

Cooling and removal of 4 g. more of tetrachloroquinone gave a red solution. This was boiled with charcoal for two hours. The resulting pale yellow solution was evaporated, finally at 50° and 80 mm., to remove dienyne. The residue, which crystallized, was recrystallized from 5 ml. of ethanol to give 300 mg. of nearly colorless substance, m. p. 75-78°.

Anal. Calcd. for $C_{14}H_{10}O_2Cl_4$: C, 47.7; H, 2.8. Found: C, 48.0; H, 2.8.

The compound was dissolved in ethanol for observation of the ultraviolet absorption.⁸ About 20 mg. dissolved in

(8) We are indebted to Mr. H. Bastron and Dr. R. E. Davis for the ultraviolet absorption data in this paper.

cold aqueous sodium hydroxide (one pellet in 4 ml.) in fifteen minutes.

Summary

1. 2,5-Dimethyl-1,5-hexadien-3-yne has been combined with *p*-benzoquinone to give a compound, $C_{20}H_{18}O_4$. This gave a decahydro compound which is probably a derivative of 8-chrysitene.

2. 2,5-Dimethyl-1,5-hexadien-3-yne and tetrachloro-*p*-benzoquinone combined mole for mole to give a crystalline adduct.

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[CONTRIBUTION FROM THE AVERY LABORATORY OF CHEMISTRY OF THE UNIVERSITY OF NEBRASKA]

Derivatives of Methylphenylarsine¹

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Derivatives of mixed aliphatic-aromatic arsenicals have generally been limited to those readily prepared, such as arsenic acids, chloroarsines, bromoarsines and hydroxyarsines. It was thought worth while to prepare a series in which the chloro, bromo, cyano, thiocyno, methoxy and acetoxy derivatives could be compared for toxicity purposes. Except for the acetoxy derivative, individual examples of the various types are listed in the literature. Since no general methods of synthesis were available, each member was prepared by the easiest route. Methylphenylarsine and methyl-(3-nitrophenyl)-arsine were chosen as basic nuclei for the study.

Methylphenylchloroarsine was first prepared by the method of Burrows and Turner.² It was later found that methyl sulfate could be substituted for methyl iodide in the preparation of methylphenylarsinic acid, simplifying the procedure considerably. The cyano, thiocyno, acetoxy and methoxy derivatives were prepared from the chloro compound by metathesis with appropriate salts. Methylphenylarsine was obtained by an adaptation of the reduction procedure of Palmer and Adams.³ Attempts to prepare a chloroacetoxy compound failed.

Methyl-(3-nitrophenyl)-arsinic acid has not been previously reported. It was most conveniently prepared from 3-nitrobenzenediazonium sulfate and methylchloroarsine. Nitration of methylphenylarsinic acid also gave appreciable yields of the desired product but the Meyer reaction of methyl sulfate and 3-nitroarsenosobenzene resulted in only sufficient material for identification purposes. Methyl-(3-nitrophenyl)-arsinic

acid was reduced to the corresponding chloroarsine and the latter converted to the cyano derivative. The bromoarsine was also prepared but the reductive properties of sodium methoxide and amalgamated zinc toward the nitro group prevented the preparation of the arsine and the methoxy derivative.

Experimental

Methylphenylarsinic Acid.—Phenyldichloroarsine (111 g., 0.5 mole) was added slowly with stirring to a solution of sodium hydroxide (96 g., 2.4 mole) in water (200 ml.), the solution cooled and placed in a 3-necked flask equipped with dropping funnel, stirrer and condenser. Methyl sulfate (78 g., 0.62 mole) was added, dropwise, with stirring, keeping the temperature between 20 and 30°. After stirring overnight, the temperature was raised to 80° for one hour. The precipitated salts were filtered off, the filtrate evaporated to 250 ml. and made neutral to litmus paper with sulfuric acid (18 *N*). The solution was treated with absolute ethanol (250 ml.) and filtered. The filtrate was made acid to congo red paper with sulfuric acid (18 *N*), the precipitated salts removed and the residual solution concentrated to 200 ml. After dilution with absolute ethanol (600 ml.), the salts which separated were removed and the ethanol solution evaporated to dryness. The salt fractions were washed out with acetone and the acetone solution also evaporated. The combined yield from the ethanol and acetone fractions was 97 g. (97%). This product was reduced to the chloroarsine by the method of Burrows and Turner.²

Methylphenylcyanoarsine.—Methylphenylchloroarsine (87 g., 0.43 mole) was added slowly with stirring to a solution of sodium cyanide (23 g., 0.47 mole) in water, keeping the temperature at 20-25°. After the heat of reaction had been dissipated the stirring was continued for thirty minutes. The oily layer was separated and the aqueous layer extracted twice with 50-ml. portions of benzene. The benzene extract and oil were combined, washed with 100 ml. of water, dried over calcium chloride and distilled.

Methylphenylmethoxyarsine.—Sodium (10 g., 0.435 mole) was dissolved in anhydrous methanol (150 ml.) in a 3-necked flask equipped with dropping funnel, stirrer and condenser. Calcium chloride tubes were used to prevent the absorption of moisture. Methylphenylchloroarsine (75 g., 0.37 mole) was added slowly with stirring and then the reaction mixture heated at reflux for thirty minutes. The precipitated salt was removed and the alcohol removed under reduced pressure. The residue was

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(1a) Official investigator.

(2) Burrows and Turner, *J. Chem. Soc.*, **119**, 1373 (1921).

(3) Palmer and Adams, *This Journal*, **44**, 1356 (1933).

TABLE I
 TABLE OF CONSTANTS

Compound	Yield, %	Color	B. p.		Molecular formula	Analyses, % As ^a		<i>d</i> ₄₁₀ ^o	<i>n</i> _D
			°C.	Mm.		Calcd.	Found		
Methylphenylchloroarsine	61	Colorless	127	23	C ₇ H ₈ AsCl	36.99	37.08	1.449 ⁸¹	1.6022 ⁸¹
Methylphenylcyanoarsine	63	Colorless	147-148	20	C ₈ H ₈ AsN	38.80	38.13	1.372 ²⁵	1.5812 ²⁶
Methylphenylthiocyanoarsine	49	Pale yellow	176-179	18	C ₈ H ₈ AsNS	33.28	33.25	1.433 ³²	1.6577 ³¹
Methylphenylmethoxyarsine	71	Colorless	101-102	17	C ₈ H ₁₁ AsO	37.82	37.93	1.295 ³¹	1.5613 ³⁰
Methylphenylacetoxyarsine	36	Pale yellow	140-142	14	C ₉ H ₁₁ AsO ₂	33.13	33.19	1.369 ³⁸	1.5612 ²⁹
Methylphenylarsine	61	Colorless	108-111	37	C ₇ H ₈ As	44.58	44.31	1.31 ²³
Methyl-(3-nitrophenyl)- arsinic acid	50	Light yellow	M. p. 223-223.5°		C ₇ H ₈ AsNO ₄	30.57	30.57
Methyl-(3-nitrophenyl)- chloroarsine	52	Light orange	162	0.8	C ₇ H ₇ AsClNO ₂	30.27	30.26	1.617 ³²	1.6272 ³⁰
Methyl-(3-nitrophenyl)- bromoarsine	54	Light yellow	174-176	0.85	C ₇ H ₇ AsBrNO ₂	25.66	25.63	1.857 ³²	1.6551 ³⁴
Methyl-(3-nitrophenyl)- cyanoarsine	66	Light yellow	M. p. 79.5-80.5°		C ₈ H ₇ AsN ₂ O ₂	31.47	31.47

^a Arsenic was determined by a modification of the Cislak and Hamilton method [THIS JOURNAL, 52, 638 (1930).]

extracted with benzene and the benzene extracts filtered and distilled.

Methylphenylthiocyanoarsine.—Methylphenylchloroarsine (50 g., 0.247 mole) was added slowly with stirring to sodium thiocyanate (23 g., 0.28 mole) in acetone (250 ml.). After one hour, the solution was filtered and the acetone removed under reduced pressure. The residue was extracted with benzene and the benzene solution filtered and distilled.

Methylphenylacetoxyarsine.—Methylphenylchloroarsine (68 g., 0.336 mole) was added dropwise to a stirring solution of anhydrous sodium acetate (34 g., 0.415 mole) in anhydrous methanol (300 ml.). After one hour, the salt was removed and the methanolic solution concentrated at reduced pressure. The residue was dissolved in benzene, the solution filtered, and the filtrate fractionated three times.

Methylphenylarsine.—Zinc amalgam was prepared from zinc dust (275 g., 4.2 moles) and a solution of mercuric chloride (55 g., 0.2 mole) in water (1.5 liters) by shaking for several hours. The amalgam was filtered off and washed several times with water and finally with methanol. The amalgam and methanol (500 ml.) were placed in a 5-liter, 3-necked flask equipped with dropping funnel, stirrer and reflux condenser. The system was in equilibrium with the atmosphere through a mercury trap connected to the condenser. Methylphenylchloroarsine (101 g., 0.5 mole) was added, dropwise, over a period of twelve hours while keeping the solution at gentle reflux with a hot plate. A yellow precipitate formed early in the reaction but disappeared gradually. When the reaction was complete, the condenser was reversed and the mixture distilled in a stream of carbon dioxide until no more oil appeared in the distillate. The oil was removed in the absence of oxygen, dried over calcium chloride, and fractionally distilled in a carbon dioxide atmosphere. The product ignited on exposure to air and had an arsine-like odor.

Methyl-(3-nitrophenyl)-arsinic Acid.—(a) *m*-Nitroaniline (17 g.), concentrated sulfuric acid (12 g.), absolute ethanol (308 ml.) and methylchloroarsine (30.8 g.) were mixed and cooled to 0°. Keeping the temperature at 0-5°, a saturated aqueous solution of sodium nitrite (8.5 g.) was added slowly with stirring. Cuprous chloride (1.2 g.) was added, the mixture thoroughly stirred, then warmed to 60°, and finally concentrated to 250 ml. The residue was filtered and the filtrate treated with sodium bicarbonate until neutral to congo red paper. The tan precipitate was recrystallized from water. (b) A mixture of concentrated sulfuric acid (260 g.), and red fuming nitric acid (130 g., sp. g. 1.59) was cooled in an ice-bath

and methylphenylarsinic acid (50 g., 0.25 mole) added slowly with stirring, keeping the temperature below 20°.

After the addition was completed, the ice-bath was removed and the mixture stirred for three hours at room temperature and twenty minutes at 60-70°. After cooling, the solution was added to sodium hydroxide (163 g.) and water (163 ml.) with sufficient ice to keep the temperature below 40°. The solution was neutralized to congo red paper with sodium bicarbonate and the crude product filtered off. The recrystallized product weighed 18 g. (30%).

Methyl-(3-nitrophenyl)-chloro and Methyl-(3-nitrophenyl)-bromoarsine.—Methyl-(3-nitrophenyl)-arsinic acid (94.5 g.) was dissolved in concentrated hydrochloric acid (220 ml.). A drop of aqueous potassium iodide was added and a stream of sulfur dioxide was passed into the solution. The oily layer which separated was dissolved in carbon tetrachloride and dried with calcium chloride. The carbon tetrachloride was removed by distillation and the residue fractionated under reduced pressure. The bromoarsine was obtained by using hydrobromic acid for hydrochloric acid.

Methyl-(3-nitrophenyl)-cyanoarsine.—A solution of methyl-(3-nitrophenyl)-chloroarsine (36 g.) in benzene (200 ml.) was added to silver cyanide (34 g.) with stirring. The temperature was gradually increased to 40° and then heated at reflux for sixty-four hours. The benzene solution was filtered free of silver salts, dried over sodium sulfate, concentrated to 200 ml. and diluted with 400 ml. of petroleum ether. Upon cooling, yellow crystals separated which were recrystallized from benzene-petroleum ether.

Summary

1. The chloro, cyano, thiocyno, methoxy, and acetoxy derivatives of methylphenylarsine were prepared for comparison of toxicities. The thiocyno, methoxy, acetoxy and arsine compounds are new.

2. Methyl-(3-nitrophenyl)-arsonic acid and the derived chloro, bromo, and cyanoarsines are described for the first time.

3. Methylphenylarsinic acid, methylphenylchloroarsine and methylphenylcyanoarsine were prepared by new methods giving better yields and purer products.

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