was treated with 0.2 g. of piperidinium acetate and six drops of piperidine. The solution darkened immediately, and water droplets appeared. Every hour for six hours the water was removed under vacuum and fresh piperidine was added. The mixture was then heated for two days at 45°. The dark red mixture was dissolved in 100 ml. of ether, and the solution was washed with water, 1 *N* sulfuric acid and 2% aqueous sodium carbonate, and was dried over sodium sulfate. After removing the ether the residue was distilled under reduced pressure. The fractions from the two such runs which distilled 170–185° (2.5 mm.) were combined (7.4 g.) and redistilled. A fraction (2.7 g.) distilling from 170–180° (2.5 mm.) was collected as methyl pseudo-ionylidenecyanoacetate. It had the following properties: $n^{24}D$ 1.5760. *Anal.* Calcd. for $C_{17}H_{23}O_2N$: C, 74.69; H, 8.48. Found: C, 74.61; H, 8.56.

The authors are indebted to Mr. Bruce Day and Mr. Robert Sprague for the combustion analyses.

Summary

The absorption spectra of a number of polyene derivatives of cyanoacetic acid and its esters have been measured and compared. Particular attention has been paid to the effects on the spectra of increasing the number of double bonds in conjugation with the cyano and carboxyl groups. The effects of methyl substitution on the olefinic linkages have been noted; and the spectra of some of the acids have been compared with those of the corresponding esters. The application of such data to the study of the structure of alkylidenecyanoacetic acids has been illustrated.

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[CONTRIBUTION FROM THE UNITED STATES PUBLIC HEALTH SERVICE VENEREAL DISEASE RESEARCH AND POSTGRADUATE TRAINING CENTER, JOHNS HOPKINS HOSPITAL]

Aminoarsenosobenzoic Acids[1]

BY G. O. DOAK, H. G. STEINMAN AND HARRY EAGLE

The failure of the carboxyl group to inhibit the treponemicidal activity of 4-arsenosoanthranilic acid has been discussed previously.[2] In order to study this effect further we have attempted the preparation of the remaining nine isomeric aminoarsenosobenzoic acids.

We have previously reported[3] unsatisfactory results with Maschmann's procedure[4] for the preparation of 2-arsono-4-nitrobenzoic acid. Similar difficulties have since been encountered in this Laboratory with the permanganate oxidation of 2-nitro-*p*-toluenearsonic acid and 4- and 6-nitro-*o*-toluenearsonic acids. Maschmann's procedure left these compounds nearly unchanged; in order to complete the reaction it was found necessary to reflux with permanganate solution for as long as a week. Accordingly, we have prepared all the desired arsononitrobenzoic acids, except 3-arsono-5-nitro- and 2-arsono-3-nitrobenzoic acids, from the corresponding amines by the Bart reaction as used by Karrer[5] for the preparation of 2-arsono-5-nitrobenzoic acid. When the amine was particularly difficult to diazotize, *e. g.*, 3-amino-4-nitrobenzoic acid, the best results were obtained by precipitating the acid from alkaline solution in a finely divided state just prior to diazotization. The majority of the arsononitrobenzoic acids were surprisingly soluble in water and the solutions from the Bart reactions had to be concentrated to small volumes before the acids could be precipitated. 3-Arsono-5-nitro, 3-arsono-2-nitro- and 2-arsono-3-nitrobenzenearsonic acids precipitated as acid salts even from solutions strongly acid to congo red. A similar effect has been noted with 4-arsono-2-nitrobenzenearsonic acid.[6] The free acids were obtained by recrystallization from hydrochloric acid. Even under these conditions, however, the 3-arsono-2-nitrobenzoic acid precipitated as an acid salt. The melting points of 4-arsono-3-nitro- and 2-arsono-4-nitrobenzoic acids prepared by this procedure, and also of the corresponding amino compounds, differed considerably from those reported by Maschmann. In view of the slowness of the permanganate oxidation, we believe that the compounds he reported were mixed with unoxidized material.

The preparation of the 3-arsono-5-nitro- and 2-arsono-3-nitrobenzoic acids offered unexpected difficulties. The Bart reaction applied to the 3-amino-5-nitrobenzoic acid, and several modifications including the Scheller reaction, failed to give any trace of an arsonic acid. The Bart reaction also failed with 3-nitro-anthranilic acid. We were unable to nitrate *m*-arsonobenzoic acid even under the most drastic conditions. Accordingly, it was necessary to prepare both 3-arsono-5-nitro- and 2-arsono-3-nitrobenzoic acids by oxidation of the corresponding nitrotoluenearsonic acids.

5-Arsonoanthranilic acid was prepared by the method of Cohen, King and Strangeways.[6] The other aminoarsonobenzoic acids were obtained by reduction of the arsononitrobenzoic acids. With compounds containing a nitro group ortho to the arsonic acid group, the method of Jacobs, Heidelberger and Rolf[7] was used, as it had previously been noted that the reduction of such compounds with Raney nickel was unsatisfactory.[8] The other arsononitrobenzoic acids were reduced with

(1) Paper IX in the series entitled "The Preparation of Phenylarsenoxides;" previous paper, THIS JOURNAL, **66**, 197 (1944).

(2) Eagle, Hogan, Doak and Steinman, *J. Pharmacol.*, **74**, 210 (1942).

(3) Doak, Steinman and Eagle, THIS JOURNAL, **66**, 194 (1944).

(4) Maschmann, *Ber.*, **57**, 1759 (1924).

(5) Karrer, *ibid.*, **48**, 1058 (1915).

(6) Cohen, King and Strangeways, *J. Chem. Soc.*, 3236 (1931).

(7) Jacobs, Heidelberger and Rolf, THIS JOURNAL, **40**, 1580 (1918).

(8) Doak, Steinman and Eagle, *ibid.*, **63**, 99 (1941).

TABLE I

DERIVATIVES OF NITRO- AND AMINOBENZOIC ACIDS

Compound: Benzoic acids or acid salts R = arsono R′ = nitro	Description	M. p., °C.	Yield, %	Formula	As analyses, % Calcd.	As Found	N analyses, % Calcd.	N Found
3-R-2-R′-, acid Na salt	Rectangular plates	228 .	49	$C_{14}H_{11}As_2N_2NaO_{14}$[a]	24.8	24.6	4.64	[b]
4-R-2-R′-, acid K salt[c]	Rectangular prisms	Sinters 319	42	$C_{14}H_{11}As_2N_2KO_{14}$	24.2	24.6	4.52	4.52
2-R-6-R′-	Needles	305 dec.	29	$C_7H_8AsNO_7$	25.8	26.0	4.81	4.68
2-R-3-R′-	Needles	[d]	59	$C_7H_8AsNO_7 \cdot H_2O$[e]	24.2	24.1	4.53	4.44
4-R-3-R′-	Hexagonal plates	244–245[n]	49	$C_7H_8AsNO_7 \cdot H_2O$[f]	24.2	24.1	4.53	4.50
3-R-5-R′-, acid K salt	Prisms.	>360	52	$C_{14}H_{11}As_2KN_2O_{14}$[g]	24.2	24.0	4.52	4.46
2-R-5-R′-[h]	Needles	331 dec.	63	$C_7H_8AsNO_7$	25.8	26.0	4.81	4.90
2-R-4-R′-, Na salt	Needles	>360	62	$C_7H_8AsNNaO_7 \cdot H_2O$[i]	22.6	22.7	4.23	4.22
2-R-4-R′-	Needles	344.5	100[j]	$C_7H_8AsNO_7$	25.8	26.0	4.81	4.84
3-R-4-R′-	Cubes	240.5–241.5	53	$C_7H_8AsNO_7 \cdot H_2O$[k]	24.2	24.2	4.53	4.41
R = arsono R′ = amino								
3-R-2-R′-, acid Na salt[l]	Rectangular plates or needles	256.5	45	$C_{14}H_{15}As_2N_2NaO_{10} \cdot H_2O$[m]	26.6	26.6	4.98	4.94
4-R-2-R′-[l,c]	Rectangular prisms	>360	88	$C_7H_8AsNO_5$	28.7	28.8	5.37	5.22
5-R-2-R′-[l,c]	Needles	246–248 dec.	75	$C_7H_8AsNO_5 \cdot H_2O$	26.9	26.7	5.02	5.13
2-R-6-R′-	Needles	>360	48	$C_7H_8AsNO_5$	28.7	28.6	5.37	5.26
2-R-3-R′-	Rectangular prisms	>360	45	$C_7H_8AsNO_5$	28.7	28.5	5.37	5.20
4-R-3-R′-[l]	Needles	>360	57	$C_7H_8AsNO_5$	28.7	28.6	5.37	5.21
3-R-5-R′-	Needles	240[n]	59	$C_7H_8AsNO_5$	28.7	28.7	5.37	5.11
2-R-5-R′-[c]	Plates	>360	72	$C_7H_8AsNO_5$	28.7	28.8	5.37	5.36
2-R-4-R′-	Needles	>360	83	$C_7H_8AsNO_5$	28.7	28.3	5.37	5.26
3-R-4-R′-	Needles	>360	67	$C_7H_8AsNO_5$	28.7	29.0	5.37	5.34
R = dichloroarsino R′ = amino hydrochloride								
3-R-2-R′-	Needles	124–124.5	99	$C_7H_7AsCl_2NO_3 \cdot H_2O$	22.3	22.6	4.16	4.15
4-R-2-R′-[c]	Rectangular prisms	195	90	$C_7H_7AsCl_2NO_3$	23.5	23.3	4.40	4.29
5-R-2-R′-	Rectangular prisms	120–121	60	$C_7H_7AsCl_2NO_3$	23.5	23.1	4.40	4.29
2-R-6-R′-	Plates	176,[n] 195	93	$C_7H_7AsCl_2NO_3$	23.5	23.2	4.40	4.33
2-R-3-R′-	Needles	Sinters 149–150	47	$C_7H_7AsCl_2NO_3$	23.5	23.9	4.40	4.56
4-R-3-R′-	Needles	220[n]	96	$C_7H_7AsCl_2NO_3$	23.5	23.2	4.40	4.46
3-R-5-R′-	Needles	221–222	87	$C_7H_7AsCl_2NO_3 \cdot H_2O$	22.3	22.1	4.16	4.19
2-R-5-R′-[c]	Rectangular prisms	187,[n] 219	80	$C_7H_7AsCl_2NO_3 \cdot H_2O$	22.3	22.0	4.16	4.19
2-R-4-R′-	Plates	191.5	98	$C_7H_7AsCl_2NO_3$	23.5	23.2	4.40	4.42
3-R-4-R′	Needles	215[n]	90	$C_7H_7AsCl_2NO_3 \cdot 2H_2O$	21.1	21.3	3.95	3.95
R = arsenoso R′ = amino								
3-R-2-R′-	Amorphous	188–189	70	$C_7H_8AsNO_3 \cdot H_2O$	30.6	30.2	5.72	5.63
4-R-2-R′-	Amorphous	>360	95	$C_7H_8AsNO_3$	33.0	33.0	6.17	6.16
2-R-6-R′-	Amorphous	214	81	$C_7H_8AsNO_3 \cdot H_2O$	30.6	30.8	5.72	5.88
2-R-3-R′-	Needles	151–152	78	$C_7H_8AsNO_3$	33.0	32.8	6.17	6.16
4-R-3-R′-	Amorphous	225–226[n]	98	$C_7H_8AsNO_3 \cdot H_2O$	30.6	31.0	5.72	5.82
2-R-5-R′-	Rectangular plates	205[n], 239–240 dec.	42	$C_7H_8AsNO_3 \cdot H_2O$	30.6	31.0	5.72	5.85
2-R-4-R′-[l,p]	Rectangular plates	167	85	$C_7H_8AsNO_3 \cdot H_2O$	30.6	30.7	5.72	5.72
3-R-4-R′-	Amorphous	221–222	77	$C_7H_8AsNO_3 \cdot H_2O$	30.6	30.5	5.72	5.79

[a] Na calcd.: 3.81. Found: Na, 3.77. [b] Both Kjeldahl and Dumas procedures gave low and erratic analyses with this compound. [c] Previously reported by Cohen, King and Strangeways, ref. 6. [d] This compound exploded violently between 280 and 295°. [e] H_2O calcd.: 5.82. Loss at 100°: 4.79. [f] H_2O calcd.: 5.82. Loss at 100°: 5.98. [g] K calcd.: 6.31. Found: K, 6.74. [h] Previously reported by Karrer, ref. 5. [i] Na calcd.: 6.95. Found: Na, 7.27. [j] Yield based on conversion from the sodium salt. [k] H_2O calcd.: 5.82. Loss at 100°: 6.09. [l] Fluoresces in aqueous solution. [m] Na calcd.: 4.09. Found: Na, 4.00. [n] Melting point by the procedure of Morgan and Hamilton, ref. 13. [o] Previously reported by Doak, Steinman and Eagle, ref. 3. [p] Previously reported by Doak, Steinman and Eagle, THIS JOURNAL, **63**, 99 (1941).

Raney nickel, following the method of Stevinson and Hamilton.[9]

To obtain the aminoarsenosobenzoic acids, the aminoarsonobenzoic acids were reduced in concentrated hydrochloric acid solution with sulfur dioxide and hydriodic acid to the dichloroarsines, which were then hydrolyzed with sodium bicarbonate solution. 3-Amino-5-arsenosobenzoic acid could not be obtained by this procedure and the amount of arsonic acid available was insufficient for further investigation. 2-Amino-5-dichloroarsinobenzoic acid hydrochloride proved unstable in aqueous solution, arsenic being cleaved from the ring, so that we were unable to obtain the desired 2-amino-5-arsenosobenzoic acid.

(9) Stevinson and Hamilton, THIS JOURNAL, **57**, 1298 (1935).

Experimental Part

The aminonitrobenzoic acids were all prepared in this Laboratory by procedures given in the literature.

5-Nitro-*m*-toluenearsonic Acid.—The Bart reaction applied to 5-nitro-*m*-toluidine gave a 10% yield of this arsonic acid. The procedure followed was similar to that employed by Karrer[10] for the preparation of *o*-toluenearsonic acid. The method of Palmer and Adams[11] gave a similarly low yield (11%). The compound crystallized from water in pale yellow needles; m. p. 307°.

Anal. Calcd. for $C_7H_8AsNO_5$: As, 28.7, N, 5.37. Found: As, 28.6; N, 5.49.

2-Arsono-3-nitrobenzoic Acid.—6-Nitro-*o*-toluenearsonic acid[7] (26.1 g.) was dissolved in 500 ml. of 0.5 *N* potassium hydroxide in a 3-neck flask equipped with stirrer, reflux condenser and dropping funnel. The solu-

(10) Karrer, *Ber.*, **48**, 305 (1915).

(11) Palmer and Adams, THIS JOURNAL, **44**, 1356 (1922).

tion was refluxed gently and 35 g. of potassium permanganate, dissolved in 2 liters of water, added over a five-day period. The hot mixture was filtered and the residual manganese dioxide washed with hot water. The filtrate and washings were evaporated to a volume of 1 liter and acidified to congo red with hydrochloric acid. The small amount of precipitate which formed on standing consisted mainly of unoxidized nitrotoluenearsonic acid. It was removed by filtration and the filtrate evaporated to a volume of 100 ml. The desired arsonic acid crystallized from the solution and was purified by several recrystallizations from hot water.

3-Arsono-5-nitrobenzoic Acid, Acid Potassium Salt.—The procedure was similar to that described for the preceding compound. An aqueous solution of 8 g. of potassium permanganate was added to an aqueous solution of 5 g. of 5-nitro-*m*-toluenearsonic acid over an eight-hour period. The reaction mixture was warmed on the water-bath for eighteen hours, filtered, and the filtrate concentrated to 25 ml. The acid salt precipitated when this solution was acidified to congo red with hydrochloric acid. It was recrystallized from hot water.

2-Arsono-4-nitrobenzoic Acid.—The following procedure illustrates the general method that was employed for the preparation of the remaining six arsononitrobenzoic acids. 4-Nitroanthranilic acid (37 g.) was triturated with 200 ml. of concentrated hydrochloric acid, 100 ml. of water added, and the paste diazotized at 0–5°. A clear solution resulted.[12] A solution of 39.6 g. of arsenic trioxide in 80 ml. of 5 *N* sodium hydroxide was then added, dropwise, to the cold diazo solution, followed by the addition of 10 *N* sodium hydroxide until the mixture was faintly acid to congo red. The mixture was cooled overnight in the ice box and the precipitate which formed removed by filtration. This was dissolved in sodium bicarbonate solution, the solution filtered, and the filtrate acidified to congo red. The monosodium salt of the desired arsonic acid precipitated from solution. It was recrystallized twice from water. The free acid was obtained by recrystallizing this salt first from 2 *N* hydrochloric acid and finally from water.

4-Amino-2-dichloroarsinobenzoic Acid Hydrochloride.—4-Amino-2-arsonobenzoic acid (5 g.), prepared from the preceding compound by reduction with Raney nickel, was dissolved in 30 ml. of concentrated hydrochloric acid, 2 drops of 10% potassium iodide added, and reduced with sulfur dioxide. The crystalline precipitate which formed was washed with concentrated hydrochloric acid and recrystallized by dissolving in the minimum amount of water and adding concentrated hydrochloric acid. It was dried *in vacuo* over sodium hydroxide.

4-Amino-2-arsenosobenzoic Acid.—Ice-cold saturated sodium bicarbonate solution (15 ml.) was added dropwise to 3 g. of the above dichloroarsine. The resulting solid was washed with cold water until free from chlorides, and recrystallized from water. A similar procedure was employed for the preparation of the other seven arsenoso compounds.

The table lists the compounds prepared. We have included several compounds prepared by other workers or previously reported from this Laboratory in order to permit comparison of all the isomeric compounds in each class. Melting points were taken by the method described in paper VI of this series.[13] The method for taking melting points recently suggested by Morgan and Hamilton[14] was also used, and where the results by the two methods differed they are so indicated in the table. The arsononitrobenzoic acids were extremely stable substances, and vigorous and prolonged digestion was necessary in order to decompose these substances prior to analysis. With one compound, however, we were unable to obtain satisfactory analyses (ref. *b* to Table I).

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Summary

The preparation of isomeric arsononitro-, aminoarsono-, aminodichloroarsino- and aminoarsenosobenzoic acids is described. Evidence is presented which indicates that some of the previous descriptions of arsononitrobenzoic acids are incorrect. Analytical and descriptive data for nine arsononitro-, ten aminoarsono-, ten aminodichloroarsino- and eight aminoarsenosobenzoic acids are presented in tabular form.

(12) In a few instances it was necessary to filter the solutions since several of the aminonitrobenzoic acids could not be diazotized completely even with an excess of sodium nitrite solution.

(13) Steinman, Doak and Eagle, THIS JOURNAL, **66**, 192 (1944).

(14) Morgan and Hamilton, *ibid.*, **66**, 874 (1944).

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The Preparation of Ethyl α-Chloro- and α-Bromo-β,β-diethoxypropionates, and their Behavior in the Reformatsky and Darzens Reactions[1]

BY WILLIAM OROSHNIK[2] AND PAUL E. SPOERRI

In view of the fact that α-formylcarboxylic esters are hydrolyzed and decarboxylated on heating with water or dilute acids,[3-6] it might be expected that similar treatment of α-formylalkylideneacetic esters would yield α,β-unsaturated aldehydes. Since α-formylalkylideneacetic esters have never been reported in the literature, it was considered of interest to investigate their preparation.

Knoevenagel condensations were attempted with formylacetic ester and aldehydes and ketones, but in no instance could the desired reaction be effected. The self-condensation of formylacetic ester to formylglutaconic and trimesic esters and undistillable tars took place preferentially.[7] In order to prevent self-condensation,

(1) This work is abstracted from the Dissertation of William Oroshnik presented in partial fulfillment of the requirements for the degree of Doctor of Philosophy at the Polytechnic Institute of Brooklyn, June, 1944.

(2) Present address: Ortho Research Foundation, Linden, New Jersey.

(3) Tschitschibabin, *J. prakt. Chem.*, [2] **73**, 331 (1906).

(4) Wislicenus, *Ber.*, **20**, 2932 (1887).

(5) Wislicenus, Boklen and Reutke, *Ann.*, **368**, 347 (1908).

(6) Claisen, *ibid.*, **297**, 26 (1897).

(7) After this work had been completed, the report of Cogan (*Chem. Abs.*, **36**, 1301 (1942)) appeared describing unsuccessful attempts to effect aldol condensations between formylacetic ester and formaldehyde and acetaldehyde. He likewise found the products of self-condensation of formylacetic ester to preponderate.