ably a mixture of stereoisomers. One stereoisomer could be isolated. As expected, this product does not show any ultraviolet absorption and its infrared spectrum does not have any bands between 5–6.8 μ. However, the intensity of the OH band is about twice as strong as in Amianthine itself.

Amianthine has one active hydrogen (Found: 0.96 mole) which is derived from a primary or a secondary OH because of the ease with which an O-acetate was formed in pyridine and acetic anhydride at room temperature. Its infrared spectrum shows a typical ester CO band at 5.8 μ in addition to the band of conjugated CO at 6.06 μ.

Acknowledgment.—We are indebted to Dr. H. Boaz for the infrared spectra and their interpretation, and to Messrs. G. M. Maciak, H. L. Hunter and W. J. Schenck for microdeterminations. We thank Mr. R. J. Armstrong for his assistance in extraction of the crude drug. We are grateful to the late Prof. Friesner, of Butler University, for confirming the identity of the plant.

Experimental[5]

Extraction of the Roots and Leaves of Amianthium Muscaetoxicum Gray.—Ground dried roots and leaves (25 kg.) were extracted, after moistening with 15 l. of dilute ammonia, with three 150-l. portions of benzene. Each extraction was made by stirring for 5 hr. and allowing to macerate for 16 hr. The extracts were drained through filter pads into a stainless steel vacuum still. The combined extracts were concentrated to 5 l. at reduced pressure, and extracted exhaustively with a total of 3 l. of 5% tartaric acid. The aqueous phase was filtered from resinous material and made basic (*p*H 8–9) with concentrated ammonia. The free bases were extracted five times with chloroform, filtered and dried over anhydrous sodium sulfate and evaporated to dryness in vacuum. The yield was 25 g. of total alkaloids (0.1%).

Amianthine.—The amorphous mixture of total alkaloids (10 g.) was dissolved in 25 ml. of acetone and allowed to stand for 72 hr. After this time, the alkaloid crystallized in long prisms (550 mg.). After three recrystallizations from acetone, 250 mg. of pure material was obtained, m.p. 251–253° (dec.), $[\alpha]^{26}D$ −87° (*c* 0.1728 in $CHCl_3$). Identical material was obtained by chromatography of total alkaloids, after elution of ester alkaloids and Jervine, using a 1:1 mixture of methanol–chloroform. For analysis, the sample was dried at 120° (0.05 mm.) for 4 hr.

Anal. Calcd. for $C_{27}H_{41}O_2N$: C, 78.78; H, 10.03; N, 3.41. Found: C, 78.56; H, 9.82; N, 3.11.

Amianthine O-Acetate.—A mixture of 50 mg. of Amianthine in 5 ml. of anhydrous pyridine and 1 ml. of acetic anhydride was allowed to stand at room temperature for 12 hr. The reaction mixture was poured into ice-water, a few drops of concentrated ammonia added, and the whole extracted three times with chloroform. The chloroform extract was washed with water, dried over anhydrous sodium sulfate and evaporated *in vacuo*. The amorphous colorless residue crystallized upon addition of dilute methanol. After two recrystallizations from dilute methanol long needles were obtained, m.p. 206–207° (dec.). For analysis the sample was dried at 120° (0.05 mm.) for 4 hr.

Anal. Calcd. for $C_{29}H_{43}O_3N$: C, 76.78; H, 9.55. Found: C, 76.52, 76.61; H, 9.56, 9.66.

Hydrogenation of Amianthine.—A mixture of 25 mg. of Amianthine in 95% methanol was hydrogenated using platinum catalyst. Absorption of two moles of hydrogen was complete after 90 minutes. After filtration of the catalyst and removal of the solvent, an amorphous residue resulted. Upon addition of aqueous methanol, the material crystallized forming thin needles and spherical crystals. The spherical modification could be mechanically separated under a magnifying glass. It melted at 266–267° (dec.). On admixture with Amianthine, it gave a depression of 25–30°. Lack of material prevented further characterization.

(5) All melting points are uncorrected. Infrared spectra were run in chloroform solution.

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The Reaction of Carbon Monoxide with Free Radicals

BY GERALD B. PORTER AND SIDNEY W. BENSON

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Calculations based on the most recent experimental data[1,2] show that the reaction

$$CH_3 + CO \longrightarrow CH_3CO \qquad (1)$$

should have little or no activation energy. To investigate this reaction, the pyrolysis of di-*t*-butyl peroxide was chosen as a source of methyl radicals.[3] In a system containing di-*t*-butyl peroxide and carbon monoxide at a temperature greater than 150°, reaction 1 may occur and the acetyl radicals formed may either decompose

$$CH_3CO \longrightarrow CH_3 + CO \qquad (2)$$

or react with methyl radicals

$$CH_3CO + CH_3 \longrightarrow CH_3COCH_3 \qquad (3)$$

In addition, carbon monoxide may reduce *t*-butoxy radicals exothermically.

$$(CH_3)_3CO + CO \longrightarrow (CH_3)_3C + CO_2 \qquad (4)$$

Reaction 4 is analogous to the reaction suggested by Stone and Taylor[4] to explain the similar exothermic formation of carbon dioxide from carbon monoxide during the photolysis of hydrogen peroxide

$$OH + CO \longrightarrow CO_2 + H \qquad (5)$$

Radioactive monoxide provides a means of measuring the extent of reactions 3 and 4. Although experimentally, no radioactivity was detectable in the condensable products, maximum values of the rate constants of reactions 1 and 4 are still calculable.

The ratio of the yields of radioactive acetone to ethane is given by

$$\frac{\text{Yield of acetone}^*}{\text{Yield of ethane}} \approx k_1k_3/k_2k_6(CO)$$

leading to a maximum value for the rate constant, k_1, of 3×10^9 $(\text{moles/cc.})^{-1}$ sec.^{-1}.

A similar calculation indicates that k_4 is less than 3×10^8 $(\text{moles/cc.})^{-1}$ sec.^{-1}.

The fact that reactions 1 and 4 were not detectable in this system is not to be taken as indicating that these reactions will not occur at all. Rather, it shows the instability of acetyl and *t*-butoxy radicals under the conditions of these experiments. Indeed, it has been frequently observed that, because of reaction 2, no biacetyl is formed during the photolysis of acetone if the temperature is much above 100°.

We should like to express our appreciation to Dr.

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Some Bis-substituted Succinamides as Curare Substitutes. IV

BY ARTHUR P. PHILLIPS

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Earlier some series of dicarboxylic acid bis-aminoamides and their quaternary ammonium salts were described.[1,2] These had been made in conjunction with a family of bis-aminoalkyl esters of dicarboxylic acids and their quaternary ammonium salts[3] in a search for new drugs possessing curare-like activity. While powerful curariform agents were found in the ester series, most outstanding in the case of succinylcholine, the analogously constituted amides were nearly inactive in this sense. However, many of the series of bis-amides proved to act as powerful potentiators, both in duration and intensity of action, of the succinylcholine class of curare-like drugs. Succinylcholine potentiating ability in the various amide series was observed to occur in a wide range of chain lengths, from the malonic through the sebacic acid derivatives, but was frequently found to be maximal in the succinic, glutaric, adipic group. Thus it seemed useful to prepare a cross section of assorted bis-substituted amides from a particular dicarboxylic acid in the optimal region. This paper presents a number of such amides made from succinic acid.

The bis-isoamylsuccinamide, the first compound of Table I, is an isostere of one of the active potentiators of succinylcholine, the bis-dimethylaminoethylsuccinamide.[1] In Table I are summarized the details of structure, melting points and analytical data for a list of alkoxyalkyl- and alkylaminoalkylsuccinamides as well as for some derived bis-quaternary ammonium salts.

The pharmacology of these substances will be reported elsewhere. None of these compounds seemed to be as effective in prolonging the neuromuscular blocking action of succinylcholine as were the compounds described earlier.[1,2]

Experimental

The amides were prepared by the procedure of the previous publications.[1,2] Yields were nearly quantitative. The simple amides were purified by recrystallization from ethyl acetate, while the quaternary salts were recrystallized from methanol–ethyl acetate mixtures.

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TABLE I

SUBSTITUTED SUCCINAMIDES $\begin{matrix}CH_2CONHCH_2CH_2R\\ |\\ CH_2CONHCH_2CH_2R\end{matrix}$

R	M.p., °C.	Formula	Carbon, % Calcd.	Carbon, % Found	Hydrogen, % Calcd.	Hydrogen, % Found	Nitrogen, % Calcd.	Nitrogen, % Found
$-CH(CH_3)_2$	141–142	$C_{14}H_{28}N_2O_2$	65.6	65.7	11.0	11.0	10.9	10.5
$-CH_2OCH_3$	146–147	$C_{12}H_{24}N_2O_4$	55.3	55.3	9.3	9.1	10.7	10.4
$-CH_2OCH(CH_3)_2$	122–123	$C_{16}H_{32}N_2O_4$	60.7	60.9	10.2	10.1	8.8	8.7
$-CH_2NHCH(CH_3)_2$	104–105	$C_{16}H_{34}N_4O_2$	61.1	61.1	10.9	10.6	17.8	17.8
$-CH_2N(CH_3)_2$	122–123	$C_{14}H_{30}N_4O_2$	58.7	58.5	10.5	10.2	19.6	19.8
$-CH_2N(CH_3)_3I$	211–212	$C_{16}H_{36}I_2N_4O_2$	33.7	33.7	6.4	6.4	9.8	9.7
$-CH_2N(CH_3)_2C_2H_5I$	167–168	$C_{16}H_{40}I_2N_4O_2$	36.1	35.9	6.7	6.4	..	..
$-CH_2N(CH_2CH_2)_2O$	125–126	$C_{18}H_{34}N_4O_4$	58.3	58.4	9.3	9.3	15.1	15.2
$-CH_2N(CH_2CH_2)_2O\cdot CH_3I$	162–163	$C_{20}H_{40}I_2N_4O_4$	36.7	36.7	6.2	6.2	..	..

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5-Acenaphtheneacetic Acid

BY HENRY J. RICHTER

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The preparation of an acenaphtheneacetic acid, from acenaphthene and α-chloroacetic acid, melting at 174–175° is described in the patent literature by Wolfram, *et al.*[1] In the equivalent British Patent, the acid is described as the 5-isomer,[2] but no melting point is indicated. In another patent[3] the same inventors describe the acid as 5-acenaphtheneacetic acid and give the melting point as 187°. Anderson and Wade[4] prepared 5-acenaphtheneacetic acid by the Willgerodt–Kindler reaction on the known 5-acenaphthenyl methyl ketone. The melting point reported is 179–180°. These authors indicate that they were unable to repeat the preparation of the acenaphthenacetic acid described by Wolfram, *et al.*, in the patent literature.

In this work 5-acenaphtheneacetic acid has been prepared by the condensation of α-chloroacetic acid and acenaphthene with the aid of ferric oxide and potassium bromide as catalysts.[5] The yield, based on the initial reactants, was quite low (28%). However, since a high proportion of the unreacted acenaphthene may be recovered, the preparation offers some advantage. A procedure for the purification of this acid involving fractional precipitation and crystallization of the sodium salt is de-

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