n-Butoxyacetaldehyde.—$d^{25}{}_4$ 0.9199; n^{25}D 1.4148; *MR* (calcd.) 31.56; (obsd.) 31.59; semicarbazone m. p. 100° (cor.). *Anal.* Calcd. for $C_7H_{15}O_2N_3$: N, 24.24. Found: N, 24.21.

Isobutoxyacetaldehyde.—$d^{25}{}_4$ 0.9214; n^{25}D 1.4080; *MR* (calcd.) 31.56; (obsd.) 31.09; semicarbazone m. p. 136° (cor.). *Anal.* Calcd. for $C_7H_{15}O_2N_3$: N, 24.24. Found: N, 24.39.

Phenoxyacetaldehyde.—Semicarbazone m. p. 146° (cor.) (literature[2] 145°); 2,4-dinitrophenylhydrazone m. p. 138° (cor.).

Oxidations Using Periodic Acid.—One-half mole of the ether (either glycerol α-methyl or α-ethyl ether) was added dropwise to a solution of 0.50 mole of potassium periodate and 12 g.[6] of sulfuric acid in 400 ml. of water in a 1-liter three-neck flask. The mixture was vigorously stirred during the addition of the ether and for two hours after addition was complete. The temperature was maintained between 25–30°. The mixture was then filtered to remove the precipitated potassium iodate. The filtrate was neutralized to a methyl red end-point with sodium hydroxide; then sufficient barium chloride was added to remove the iodate and the sulfate ions as barium salts. It is necessary to remove the iodate ion to prevent further oxidation of the product during subsequent distillation.

With methoxyacetaldehyde, the filtrate, after removal of the barium salts, was distilled through an 18-inch helix packed column and a 50-ml. fraction boiling 88–98.5° obtained. This fraction was refractionated through a 4 ft. helix packed column and 21.5 g. of the azeotrope with water (88–89°) was obtained. This represents a yield of 51% since the azeotrope contains 12.8% water.[8] With ethoxyacetaldehyde the filtrate gave, without redistillation, 22.5 g. of a water azeotrope boiling 90–91°. This represents a yield of 40% since the azeotrope contains 21.8% water.[3]

The methoxyacetaldehyde gave a 2,4-dinitrophenylhydrazone melting at 124°. The ethoxyacetaldehyde gave a 2,4-dinitrophenylhydrazone melting at 116°.

Summary

1. Methoxy- and ethoxyacetaldehydes have been prepared by the oxidation of the corresponding glycerol α-alkyl ethers using periodic acid.

2. n-Propoxy-, n-butoxy-, isobutoxy- and phenoxyacetaldehydes have been prepared by the oxidation of the corresponding glycerol α-alkyl ethers using lead tetraacetate, and several of their properties were determined.

3. Glycerol α-isobutyl ether was prepared and characterized.

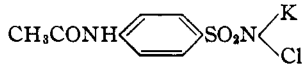
AUSTIN, TEXAS RECEIVED AUGUST 25, 1944

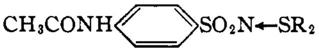
[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY OF THE UNIVERSITY OF ROCHESTER]

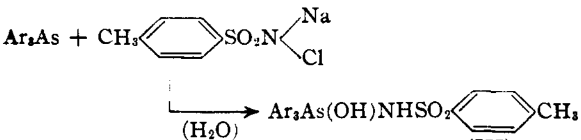
Arsinimines Derived from Sulfanilamide. The Condensation of Triaryl Arsines and Arsine Oxides with Sulfanilamide and its Derivatives

BY D. S. TARBELL AND JAMES R. VAUGHAN, JR.[1]

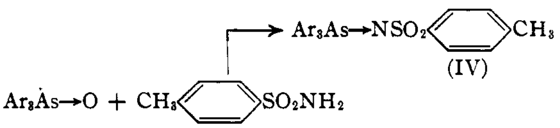
In a previous article[2] methods were described for the preparation of N^1-potassiochloro-N^4-acetylsulfanilamide (I) and similar compounds from N^4-acetylsulfanilamide, and it was found that compounds of this type would condense with organic sulfides to form sulfilimines (II). Furthermore, it has been reported by Mann[3] that triarylarsines and their oxides condense with chloramine-T and p-toluenesulfonamide, respectively, to yield the corresponding arsinimines, either in the hydrated form (III) or as the anhydrous arsinimines (IV).


I


II

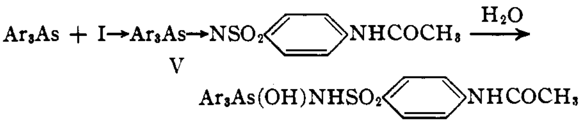

(III)

or


(IV)

In view of the possible bacteriological importance of compounds of this type, we have prepared a number of arsinimines derived from sulfanilamide by these general methods. Results from tests on these compounds for both arsenic and sulfanilamide type effects will be reported elsewhere.

Two methods of preparation were used. In the first method, triarylarsines were condensed with I under mild conditions in anhydrous solvents to yield the corresponding arsinimines (V) which were usually isolated in the hydrated form (VI) under the conditions of the reaction. In only one case, using tri-p-tolylarsine, was the arsinimine (VII) isolated in the anhydrous form. With triphenylarsine or tri-o-tolylarsine, only the hydrated arsinimines (VIII and IX) were obtained.


V

VI

VII, Ar = p-$CH_3C_6H_4$

VIII, Ar = C_6H_5

IX, Ar = o-$CH_3C_6H_4$

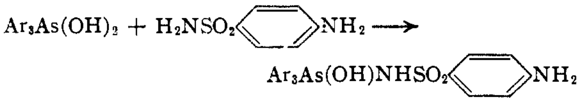
---

[1] Present address: American Cyanamid Company, Stamford, Connecticut.

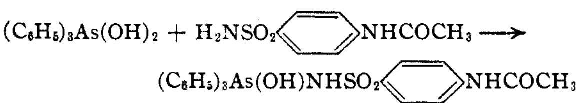
[2] Todd, Fletcher and Tarbell, THIS JOURNAL, **65**, 350 (1943).

[3] (a) Mann, *J. Chem. Soc.*, 958 (1932); (b) Mann and Chaplin, *ibid.*, 527 (1937).

In the second method, arsinimines of type VI were prepared directly by condensation of the hydrated triarylarsine oxides (also called arsine dihydroxides) with N^4-acetylsulfanilamide or sulfanilamide itself.



X, Ar = p-$CH_3C_6H_4$
XI, Ar = o-$CH_3C_6H_4$
XII, Ar = C_6H_5



XIII

In several instances, however, condensation failed to take place although it was anticipated by analogy with other compounds. Thus, both tri-p-tolylarsine dihydroxide and its o-isomer failed to condense with N^4-acetylsulfanilamide, although they condensed with sulfanilamide, yielding X and XI. Triphenylarsine dihydroxide, however, condensed with both sulfanilamide and its N^4-acetyl derivative to yield XII and XIII, respectively.

The stability toward hydrolysis of the arsinimines derived from sulfanilamide was investigated using tri-o-tolylarsinehydroxy-p-acetylaminobenzenesulfonamide (IX). This compound was found to be stable toward dilute alkali, but was cleaved readily by 5% hydrochloric acid to yield acetic acid (not isolated), sulfanilamide and tri-o-tolylarsine hydroxychloride (XIV). This compound was identified by its conversion to tri-o tolylarsine dihydroxide and its preparation from the dihydroxide and hydrochloric acid. The stability of this arsinimine to dilute alkali and its rapid hydrolysis by dilute acid recalls the similar behavior of sulfilimines derived from p-toluenesulfonamide.[4] It is in contrast, however, to the behavior of sulfilimines derived from sulfanilamide, which were found to be cleaved readily by both dilute acids and bases.[2]

The compounds were tested *in vitro*, through the kindness of Dr. R. O. Roblin, Jr., and Dr. H. J. White of the American Cyanamid Company. They showed no or very slight trypanocidal activity, although the tests were hampered by the very slight water-solubility of the compounds.

Experimental

Analytical Procedures.—Satisfactory carbon and hydrogen values were obtained by adding a 4–6 cm. section of copper oxide to the usual combustion tube packing.[5]

Arsenic was determined by decomposing a 0.20–0.25 g. sample by heating with 5 cc. each of concentrated nitric and sulfuric acids in a Kjeldahl flask. After boiling for one hour, the same amount of mixed acid was added and the boiling continued for a second hour. The mixture was then cooled and washed into an Erlenmeyer flask with 100 cc. of water; 25 cc. of 10% urea solution was added and the solution boiled for ten minutes. Then 20 cc. of 20% potassium iodide solution was added, the mixture cooled, and the iodine titrated with thiosulfate solution.

This method gave good results on a number of organic arsenicals, but with triarylarsines the results were consistently 5% low; the procedure was standardized using tri-o-tolylarsine and a correction factor employed. Compounds containing free amino groups on the ring, which are described in a later paper, gave better values if the correction factor was omitted; this was verified using arsanilic acid. Doubtless the amino groups ensure the complete decomposition of the molecule.

Nitrogen was determined by a modified Kjeldahl method, using as the oxidizing medium 25 cc. of glacial acetic acid, to which was added dropwise 10 cc. of a mixture containing 50% chromium trioxide, 25% glacial acetic acid and 25% water.

Triphenylarsine Dihydroxide.—This product, prepared in 82% yield from triphenylarsine[6] by the method of Philips,[7] had the m. p. 114–117°.

Tri-o-tolylarsine, prepared from arsenic trichloride and o-tolylphenylmagnesium bromide, was obtained in 39% yield, after three recrystallizations from alcohol, m. p. 108–110°. The reported[3a] m. p. is 108–109°.

Tri-p-tolylarsine, prepared by the same method, was obtained in 46% yield after recrystallization from 1:1 benzene–alcohol, m. p. 147–148°. It is advantageous in this preparation to extract the Grignard reaction mixture with benzene instead of ether, because the product is sparingly soluble in the latter. The reported[8] m. p. is 146°.

Tri-p-tolylarsine dihydroxide was obtained in 92% yield by the above method,[7] m. p. 93–95°.[9]

Tri-o-tolylarsine Dihydroxide.—This product was prepared from tri-o-tolylarsine in 68% yield by the method of the preceding paragraph. The m. p. of the product, 125–126°, was unchanged by recrystallization from dioxane.

Anal. Calcd. for $C_{21}H_{23}AsO_2$: C, 65.97; H, 6.06; As, 19.59. Found: C, 66.05; H, 6.48; As, 19.37.

Tri-o-tolylarsinehydroxy-p-acetylaminobenzenesulfonamide (IX).—A mixture of 2 g. of tri-o-tolylarsine and 1.64 g. of N'-potassiochloro-N^4-acetylsulfanilamide[1] (I) in 30 cc. of purified, anhydrous dioxane was refluxed for about fifteen minutes. The solution was concentrated to 10 cc., the precipitated potassium chloride filtered off, and the filtrate cooled. The crystals (2.80 g., 88%, m. p. 138–143° with dec.) obtained were recrystallized from 25 cc. of a 2:1 dioxane–alcohol mixture, giving 2.00 g. (63%) of product, which, after drying two weeks *in vacuo* over sulfuric acid, melted at 215–217° with dec.

Anal. Calcd. for $C_{29}H_{31}AsN_2O_4S$: C, 60.20; H, 5.41; N, 4.84; As, 12.95. Found: C, 60.33; H, 6.17; N, 4.82; As, 12.81.

Tri-p-tolylarsine-p-acetylaminobenzenesulfonylimine (V).—By the same procedure, 8.76 g. of tri-p-tolylarsine and 7.17 g. of N'-potassiochloro-N^4-acetylsulfanilamide in dioxane yielded 7.60 g. (54%) of product of m. p. 150–155° with dec. Recrystallization from 20 cc. of dioxane yielded 4.58 g. of product, which melted at 179–180° with dec. after drying at 85° for a day.

Anal. Calcd. for $C_{29}H_{29}AsN_2O_3S$: C, 62.14; H, 5.22; N, 5.00; As, 13.36. Found: C, 61.81; H, 5.55; N, 5.20; As, 13.45.

Triphenylarsinehydroxy-p-aminobenzenesulfonamide (XII).—A mixture of 2.00 g. of triphenylarsine dihydroxide and 1.00 g. of sulfanilamide in 10 cc. of dioxane was heated just under the boiling point for about ten minutes. The

---

[4] Tarbell and Weaver, This Journal, **63**, 2939 (1941).

[5] We are indebted to Dr. Carl Niemann of The California Institute of Technology for his helpful advice on this point. Carbon-hydrogen analyses by C. J. Claus and W. A. Gleich.

[6] Pfeiffer, *Ber.*, **37**, 4621 (1904).

[7] Philips, *ibid.*, **19**, 1031 (1886); Michaelis, *Ann.*, **321**, 164 (1902), gives the melting point as 115–116°.

[8] Michaelis, *Ann.*, **321**, 201 (1901); Sachs and Kantorowicz, *Ber.*, **31**, 2769 (1908).

[9] Michaelis (*Ann.*, **321**, 203 (1902)) reports 96°.

hot solution was filtered and, on cooling, 2.19 g. (79%) of light orange crystals separated, m. p. 151–155° with dec. Recrystallization from 5 cc. of dioxane yielded 1.79 g. (63%) of product which, after drying several days *in vacuo* over sulfuric acid, melted at 163–164° with dec.

Anal. Calcd. for $C_{24}H_{23}AsN_2O_3S$: C, 58.30; H, 4.69; N, 5.67; As, 15.15. Found: C, 58.29; H, 4.35; N, 5.54; As, 15.15.

Tri-*p*-tolylarsinehydroxy-*p*-aminobenzenesulfonamide (X).—This product was obtained by the above method in 63% yield, from tri-*p*-tolylarsine dihydroxide and sulfanilamide. The product was recrystallized from 10 cc. of dioxane and dried over sulfuric acid, then a day at 85°; m. p. 149–150° with dec.

Anal. Calcd. for $C_{27}H_{29}AsN_2O_3S$: C, 60.44; H, 5.45; N, 5.22. Found: C, 60.17; H, 5.42; N, 4.88.

Tri-*o*-tolylarsinehydroxy-*p*-aminobenzenesulfonamide (XI).—This compound was prepared from tri-*o*-tolylarsine dihydroxide and sulfanilamide; after recrystallization from dioxane and drying over sulfuric acid *in vacuo*, it melted at 186–187°.

Anal. Calcd. for $C_{27}H_{29}AsN_2O_3S$: C, 60.44; H, 5.45; N, 5.22; As, 13.96. Found: C, 60.20; H, 5.60; N, 5.07; As, 14.03.

Triphenylarsinehydroxy-*p*-acetylaminobenzenesulfonamide (VIII).—Triphenylarsine dihydroxide and N^4-acetylsulfanilamide condensed in boiling dioxane to yield 86% of product, m. p. 148–153° with dec. Recrystallization from dioxane yielded material of m. p. 158–159° with dec.

Anal. Calcd. for $C_{26}H_{25}AsN_2O_4S$: C, 58.21; H, 4.70; N, 5.22; As, 13.96. Found: C, 58.13; H, 4.71; N, 5.47; As, 14.25.

Attempted Condensations: Tri-*p*-tolylarsine dihydroxide and acetylsulfanilamide failed to condense in boiling dioxane; both starting materials were recovered. The reaction was also unsuccessful in acetic anhydride solution.

Tri-*o*-tolylarsine dihydroxide failed to condense with acetylsulfanilamide in boiling dioxane.

Hydrolysis of Tri-*o*-tolylarsinehydroxy-*p*-acetylaminobenzenesulfonamide (IX).—The compound was unchanged by heating on the steam-bath for thirty minutes in 5% sodium hydroxide.

A 0.5-g. sample was heated for thirty minutes on the steam-bath with 5% hydrochloric acid, which gave a clear solution. On standing overnight, large white crystals of **tri-*o*-tolylarsine hydroxychloride (XIV)**, m. p. 222–225°, separated. This product was synthesized as described below. After neutralizing the filtrate from this compound with sodium hydroxide, a small amount of material was obtained by ether extraction and recrystallization from dilute alcohol. This was shown to be sulfanilamide by mixed m. p. determination with an authentic sample.

Tri-*o*-tolylarsine Hydroxychloride (XIV).—A suspension of 1.0 g. of tri-*o*-tolylarsine dihydroxide in 20 cc. of 5% hydrochloric acid was warmed on the steam-bath until solution was complete. After filtration and cooling a few drops of concentrated hydrochloric acid were added to promote crystallization; the product (0.88 g., 84%) separated as well-formed colorless crystals, m. p. 224–226°. This product was shown to be identical by mixed m. p. with that formed by hydrolysis of the arsinimine IX. The compound is only slightly soluble in cold water, very soluble in alcohol, and gives a positive test for chloride ion.

Anal. Calcd. for $C_{21}H_{22}ClAsO$: C, 62.93; H, 5.53; As, 18.69. Found: C, 61.94; H, 5.76; As, 18.32.

Summary

1. Triphenylarsine and tri-*o*-tolylarsine have been condensed with N^1-potassiochloro-N^4-acetylsulfanilamide to yield the corresponding hydrated arsinimines, while tri-*p*-tolylarsine yields the unhydrated arsinimine.

2. Several triarylarsine dihydroxides (arsine oxide hydrates) have been condensed with sulfanilamide or N^4-acetylsulfanilamide to yield hydrated arsinimines.

3. Tri-*o*-tolylarsinehydroxy-*p*-acetylaminobenzenesulfonamide is much more stable to alkaline than to acidic hydrolysis; the latter leads to sulfanilamide and tri-*o*-tolylarsine hydroxychloride, which has been synthesized and characterized.

ROCHESTER, NEW YORK RECEIVED AUGUST 15, 1944

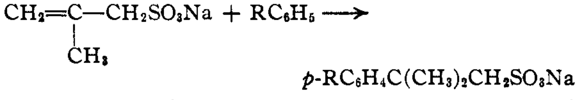
[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF NORTHWESTERN UNIVERSITY]

The Condensation of Sodium 2-Methyl-2-propenesulfonate with Aromatic Hydrocarbons

BY S. ARCHER,[1] J. D. MALKEMUS[2] AND C. M. SUTER[1]

A convenient preparation and the proof of structure of sodium 2-methyl-2-propenesulfonate were presented in a previous paper.[3] In this communication there is described the reaction of this salt with aromatic hydrocarbons.

The catalytic alkylation of aromatic substances with olefinic compounds has been thoroughly investigated in recent years. Catalysts which have been used successfully to effect such condensations include aluminum chloride, sulfuric acid, boron fluoride and hydrogen fluoride.[4,5] It has now been found that the reaction



$$CH_2{=}\underset{\displaystyle CH_3}{\underset{|}{C}}{-}CH_2SO_3Na + RC_6H_5 \longrightarrow p\text{-}RC_6H_4C(CH_3)_2CH_2SO_3Na$$

may be carried out in the presence of sulfuric acid or, better, with boron fluoride–sulfuric acid as the condensing agent.

Thus, when a suspension of sodium 2-methyl-2-propenesulfonate in excess toluene is stirred with sulfuric acid at low temperatures, there may be

---

[1] Present address: Winthrop Chemical Company, Inc., Rensselaer, N. Y.

[2] Present address: Colgate-Palmolive-Peet Company, Jersey City, N. J.

[3] Suter, Malkemus and Archer, THIS JOURNAL, 63, 1594 (1941).

[4] Thomas, "Anhydrous Aluminum Chloride in Organic Chemistry," Reinhold Publishing Company, New York, N. Y., 1941.

[5] Ipatieff, Pines and Schmerling, *J. Org. Chem.*, 5, 253 (1940), give a sizable bibliography.