

salts, the mono-acetate and monobenzoate and the dianilino derivative are colored and have the quinoid structure. The diacetate and the dichloride are derivatives of the lactoid modification.

6. Sulfonefluorescin, its zinc salt and its diacetate have been made. They are colorless. Sulfonefluorescin is very readily oxidized by the air to sulfonefluorescein.

7. With ammonia, sulfonefluorescein forms a stable mono-ammonium salt.

8. Dibromo-sulfonefluorescein and di-iodo-sulfonefluorescein have been made and studied. Like sulfonefluorescein they are tautomeric substances, having themselves the colored quinoid structure and yielding diacetates having the lactoid structure. The tetrabromo-sulfonefluorescein described by Sisley could not be made.

9. With ammonia, dibromo-sulfonefluorescein forms a stable mono-ammonium salt.

10. It has been shown that the fluorescence of sulfonefluorescein is about 10% more intense than that of fluorescein.

ITHACA, NEW YORK

[CONTRIBUTION FROM THE CHEMICAL LABORATORIES OF COLUMBIA UNIVERSITY, No. 445]

RESEARCHES ON SELENIUM ORGANIC COMPOUNDS. IV THE SYNTHESIS OF BENZO-BIS-SELENAZOLES AND SELENAZOLO-BENZOTHIAZOLES, NEW HETEROCYCLIC SYSTEMS

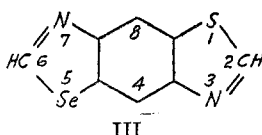
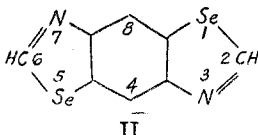
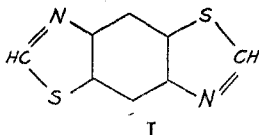
BY MARSTON TAYLOR BOGERT AND HORACE H. HOPKINS

RECEIVED APRIL 16, 1924

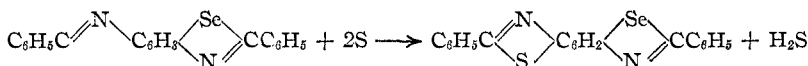
PUBLISHED AUGUST 5, 1924

Introductory

Benzo-bis-thiazoles (I) have been described previously,^{1,2} but benzo-bis-selenazoles (II) and selenazolo-benzothiazoles (III) have been unknown hitherto.



The synthesis of derivatives of heterocycles II and III has been accomplished by fusion of the 6-benzalamino-2-phenyl-benzoselenazole with selenium or sulfur.



¹ Green and Perkin, *J. Chem. Soc.*, **83**, 1207 (1903).

² Bogert and Abrahamson, *THIS JOURNAL*, **44**, 826 (1922).

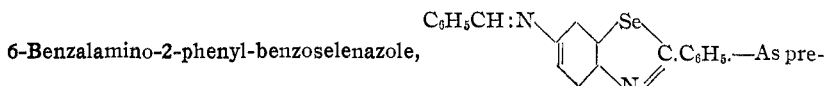
The selenazolo-benzothiazole is interesting on account of its being simultaneously both a thiazole and a selenazole. Hence, it offers an excellent opportunity to compare the behavior of these two cycles toward various reagents.

The synthesis of this selenazolo-benzothiazole from the benzalamino-benzoselenazole was carried out many times. In one of these experiments, run exactly like the others so far as we could see, the reaction pursued a different course and, instead of the selenazolo-benzothiazole, there was obtained a new base, $C_{27}H_{18}N_2S_2Se$, which when nitrated yielded a product whose analysis gave figures agreeing with those for a simple dinitro derivative. But when this supposititious dinitro derivative was reduced with tin and hydrochloric acid, its oxygen was replaced by hydrogen and an atom of sulfur was removed in the form of hydrogen sulfide, leaving a compound, $C_{27}H_{20}N_4SSe$. In spite of numerous attempts, we were unable to get any more of this $C_{27}H_{18}N_2S_2Se$ compound, and are still in the dark as to its character.

As further proof of the structure assigned to these new heterocycles, the diphenyl-benzo-bis-selenazole was synthesized also from dibenzal-*p*-phenylenediamine.

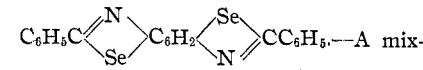
Attempts to carry out analogous reactions with 6-furalamino-2-phenyl-benzoselenazole failed, because fusion of this compound with either sulfur or selenium decomposed it.

Experimental Part



pared by the method of Bogert and Chen,³ this substance melted at 157° (corr.), in agreement with the figure given by them.

In the purification of the initial 2-phenyl-benzoselenazole, it was found advantageous to distil it under diminished pressure (b. p., 220 – 230° at 28 mm.) before crystallizing it from alcohol; yield, 40%. For the crystallization of the 6-nitro derivative, *n*-butyl alcohol proved superior to ethyl alcohol, and for the reduction to the corresponding amine, tin and hydrochloric acid were found to be more satisfactory than stannous chloride.

2,6-Diphenyl-*p*- β -benzo-bis-selenazole, —A mixture of 25 g. of 6-benzalamino-2-phenyl-benzoselenazole and 15 g. of selenium was boiled gently for 23 hours on a sand-bath. The cold melt was extracted with concd. hydrochloric acid, the filtered acid solution precipitated by large dilution, and the precipitate collected, washed and dried; yield, 13 g. of yellow powder. By repeated crystallization from glacial acetic acid and from *n*-butyl alcohol, fine lemon-yellow needles were obtained; m. p., 217° (corr.); yield, 17%.

Anal. Calc. for $C_{26}H_{18}N_2Se_2$: C, 54.80; H, 2.74. Found: C, 55.16; H, 2.71.

³ Bogert and Chen, THIS JOURNAL, 44, 2352 (1922).

The compound was somewhat soluble in glacial acetic acid or *n*-butyl alcohol, as noted above, less soluble in ethyl alcohol or benzene, and practically insoluble in ether, ethyl acetate or carbon tetrachloride.

The same compound was obtained by fusing 30 g. of dibenzal-*p*-phenylenediamine (m. p., 139°) with an equal weight of selenium for 24 hours, but the yield of pure product was only 3%. It melted at 217.2–217.7° (corr.), and an intimate mixture of this with the product obtained by the other method melted at the same point.

ACETYL CHLORIDE ADDITION PRODUCT, C₂₀H₁₂N₂Se₂.CH₃COCl.—To a hot solution of 0.5 g. of the bis-selenazole in 50 cc. of toluene, 4 cc. of acetyl chloride was added and the solution left overnight at the laboratory temperature. Minute, golden-yellow needles (0.6 g.) crystallized.

Anal. Calc. for C₂₂H₁₅ON₂ClSe₂: C, 51.12; H, 2.93. Found: C, 51.57; H, 3.06.

These crystals lost acetyl chloride quite easily on standing or when heated, so that when crystallized repeatedly from toluene the original bis-selenazole was regenerated.

Mononitro-2,6-diphenyl-*p*- β -benzo-bis-selenazole.—To a solution of 5 g. of the bis-selenazole in 17 cc. of concd. sulfuric acid at 0°, a mixture of 0.8 cc. of concd. nitric and 7 cc. of concd. sulfuric acids was added gradually. After the mixture had been stirred for three hours, it was poured into a large volume of ice water, the precipitate collected, washed thoroughly with hot acetic acid and dried. There remained 4.5 g. of crude nitro derivative. When 1 g. of this was crystallized repeatedly from a mixture of 2 parts of glacial acetic acid with 3 parts of nitrobenzene, orange-yellow needles were obtained, m. p., 296.1–297.1° (corr.), slightly soluble in glacial acetic acid, and practically insoluble in ethyl or *n*-butyl alcohol, ether, acetone or benzene. This product still contained small amounts of the dinitro derivative. On account of the losses involved in further crystallizations, and because it was found simpler to purify the products derived from this mononitro compound, attempts at complete purification were abandoned.

Anal. Calc. for C₂₀H₁₁O₂N₃Se₂: C, 49.65; H, 2.28. Found: C, 47.64; H, 2.21.

Dinitro-2,6-diphenyl-*p*- β -benzo-bis-selenazole.—A solution of 1.5 g. of the diphenyl-benzo-bis-selenazole in 7 cc. of concd. sulfuric acid was nitrated at 0° by a mixture of 0.8 cc. of concd. nitric and 3 cc. of concd. sulfuric acid. After having been stirred for three hours, the mixture was heated at 80° for half an hour and then poured into ice water. The precipitate was removed, dried and washed with boiling glacial acetic acid; yield, 1.3 g., or 72%. By repeated crystallization of this crude product from nitrobenzene, minute, greenish-yellow needles were obtained, which darkened in the neighborhood of 320° and melted at 332.4–333.4° (corr.).

Anal. Calc. for C₂₀H₁₀O₄N₄Se₂: C, 45.45; H, 1.89. Found: C, 45.70; H, 2.13.

Mono-amino-2,6-diphenyl-*p*- β -benzo-bis-selenazole was secured by reduction of the corresponding nitro compound with tin and hydrochloric acid. Upon the completion of the reduction, the acid solution was made strongly alkaline by addition of sodium hydroxide solution. The precipitate was removed, washed with water, dried and extracted with hot aniline. As the aniline extract cooled, the crude amino-selenazole separated; yield, 30%. The crude product was crystallized several times from aniline and decolorized by Norite. There resulted orange needles, which sintered at about 260° and melted at 279.4–281° (corr.).

Anal. Calc. for C₂₀H₁₃N₃Se₂: C, 52.92; H, 2.87. Found: C, 53.54; H, 3.13.

The compound was practically insoluble in ethyl or *n*-butyl alcohol, ether or carbon tetrachloride.

BENZAL DERIVATIVE.—A mixture of 0.5 g. of the amine just described, 0.8 cc. of benzaldehyde and 8 cc. of *n*-butyl alcohol was boiled gently under a reflux condenser for

an hour. When the solution cooled, 0.51 g. of glistening, golden-yellow scales separated; yield, 85%. Recrystallized from toluene, the product melted at 233.5–235.5° (corr.).

Anal. Calc. for $C_{27}H_{17}N_2Se_2$: C, 59.84; H, 3.16. Found: C, 60.70; H, 3.36.

2,6-Diphenyl-*p*- β -selenazolo-benzothiazole, $C_6H_5C \begin{array}{c} \diagup N \\ \diagdown S \end{array} C_6H_5 \begin{array}{c} \diagdown Se \\ \diagup N \end{array} CC_6H_5$.—A

mixture of 12.5 g. of 6-benzalamino-2-phenyl-benzoselenazole and 5.2 g. of sulfur was fused for eight hours at 250–260°. The cold pulverized melt was extracted with hot concd. hydrochloric acid and the filtered extracts precipitated by dilution. The yellow precipitate was collected, washed and dried. By repeated crystallization from *n*-butyl alcohol, it was obtained in lustrous straw-colored needles; m. p., 220.4–221.5° (corr.); b. p., 345–350° (11 mm.); yield, 6 g., or 47%. These needles were soluble also in hot glacial acetic acid, toluene or aniline, but dissolved only slightly in ethyl alcohol, carbon tetrachloride or acetone.

Anal. Calc. for $C_{20}H_{12}N_2SSe$: C, 61.35; H, 3.07; N, 7.16; S, 8.19. Found: C, 61.67; H, 3.23; N, 7.30; S, 8.57.

TETRABROMIDE.—A solution of 1 g. of the selenazole in 30 cc. of hot chloroform was treated with a warm solution of 2 cc. of bromine in 5 cc. of chloroform and the mixture left for half an hour at laboratory temperature. Minute, light brown needles separated. These were removed, suspended in warm chloroform, again filtered out, washed with chloroform and dried; yield, 1.6 g., or 85%. On standing, the product decomposed slowly with loss of bromine. When heated, it decomposed at 238–243° (corr.) with evolution of gas.

Anal. Calc. for $C_{20}H_{12}N_2SSeBr_4$: Br, 44.95. Found: 44.57, 44.79.

A large excess of bromine was necessary to get a pure tetrabromide. The bromine was determined by adding the sample to a 1% sodium bisulfite solution, boiling for a half hour, filtering out the precipitated selenazolo-thiazole, acidifying the filtrate and precipitating bromide ion as silver bromide.

MONO-ACETYL CHLORIDE ADDITION PRODUCT.—To a solution of 1 g. of the selenazolo-thiazole in 100 cc. of hot glacial acetic acid, was added 3 cc. of acetyl chloride. The flask was stoppered immediately and left overnight at laboratory temperature. The microscopic, pale yellow needles which separated were removed, dried and crystallized from toluene, and then appeared in fine needles, m. p., 224–225° (corr.), with evolution of acetyl chloride; yield, 0.7 g., or 59%.

Anal. Calc. for $C_{22}H_{18}ON_2SSeCl$: C, 56.25; H, 3.20. Found: C, 56.33; H, 3.37.

Action of Methyl Iodide upon the Selenazolo-thiazole.—A mixture of 1.5 g. of the selenazolo-thiazole and 4.5 cc. of methyl iodide was heated in a sealed tube for eight hours at 100°. The crude product was rinsed out of the tube with alcohol, the mixture filtered and the insoluble material washed with alcohol. This insoluble material weighed 1.4 g., and proved to be the unchanged initial selenazolo-thiazole (m. p., 220–221°, corr.).

Dinitro-2,6-diphenyl-*p*- β -selenazolo-benzothiazole.—A solution of 1 g. of the selenazole in concd. sulfuric acid was nitrated at 0° by the slow addition of a mixture of 5 cc. of concd. sulfuric and 0.5 cc. of concd. nitric acid. After standing for two hours, the mixture was poured into 50 cc. of ice water, the yellow precipitate collected, washed, dried, washed with hot glacial acetic acid and crystallized from nitrobenzene. Microscopic, greenish-yellow needles were thus obtained; m. p., 295–297° (corr.); yield, 0.6 g., or 50%.

Anal. Calc. for $C_{26}H_{16}O_4N_4SSe$: C, 49.88; H, 2.08. Found: C, 50.46; H, 2.60.

As the figures for both carbon and hydrogen are high, it is quite likely that the product was contaminated with some of the mononitro derivative.

Synthesis of a New Base, $C_{27}H_{18}N_2S_2Se$.—In one of the experiments for the production of the diphenyl selenazolo-benzothiazole, 43 g. of 6-benzalamino-2-phenyl-benzoselenazole was fused with 15 g. of sulfur at 250–260° as long as hydrogen sulfide was evolved (23 hours). Instead of the expected diphenyl-selenazolo-benzothiazole, there resulted a new base, resembling the selenazole in appearance and solubilities, but quite distinct therefrom. It crystallized from toluene or *n*-butyl alcohol in long, glistening, straw-colored needles, m. p., 226.5° (corr.), or 5° higher than the thiazole; yield, 16 g., or 25%.

Anal. Calc. for $C_{27}H_{18}N_2S_2Se$: C, 63.20; H, 3.51; N, 5.45; S, 12.45. Found: C, 63.63, 63.47; H, 3.13, 3.47; N, 5.48; S, 12.87.

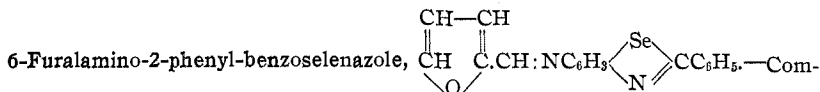
In spite of numerous attempts, we could not secure this product again.

DINITRO DERIVATIVE.—Nine g. of the base described above was nitrated with 1.7 cc. of concd. nitric and 30 cc. of concd. sulfuric acid for three hours at 0°. The crude product was purified by crystallization from nitrobenzene, and yielded 1.5 g. of microscopic, golden-yellow needles; m. p., 283° (corr.).

Anal. Calc. for $C_{27}H_{16}O_4N_4S_2Se$: C, 53.70; H, 2.67; N, 9.28. Found: C, 53.61; H, 2.83; N, 9.60, 9.54.

Reduction of the Dinitro Derivative. Formation of a Base, $C_{27}H_{20}N_4SSe$.—When the dinitro derivative was reduced with tin and hydrochloric acid, it yielded a new base with evolution of hydrogen sulfide. From 2 g. of the dinitro derivative, there was obtained 0.32 g. of pale, brownish-yellow needles (from aniline); m. p., 305° (corr.), with decomposition.

Anal. Calc. for $C_{27}H_{20}N_4SSe$: C, 63.30; H, 3.91. Found: C, 63.69; H, 3.93.



mmercial fural was distilled at 21.5 mm. pressure and the portion boiling at 69–70° was caught in three separate fractions, 15%, 65% and 20%. Only the 65% fraction was used in our experiments.

A solution of 14 g. of 6-amino-2-phenyl-benzoselenazole in an excess (50 g.) of fural was heated for an hour at 100°. As it cooled, the solution congealed to a mass of yellow needles. These were filtered out, washed with a little alcohol and recrystallized from the same solvent. Glistening yellow needles were obtained; m. p., 147.5° (corr.); yield, 13 g. or 57%. The compound was soluble also in carbon tetrachloride, acetone, ethyl acetate or benzene.

Anal. Calc. for $C_{18}H_{12}ON_2Se$: C, 61.50; H, 3.42. Found: C, 61.76; H, 3.53.

Fusion of the Furalamino Derivative with Selenium.—A mixture of 3 g. of this furalamino derivative with 3 g. of selenium was fused in a nitrate bath whose temperature was raised slowly to 330°. Charring and decomposition ensued, but no evolution of hydrogen selenide. Since the fural derivative apparently decomposed below the melting point of selenium (217°), the experiment was not repeated.

Fusion of the Furalamino Derivative with Sulfur.—Equal weights (5 g.) of the furalamino derivative and sulfur were heated together for 16 hours at 150°. Hydrogen sulfide was evolved copiously and the melt gradually darkened. It was cooled, pulverized, extracted with hot concd. hydrochloric acid, and the filtered extracts largely diluted with water. The yellow precipitate which separated was collected, washed and dried; yield, 0.8 g. No satisfactory solvent was found for the purification of this crude product. It was very sensitive to heat, being decomposed even when suspended in boiling *n*-butyl alcohol (b. p., 116.8°).

Summary

1. By fusion of benzalamino-benzoselenazoles with sulfur, and with selenium, selenazolo-benzothiazoles and benzo-bis-selenazoles, new heterocyclic types, have been prepared and studied, together with some of their derivatives. The bis-selenazole was also obtained from the dibenzal-*p*-phenylenediamine, by heating it with selenium.

2. The formation of another new base, $C_{27}H_{18}N_2S_2Se$, was observed in one of these experiments, but it could not be obtained a second time and was not identified.

3. Fusion of furalamino-benzoselenazoles with either selenium or sulfur gave only decomposition products.

4. The following new compounds were prepared: 2,6-diphenyl-*p*- β -benzo-bis-selenazole, its acetyl chloride addition product, mononitro, dinitro, mono-amino and benzalamino derivatives; 6-furalamino-2-phenyl-benzoselenazole; 2,6-diphenyl-*p*- β -selenazolo-benzothiazole, its tetra-bromide, acetyl chloride addition product and dinitro derivative; a base, $C_{27}H_{18}N_2S_2Se$, its dinitro derivative and a reduction product of the latter.

NEW YORK, N. Y.

[CONTRIBUTION FROM THE LABORATORY OF ORGANIC CHEMISTRY OF THE UNIVERSITY OF WISCONSIN]

DIPHENEINS FROM RESORCINOL AND SUBSTITUTED DIPHENIC ANHYDRIDES. STRUCTURE OF CERTAIN DIPHENYL DERIVATIVES

BY HOMER ADKINS, EDW. F. STEINBRING AND ELIZABETH PICKERING¹

RECEIVED MAY 9, 1924

PUBLISHED AUGUST 5, 1924

Experimental work based upon the idea that diphenic anhydride should behave similarly to phthalic anhydride has been described in two papers dealing with the condensation of the former with resorcinol. These papers appeared in successive months, the first by Dutt,² and the second by Bischoff and Adkins.³ The two reports are in essential agreement, to the effect that the resorcinol condenses with diphenic anhydride to form a strongly fluorescent compound, analogous to fluorescein, which may be brominated to form a compound analogous to eosin. Later Underwood and Kochmann⁴ questioned these results and claimed first, that the condensation product of diphenic anhydride and resorcinol is not fluorescent and second, that the previous investigators had not touched upon the

¹ Mr. Steinbring performed all of the experimental work described in this paper, although the work was based on certain observations made by Miss Pickering.—H. A.

² Dutt, *J. Chem. Soc.*, **123**, 225 (1923).

³ Bischoff and Adkins, *THIS JOURNAL*, **45**, 1030 (1923).

⁴ Underwood and Kochmann, *ibid.*, **45**, 3071 (1923).