sup> that a carbonyl oxide produced via ozonolysis of a suitable PAH absorbed on a model particulate surface (silica gel) leads to the formation of a K-region oxide by intramolecular O atom transfer. It is now well established that carcinogenic PAH require metabolic activation, i.e., oxidation, prior to displaying ultimate carcinogenicity. Such metabolic activation produces arene oxides and other metabolites. Production of arene oxides in polluted atmospheres, as postulated here, would thus increase the negative impact of such atmospheres on environmental health.

**Acknowledgment.** We gratefully acknowledge support of this work by the National Institute of Environmental Health Sciences (Grant ES01984).

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### Shikimate-Derived Metabolites. 13. A Key Intermediate in the Biosynthesis of Anthranilate from Chorismate

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Received January 31, 1984

It has been established in microorganisms that chorismic acid (**1**) is the precursor of anthranilic acid (**4**), a key metabolic intermediate in tryptophan biosynthesis.<sup>1</sup> Although much is known about anthranilate synthase (AS),<sup>2</sup> the enzyme that transforms **1** into **4** using ammonia or glutamine, the step-by-step chemical events mediated by the protein remain obscure. In 1962, McCormick et al. reported that amino alcohol **2** was produced by a strain of *Streptomyces aureofaciens*,<sup>3,4</sup> prompting the suggestion<sup>5</sup> that trans enol pyruvate **3** was a likely intermediate between **1** and **4** (drawings denote absolute stereochemistry). Since then, several efforts to isolate and characterize this species have failed,<sup>6</sup> and even its proposed structure remains controversial.<sup>1</sup>

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