procedures in the literature given such a product.

To check the structure of the nitration product, an alternate synthesis was carried out from *p*-nitrochlorobenzene and *p*-nitroaniline in the presence of copper. (This reaction[6] occurs without rearrangement of the *p*-nitro group to give 4-nitrotriphenylamine both from diphenylamine and *p*-iodonitrobenzene[7] and from 4-nitrodiphenylamine and iodobenzene.[8]) The product was identical to the nitration product obtained by Herz's procedure, confirming the structural assignment in Beilstein.

The behavior of the substance on heating suggests the existence of more than one polymorphic form; the material reported to melt at 280° might have been an additional metastable crystal form of the same compound.

Experimental

Preparation of 4,4′,4″-Trinitrotriphenylamine.—A number of runs of the nitration procedure of Herz[3] gave 75–80% of a fine yellow powder. Analysis showed that this was contaminated with lower nitration products. These impurities are more soluble in the common solvents than the very slightly soluble trinitro compound, but in nitromethane and nitrobenzene the latter seems to be the more soluble, for fractional crystallization gave successively purer crops of diamond-shaped plates. The third crop from nitromethane was taken for analysis.

Anal. Calcd. for $C_{18}H_{12}N_4O_6$: C, 56.84; H, 3.18; N, 14.73. Found: C, 56.94; H, 3.28; N, 14.84.

Alternatively, 138 g. (1 mole) of *p*-nitroaniline, 315 g. (2 moles) of *p*-nitrochlorobenzene, 160 g. of powdered anhydrous potassium carbonate, 5 g. of copper powder (copper bronze previously washed with ether was used) and 750 ml. of nitrobenzene were refluxed with stirring for 17 hours in an all-glass apparatus designed to condense nitrobenzene but pass water through.[9] The reaction mixture was steam distilled to remove nitrobenzene, filtered, and the pasty mass washed with acetone three times by decantation. Finally, it was extracted with acetone in a Soxhlet apparatus for two hours to remove unreacted reagents and nitrobenzene. The resulting coarse yellowish powder weighed 182 g., yield 48%. Continued extraction with acetone for 72 hours gave 0.8 g. of irregular crystals in the extract. *Anal.* Calcd. values above. Found: C, 56.74; H, 3.39; N, 14.59.

Behavior on Melting.—Observation on the Kofler hot stage, for which a 500° thermometer was calibrated, showed no melting at 280° of samples previously purified by recrystallization from nitromethane, nitrobenzene–ethanol or acetone. Instead, all samples sublimed, beginning at 270–280°, to give fine needles on the cover glass. (The synthetic material can be sublimed rapidly and quantitatively at 290°, and the product is pure. The nitration product is not purified by this procedure, since the partial nitration products also sublime.) Above 375°, the needle sublimate and any unsublimed residue undergo transition to irregular crystalline plates. These melt at 382–383°. Both preparations individually, and a mixture, showed this sequence of changes.

X-Ray powder photographs were taken of the plates prepared by recrystallization from nitromethane, the needle sublimate, and these needles heated to 375° under a cover plate. The patterns were identical, indicating that if any of these samples were polymorphs, the high temperature crystal forms reverted quickly to the room temperature form on cooling.

SCHOOL OF CHEMISTRY
RUTGERS UNIVERSITY
NEW BRUNSWICK, N. J.

---

(6) I. Goldberg, *Ber.*, **39B**, 1691 (1906).

(7) S. Kawai, *J. Chem. Soc., Japan*, **49**, 235 (1928), in *C. A.*, **24**, 80 (1930).

(8) J. Piccard and L. M. Larsen, THIS JOURNAL, **39**, 2008 (1917).

(9) F. D. Hager in "Organic Syntheses," Coll. Vol. I, John Wiley and Sons, Inc., New York, N. Y., 1932, p. 544.

A New Alkaloid from *Amianthium Muscaetoxicum* Gray

BY NORBERT NEUSS

RECEIVED FEBRUARY 23, 1953

Amianthium muscaetoxicum Gray, also called Stagger grass or Fly poison,[1] has long been known to be poisonous to cattle and sheep.[2] Over forty years ago, Alsberg[3] studied its pharmacology and found that it contained a very poisonous alkaloid which he was not able to crystallize. He claimed that the alkaloid resembled Veratrine chemically, although it did not produce a typical veratrinic response.

In view of these findings, we have undertaken a systematic investigation of Stagger grass alkaloids. The chromatographic separation of total alkaloids on acid-washed alumina, using Reichstein's technique,[4] yielded four fractions. One was readily identifiable as Jervine. Two were unidentified ester alkaloids (tentatively called Alkaloid E and F) which were shown to be responsible for the high toxicity and hypotensive action of the plant extract. The last fraction was an alkamine which has never been isolated previously. It was also isolated directly from the total alkaloids by treatment with acetone. Initial observations indicated that it might be related to steroidal alkamines. In view of recent interest in veratrum alkaloids, we would like to give our preliminary results now. The chemistry of the hypotensive principles of the plant will be published in detail later. The pharmacology of all active principles will be published elsewhere.

The new alkaloid, for which we propose the name Amianthine, is a C_{27} compound. This formulation as well as the presence of Jervine in total alkaloids and the close relationship of Stagger grass to *Veratrum* species favor the assumption that it might be a steroidal or modified steroidal alkamine.

When Amianthine is dissolved in concentrated sulfuric acid it gives a yellow color. However, it remains colorless in 84% sulfuric acid, and in this respect it is significantly different from most alkamines isolated from *Veratrum album* and *Veratrum viride*. The alkaloid has a pK_a value of *ca.* 9.7 and appears to be a tertiary base. The infrared spectrum does not show a resolved band corresponding to NH between the OH band at 2.87 μ and a very weak band at 3.14 μ. There is a very strong band corresponding to a conjugated CO at 6.06 μ and a band half as strong at 6.20 μ indicative of a carbon–carbon double bond. The ultraviolet absorption spectrum in alcohol exhibits a maximum at 250 mμ, log ϵ 4.04, which also corresponds to a conjugated CO.

It readily absorbs two moles of hydrogen in acetic acid or alcohol solution using platinum as a catalyst. The tetrahydro derivative formed is prob-

---

(1) W. C. Muenscher, "Poisonous Plants of the U. S. A.," The Macmillan Co., New York, N. Y., 1951.

(2) C. D. Marsh, A. B. Clawson and H. Marsh, *U. S. Dept. Agr. Bull.*, 710 (1918).

(3) C. L. Alsberg, *Science*, **39**, 958 (1914); C. L. Alsberg, *J. Phar. Exp. Therap.*, **3**, 473 (1911–1912).

(4) T. Reichstein and C. W. Shoppee, *Discussion of the Faraday Society*, No. **7**, 305 (1949).

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.), $[\alpha]^{20}\text{D}$ −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.

THE LILLY RESEARCH LABORATORIES
ELI LILLY AND COMPANY
INDIANAPOLIS, INDIANA

The Reaction of Carbon Monoxide with Free Radicals

BY GERALD B. PORTER AND SIDNEY W. BENSON

RECEIVED FEBRUARY 10, 1953

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

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

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

A similar calculation indicates that k_4 is less than 3×10^6 (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.

---

[5] All melting points are uncorrected. Infrared spectra were run in chloroform solution.

[1] M. Szwarc, *Chem. Revs.*, **47**, 75 (1950).

[2] D. H. Volman and W. M. Graven, *J. Chem. Phys.*, **20**, 919 (1952).

[3] J. H. Raley, F. F. Rust and W. E. Vaughan, THIS JOURNAL, **70**, 88 (1948).

[4] F. S. Stone and H. S. Taylor, *J. Chem. Phys.*, **20**, 1339 (1952).