SiH_3Br beyond the evolution of small amounts of silane and a non-condensable gas, presumably hydrogen, and the deposition of a small amount of silicon. Eighty-five to 90% of the SiH_3Br could be recovered after the reaction, while the amounts of SiH_4 produced varied between 4 and 6% of the SiH_3Br originally present in the reaction mixture. These results are consistent with the interpretation that between 8 and 12% of the original amount of SiH_3Br reacted with Mg according to the over-all equation

$$2SiH_3Br + Mg \longrightarrow SiH_4 + H_2 + Si + MgBr_2$$

Thus our work, as well as that of Emeleus, Maddock and Reid,[2] suggests that reaction between silyl radicals leads to drastic disproportionation rather than recombination. Presumably this means that the free energy of formation of SiH_4 (−9.4 kcal./mole[3]) is more favorable than that of Si_2H_6.

A possible explanation for the great difference between the bromide and iodide in their ease of reaction with magnesium may be had by a consideration of bond strengths (dissociation energies). In carbon systems Grignard reagents are in general more difficult to prepare with chlorides than with the corresponding bromides which latter have lower bond strengths. While data are not available from which to compute the silicon–halogen bond strengths in SiH_3Br and SiH_3I, one can estimate from data tabulated by the Bureau of Standards[3] that the average Si–Br bond strength in $SiBr_4$ is 70.2 kcal. while the corresponding Si–I bond strength is 51.4 kcal., a difference of 19 kcal. Although these values are not directly applicable, we would certainly predict on their basis a much lessened reactivity in the case of SiH_3Br compared with SiH_3I.

Experimental

All experimental work was carried out in a high vacuum apparatus, using glass stopcocks greased with Apiezon N which was stable toward SiH_3Br at moderately low pressures.

Preparation of Silane.—Although the greater part of the SiH_4 used was supplied through the courtesy of the General Electric Company, supplementary amounts were prepared by the method of Finholt, Bond, Wilzbach and Schlesinger[4] which employs reduction of $SiCl_4$ by $LiAlH_4$ in ethyl ether solution. Purity was controlled by checking vapor pressures at two different temperatures and comparing with the values given by Stokland.[5]

Preparation of SiH_3Br.—The method used was essentially that of Stock and Somieski.[6] Silane was heated for two hours at 100–110° with a 15% excess of dry HBr in the presence of $AlBr_3$ in a previously evacuated flask immersed in an oil-bath. Purification was accomplished, after removal of non-condensable gases, by a distillation at −126° to remove unreacted SiH_4 and then several distillations at −96° to separate the SiH_3Br from higher bromides. When the vapor pressures checked at two temperatures with those reported by Stock and Somieski,[6] the SiH_3Br was considered pure.

Since SiH_3Br tends to disproportionate readily, it was kept at Dry Ice temperatures till needed, closed off by a stopcock. There was no detectable deterioration for periods of several weeks as verified by vapor pressure measurements.

Reaction of SiH_3Br with Mg.—A small shaving of Mg, burnished with a knife and washed with ether, was placed in a 0.6 × 5 cm. tube which was sealed into the vacuum apparatus, evacuated, and well flamed to remove surface adsorbed water. C.P. dibutyl ether was distilled over sodium into the tube. The SiH_3Br was then distilled into the tube and frozen with liquid nitrogen. The ratio of bromide to ether was varied in the different runs. The amounts of SiH_3Br varied from about 0.0005 mole (0.055 g.) to about 0.001 mole (0.11 g.) in quantities of ether ranging from about 0.1 to 0.5 ml. No correlation was evident between the ratio of halide to ether and extent of reaction.

The mixture was allowed to warm to room temperature, whereupon the SiH_3Br dissolved in the ether to form a clear solution. Loss of volatile SiH_3Br to the vapor state was minimized by using short lengths of small bore tubing, and closing the reaction tube with a stopcock. Gradually, over a period of 3 or 4 hours a dark deposit began to form on the Mg. Except for a small amount of bubbling, which could have been caused by vaporization into the vacuum above, there was no other evidence of reaction. In a few trials the mixture was allowed to stand overnight, but no further reaction could be observed.

To separate the products, the mixture was frozen with liquid nitrogen, and the non-condensable gas (H_2) removed. Distillation at −126° removed SiH_4, and the unreacted SiH_3Br was recovered by distilling at −63° and later purified by redistillation at -96°. There was no evidence of disilane. Four to 6% of SiH_4 was found on the basis of the original SiH_3Br and 85–90% of the SiH_3Br was recovered.

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(3) Natl. Bur. Standards, "Selected Values of Chemical Thermodynamic Properties," Series I, 1949.

(4) A. E. Finholt, A. C. Bond, K. E. Wilzbach and H. I. Schlesinger, THIS JOURNAL, **69**, 2692 (1947).

(5) K. Stokland, *Kgl. Norske Videnskab. Selskabs, Forh.*, **12**, 122 (1939).

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Fluorene Analog of Trypan Blue[1] (2,7-Bis-(8'-amino-3',6'-disulfo-1'-hydroxy-2'naphthylazo)-fluorene)

BY SIEGFRIED WOISLAWSKI

RECEIVED NOVEMBER 5, 1951

In continuation of previous work[2] on compounds useful in cancer research, 2,7-diaminofluorene dihydrochloride has been tetrazotized coupled with H-acid to form an analog of Trypan Blue. Novelli[3] reported the preparation of this compound but gave no details of yield or purity. When prepared by his method the compound was not homogenous. Both Trypan Blue and the fluorene analog have an absorption maximum at 590 mμ, Fig. 1.

Experimental

To a solution of 5.38 g. (0.02 mole) of 2,7-diaminofluorene dihydrochloride in 100 ml. of water was added 4.5 ml. (0.06 mole) of concentrated hydrochloric acid (sp. gr. 1.18) and 50 g. of ice. After cooling to 2°, agitation was started and 90% of 2.8 g. (0.04 mole) of sodium nitrite (95%) in 40 ml. of water was added rapidly, and the balance dropwise until a distinct test for nitrous acid was obtained. This excess was maintained for 0.5 hour. Throughout the tetrazotization tests were made for an excess of acid by means of congo red paper. When the tetrazotization was completed, excess nitrous acid was eliminated by adding 0.3 g. of urea. The brown tetrazonium chloride may form an emulsion that can easily be broken up by adding ice or a few drops of capryl alcohol. The temperature during the tetrazotization was kept at 0–5°.

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(1) Supported by Grant C-1356 from the National Cancer Institute of the National Institutes of Health, U. S. Public Health Service.

(2) H. S. Block and F. E. Ray, *J. Nat. Cancer Inst.*, **7**, 61 (1946).

(3) A. Novelli, *Anales Soc. espan. fis. quim.*, **28**, 362 (1930).

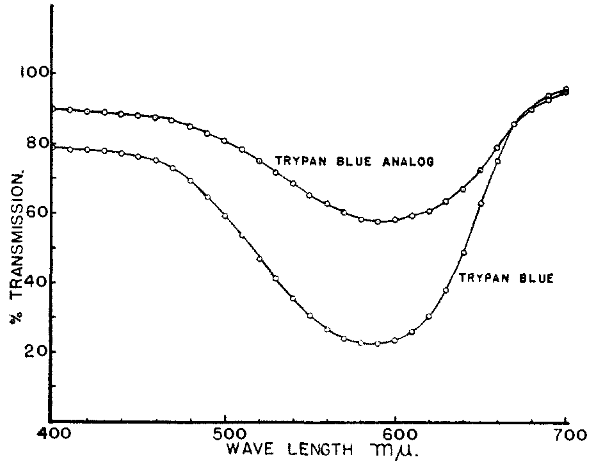

Fig. 1.

Since technical H-acid contains an impurity that forms a red dye with the tetrazonium chloride, it was purified by dissolving 27 g. of H-acid in 200 ml. of hot water and filtering. After reheating to 70°, it was salted out by the addition of 60 g. of sodium chloride. This procedure was repeated twice and the final product dried in a vacuum desiccator. This purification reduced the amount of the impurity but did not eliminate it entirely. It is therefore possible that it might be caused by mono-coupling.

Then 13.72 g. (0.04 mole) of H-acid was dissolved in 100 ml. of water containing 0.72 g. of sodium hydroxide (filtering if necessary). The solution was thus left faintly acid until just before coupling. This solution was cooled to 18°, 3.4 g. of sodium bicarbonate was added, and the tetrazonium chloride was run rather rapidly into the vigorously stirred alkaline solution of H-acid. It is important that the coupling mixture be kept alkaline, adding more sodium bicarbonate if necessary. Agitation was continued for 2 hours to ensure complete coupling. Tests were done for excess tetrazonium chloride and H-acid. The mixture was heated to 85°, 5 g. of decolorizing carbon was added, and the solution stirred for 15 minutes and filtered. The filtrate was reheated to 85° with agitation, and 27 g. of hydrated sodium acetate for each 100 ml. of solution was added slowly in four or five portions. The mixture, while still warm, was centrifuged, and the supernatant decanted. This procedure was repeated twice, and although it makes the filtration easier, it still was not possible to remove the red dye completely. For further purification, the dye was refluxed four times with 300-ml. portions of 95% ethyl alcohol which removes both the red dye and sodium acetate. To test for sodium acetate, a few drops of concentrated sulfuric acid were added to 10 ml. of filtrate until no turbidity was formed on cooling with ice. The absence of red dye was proven by the capillary test and by chromatography, using equal amounts of Hyflo-Super-cel and adsorptive magnesia. The dye was thus free of organic impurities; yield 42%.

Solubilities of the Dye.—Soluble in water, methyl alcohol, glacial acetic acid and methyl cellosolve; difficultly soluble in ethyl alcohol; insoluble in acetone, benzene, chloroform, dioxane, ether and petroleum ether.

Anal. Calcd. for $C_{33}H_{20}N_6O_{14}S_4Na_4$: N, 8.9; S, 13.6. Found: N, 8.9; S, 13.2.

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COMMUNICATIONS TO THE EDITOR

GERMBUDINE, ISOGERMIDINE AND VERATETRINE THREE NEW HYPOTENSIVE ALKALOIDS FROM VERATRUM VIRIDE

Sir:

Recent studies[1,2] have disclosed the isolation of the hypotensive ester alkaloids germitrine, neogermitrine and germidine from *Veratrum viride*. Fried, White and Wintersteiner have also shown that the triester germitrine can be partially hydrolyzed to the hypotensive diester germerine.

We wish to report that present investigations in our laboratories, on the alkaloids extractable from the ground roots and rhizomes of commercial *Veratrum viride*, have yielded germerine together with three new, highly potent, ester alkaloids for which we propose the names germbudine, isogermidine and veratetrine.

The benzene-extractable alkaloids, obtained by the procedure of Jacobs and Craig,[3] were separated into a crystalline non-ester alkaloid fraction and an amorphous fraction which contained the bulk of the hypotensive activity. This amorphous material was subjected to a 24-plate Craig counter-current distribution between benzene and 2 *M* acetate buffer at *p*H 5.5. The known triester neogermitrine was obtained by crystallizing the material in tubes 12–20 from acetone. Crystallization of the material in tubes 4–11 from benzene gave germerine (m.p. 203–205°; $[\alpha]^{26}D - 14.2°$ (*c*, 1 in pyridine), +6° (*c*, 1 in chloroform); the sample was identified further by comparison of its infrared spectrum, and by mixed melting point with authentic germerine kindly provided by Dr. J. Fried). In a personal communication, the latter disclosed that Dr. D. R. Walters of Squibb and Sons has also isolated germerine from *Veratrum viride*.

The alkaloids in tubes 0–3 were given a 72-plate Craig distribution between benzene and 2 *M* acetate at *p*H 6.5 and three fractions from this distribution, A, B and C, were crystallized from benzene to give three new alkaloids.

Fraction A (tubes 1–3), yielded germbudine (m.p. 158–160°, $[\alpha]^{27}D - 8.4°$ (*c*, 1 in pyridine), + 10.7° (*c*, 1 in chloroform)). Analytical data indicate the empirical formula $C_{37}H_{59}O_{18}N$ (calcd. C, 61.2; H, 8.20; eq. wt., 726; found: C, 61.0; H, 8.21; eq. wt., 732). Volatile acid determination, found: 0.91 equivalent of acid. Alkaline hydrolysis of germbudine afforded the alkamine germine and an acid fraction. The acids were converted to their *p*-phenylphenacyl esters which were separated chromatographically into the ester of α-meth-

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