TABLE I

THE REACTION OF *cis*-1,2,3-TRIPHENYLAZIRIDINE AND *m*-CHLOROPERBENZOIC ACID

Product	Solvent	Temp, °C	Moles of peracid	Yield, %
PhCHO	CH_2Cl_2	25	1.0	16
PhCHO	$ClCH_2CH_2Cl$	85	1.0	34
PhCHO	$ClCH_2CH_2Cl$	85	4.0	23
$PhNO_2$	CH_2Cl_2	25	1.0	14
$PhNO_2$	$ClCH_2CH_2Cl$	85	1.0	5
$PhNO_2$	$ClCH_2CH_2Cl$	85	4.0	5
PhCH=NPh	CH_2Cl_2	25	1.0	8
PhCH=NPh	$ClCH_2CH_2Cl$	85	1.0	6
PhCH=NPh	$ClCH_2CH_2Cl$	85	4.0	..
PhCH=CHPh	CH_2Cl_2	25	1.0	7
PhCH=CHPh	$ClCH_2CH_2Cl$	85	1.0	5
PhCH=CHPh	$ClCH_2CH_2Cl$	85	4.0	..
PhCH—CHPh (O)	CH_2Cl_2	25	1.0	19

thermal rearrangement of benzyldialkylamine oxides to trialkylhydroxylamines bears similar characteristics.[11]

The structures of fluorinated oxazetidines have been deduced from the identities of the perfluoro(alkylenealkylamines) and carbonyl halides that are produced in essentially quantitative yields by pyrolysis.[12] An interesting feature of the reaction involving aziridines and peracids is that a significant proportion (14%) of cleavage of the transient oxazetidine occurs in a direction opposite to that involved in the fluorinated case. Thus the isolation of nitrobenzene can be explained by cleavage of the C–N and C–O bond of the oxazetidine ring followed by subsequent oxidation of nitrosobenzene.

The formation of a mixture of *cis*- and *trans*-stilbene suggests either that the transient oxazetidine was present in the reaction as *cis* and *trans* isomers or the fragmentation of the heterocyclic ring does not occur *via* a concerted path. Clearly, no definite conclusion can be reached regarding these possibilities at this time. Further study of the scope, mechanism and utility of oxidation of such aziridines is in progress.

Experimental Section

***m*-Chloroperbenzoic Acid Oxidation of *cis*-1,2,3-Triphenylaziridine.**—A solution of 0.225 g of *cis*-1,2,3-triphenylaziridine and 0.220 g of *m*-chloroperbenzoic acid in 10 ml of methylene chloride was stirred for 12 hr at room temperature. After this time no more active oxygen content remained as evidenced by the lack of iodine liberation from an acidic potassium iodide solution. The reaction mixture was concentrated under reduced pressure and the residue was analyzed by vapor phase chromatography. The analytical gas chromatography was performed on an Aerograph 350-B instrument with helium as the carrier gas on a column of Ucon LB-1715 (5% on Chromosorb P) at a flow rate of 60 cc/min. Analysis of the crude residue showed that the product was composed of seven components with retention times of 1.5 (16%), 2.6 (14%), 4.2 (6.8%), 10.6 (8%), 11.4 (7%), 14.5 (9%), and 17.1 (10%) min on the Ucon column. Comparison of retention times and infrared spectra with those of known samples of benzaldehyde, nitrobenzene, *cis*-stilbene, benzylidenaniline, *trans*-stilbene, and *cis*- and *trans*-stilbene oxide established the identity of the products.

In an attempt to maximize the formation of products, the reaction between the aziridine and peracid was repeated at various experimental conditions and the yields obtained are described in Table I.

Reaction of *cis*-1,2-Diphenylaziridine with *m*-Chloroperbenzoic Acid.—A mixture of 0.25 g of *cis*-1,2-diphenylaziridine and 0.25 g of *m*-chloroperbenzoic acid in 10 ml of 1,2-dichloroethane was heated to reflux for 1 hr. The solution was concentrated under reduced pressure and separated by glpc on a Ucon LB-1715 column at 165°. The materials of retention times 1.5, 10.6, and 11.4 min were collected in a Dry Ice–acetone trap connected to the gas outlet. The colorless liquids had infrared and ultraviolet spectra that were identical to benzaldehyde and *cis*- and *trans*-stilbene.

Acknowledgment.—The authors are grateful to the National Science Foundation for support of this research through Grant GP-3972.

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Selective O-Alkylation of Tyrosine

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The synthesis of alkyl ethers of tyrosine has been reported by Weiss and co-workers.[1] Their method requires the protection of the amino group by formylation, and the over-all yield of the three-step method is 30–40% (as the hydrochloride). Earlier, Aberhalden and Guggenheim[2] reported the synthesis of the glycerine monoether, in unspecified yield, through the disodium salt of tyrosine.

In view of the ability of dimethyl sulfoxide to enhance base-catalyzed condensations,[3-5] it seemed worthwhile to investigate the O-alkylation of L-tyrosine in this solvent without protecting the amino group. After our initial investigation had been completed, our findings were confirmed by the publication of Kingsbury's work,[6] in which he reported that dimethyl sulfoxide was particularly effective in promoting O-alkylations.

For this purpose L-tyrosine was dissolved in a mixture of DMSO and aqueous sodium hydroxide and treated with the appropriate alkyl halide (usually bromide) at an elevated temperature. Under these conditions no significant N-alkylation was observed. The major by-product was the ether ester resulting from dialkylation. This by-product could be avoided by carrying out the reaction with a slight excess of the amino acid or eliminated by saponification with dilute base before isolation of the product.

The highest yields of ethers from these reactions were normally obtained by maintaining homogeneous conditions throughout the reaction. This was generally achieved by using 2 equiv of 10–25% sodium hydroxide in about 3–10 vol of DMSO and carrying out the reaction at 70–90°. If the ether ester is the desired product, it may be obtained by using more concentrated

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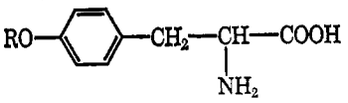
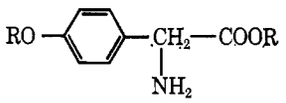
TABLE I
ALKYL ETHERS OF L-TYROSINE



R	Yield, %	Mp, °C	Calcd,[a] % C	H	N	Found, % C	H	N
n-Butyl	40	233.0–233.5	65.79	8.07	5.90	65.90	8.43	5.84
n-Hexyl	72	223.0–224.0	67.89	8.74	5.28	67.25	8.85	5.41
n-Heptyl	82	225.0–227.0	68.79	9.02	5.01	69.15	9.10	4.88
Phenethyl	42	229.0–230.0	71.56	6.71	4.91	71.73	6.84	4.67
n-Decyl	76	218.0–220.0	70.99	9.72	4.35	71.25	9.75	4.27
n-Octadecyl	74	215.0–217.0	74.78	10.92	3.23	74.10	10.72	3.45

[a] See footnote 7.

TABLE II
ALKYL ETHER ESTERS OF L-TYROSINE



R	Yield, %	Mp, °C	Calcd, % C	H	N	S	Found, % C	H	N	S
n-Butyl	31	80.5–82.5	69.24	9.27	4.77		68.89	9.33	5.16	
n-Hexyl	25	81.5–82.0	72.20	10.03	4.01		71.79	10.48	4.14	
a		231.0–232.0	63.31	9.05	3.52	4.02	63.35	8.96	3.62	4.20
n-Heptyl	23	82.0–83.0	73.17	10.41	3.71		73.21	10.10	3.83	
a		222.0–224.0	64.79	9.39	3.29	3.76	64.22	9.22	3.20	3.76
Phenethyl	42	69.5–70.5	77.25	7.04	3.71		77.01	7.10	3.73	
n-Decyl	15	70.0–70.5	75.43	11.13	3.03		74.76	11.17	3.19	
a		221.0–222.0	68.23	10.19	2.75	3.14	68.01	10.05	3.09	3.51
n-Octadecyl	27	68.5–70.0	78.83	12.11	2.04		78.66	12.28	2.12	

[a] For $(p\text{-}ROC_6H_3CH_2CHNH_2COOR)_2 H_2SO_4$.

sodium hydroxide and adding 2 equiv of alkyl halide. The ethers prepared by this method are summarized in Table I, and the ether esters in Table II.

The identity of the compounds prepared by the method of Weiss, *et al.*, with those prepared by the present method can be confirmed by melting points and infrared spectra; this was done in several cases.

Experimental Section[7]

All compounds listed in the tables were prepared by the same two methods. One example will be given for the ethers and one for the ether esters. The starting materials were commercially available reagent grade chemicals. No significant improvement in yield was obtained by further purification.

I. O-*n*-Hexyl-L-tyrosine.—A solution of 9.1 g (0.05 mole) L-tyrosine in 40 g (0.10 mole) 10% aqueous sodium hydroxide was added to 200 ml of dimethyl sulfoxide and heated in a water bath to 80°. To this was added, with stirring, 8.25 g (0.05 mole) 1-bromohexane. Heating and stirring were continued for 2 hr and the reaction mixture was then poured into 250 g of crushed ice. The pH was adjusted to *ca.* 7.5 and the resulting precipitate was filtered off, washed with water, and dried. The crude product was recrystallized from 60% acetic acid to give 9.6 g (71.6% yield) of white leaflets. The melting point and analysis are shown in Table I.

II. Phenethyl Ester of O-Phenethyl-L-tyrosine.—A mixture of 9.1 g (0.5 mole) L-tyrosine in 8.0 g (0.10 mole) of 50% aqueous sodium hydroxide and 500 ml of dimethyl sulfoxide was heated to *ca.* 120° to form a clear solution. The solution was cooled to 60–70° and 20.4 g (0.11 mole) (2-bromoethyl) of benzene was added with stirring. The temperature was raised to 115–125° an heating and stirring were continued for 1 hr. The reaction mixture was then poured into 500 g of crushed ice. The aqueous suspension was extracted with 3–100-ml portions of diethyl ether. The ether solution was dried over anhydrous sodium sulfate, filtered, and evaporated to dryness at reduced pressure. The residue was recrystallized from a large volume of hexane to give 8.1 g (42% yield) of white crystals. The melting point and analysis are shown in Table II.

In some cases it was advantageous to isolate the product as the dibasic salt of sulfuric acid. This could be done by pouring the reaction mixture into ice containing a small excess of sulfuric acid. The salt which precipitated was filtered off and dried. It was then recrystallized from 95% ethanol. The free ether ester could be regenerated in high yield, (>70%) by treating the salt with an aqueous suspension of powdered calcium carbonate. The mixture was then extracted with ether and the solution handled as above.

(7) Elemental analyses were performed by Berkeley Analytical Laboratories, Berkeley, Calif. Melting points are corrected. Infrared spectra were determined on a Perkin-Elmer Model 521 grating spectrophotometer.

The Alleged Functionalized Episulfones of Etlis[1]

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Episulfones have been prepared by the reaction of diazomethane and its derivatives with sulfur dioxide[3] or sulfenes.[4a] In contrast, numerous attempts to

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