3. It gives a practically pure product, in large yields, with ease.

II. A method has also been described for the preparation of secondary arsanilic acid, di-*p*-aminophenylarsinic acid. It has the following advantages:

1. It is practically free from the primary arsanilic acid.
2. (*a*) No concentration of the mother liquid is required, and
   (*b*) no expensive apparatus nor materials are needed.
3. It gives a practically pure product, in large yields, with ease.

III. The theoretical considerations have been briefly described.

[CONTRIBUTION FROM THE LABORATORIES OF THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH.]

ON CERTAIN AROMATIC AMINES AND CHLOROACETYL DERIVATIVES.

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The compounds described in the present paper represent intermediates in the preparation of a number of aromatic arsenic compounds which are included in a series of papers now being prepared for publication. It is desired to record these intermediates separately in order not to encumber the final papers with descriptions of non-arsenical compounds. It is also hoped that many of these substances, as well as the methods employed in their preparation, may prove of sufficient intrinsic interest to justify the present paper on general grounds.

Experimental.

o-Chloroacetylaminophenol.—This substance was first obtained by Aschan[1] and later by the present authors.[2] More recent experiments have shown the following method to be most suitable for the preparation of this compound: 22 g. *o*-aminophenol are dissolved in 250 cc. of dry acetone, the solution is then chilled, and treated drop by drop, with stirring, with 8.5 cc. (1 mol.) chloroacetyl chloride. 75 cc. 2 *N* aqueous sodium hydroxide are then added in one portion and the mixture further treated with 8.5 cc. chloroacetyl chloride. After acidifying to congo-red with hydrochloric acid the mixture is concentrated to dryness *in vacuo* and the residue suspended in water, filtered off, washed with water, and recrystallized from 50% alcohol. The yield was 31 g., melting at 138–40°.

o-Chloroacetylaminophenyl Acetate.—On adding a drop of concentrated sulfuric acid to a mixture of 2.5 g. *o*-chloroacetylaminophenol and 5 cc. acetic anhydride a clear solution was at once obtained. After warming on the water bath for ten minutes the solution was cooled, treated

[1] *Ber.*, **20**, 1524 (1887).

[2] *J. Biol. Chem.*, **21**, 131 (1915).

with water, and the resulting crystals recrystallized from 85% alcohol and benzene. The melting point was then constant at 113.5–114.5°, with preliminary softening. The acetate is sparingly soluble in the cold in acetic acid, benzene, or absolute alcohol, readily on heating, and dissolves with difficulty in ether.

0.1791 g. subst. (Kjeldahl); 7.9 cc. 0.1 *N* HCl.
Calc. for $C_{10}H_{10}O_3NCl$: N, 6.18%. Found: N, 6.16%.

2-Methyl-5-chloroacetylaminophenol.—20 g. 2-methyl-5-aminophenol (from monoacetyltoluylenediamine, by diazotization and boiling in the usual way) were dissolved in a mixture of 100 cc. each of acetic acid and saturated sodium acetate solution, chilled in ice-water, and treated with 19.5 cc. chloroacetyl chloride.[1] The chloroacetyl derivative separated at the end and was filtered off after the addition of an equal volume of water and allowing the mixture to stand one-half hour. The yield was 27.6 g. For analysis a portion was recrystallized successively from 50% alcohol, toluene, and glacial acetic acid, separating as rhombic plates which melt constantly at 154–5° with preliminary softening. The substance is sparingly soluble in boiling water or chloroform, dissolving readily, however, in alcohol or acetone. It is very difficultly soluble in cold acetic acid but dissolves freely on boiling. An alkaline solution couples readily with diazotized sulfanilic acid.

0.1754 g. subst. (Kjeldahl); 8.70 cc. 0.1 *N* HCl.
Calc. for $C_9H_{10}O_2NCl$: N, 7.03%. Found: N, 6.95%.

4-Methyl-5-chloroacetylaminophenol. — The 4-methyl-5-aminophenol used as starting material was prepared from the corresponding nitrotoluidine by diazotization and reduction of the resulting nitrocresol by means of tin and hydrochloric acid. It melts at 157° as stated by Bamberger and Blangey,[2] not at 144.5° as given by other workers. 12 g. of the aminocresol were dissolved in a warm mixture of 60 cc. acetic acid and 60 cc. of saturated sodium acetate solution, chilled in ice-water and treated in the usual way with 11 cc. chloroacetyl chloride. At the end the chloroacetyl derivative crystallized out and the mixture was diluted with an equal volume of water, let stand one-half hour, and filtered. After recrystallization from 50 per cent. alcohol 11.7 g. of the compound were obtained as flat, grayish, narrow plates, melting at 148–51° with preliminary softening. After two further recrystallizations from toluene the compound forms practically colorless, silky needles, which melt constantly at 151–2.5° with preliminary softening. A mixture with the 2-methyl isomer softens above 120° and melts almost entirely at 126–7° to a liquid which clears at 145°. The chloroacetyl derivative is more soluble in the usual solvents than is its 2-methyl isomer and, in aqueous

[1] THIS JOURNAL, **39**, 1441 (1917).
[2] *Ann.*, **390**, 172, footnote (1912).

suspension, gives a violet color with ferric chloride. A solution in dilute sodium carbonate couples readily with diazotized sulfanilic acid.

0.1509 g. subst. (Kjeldahl); 7.35 cc. 0.1 *N* HCl.
Calc. for $C_9H_{10}O_2NCl$: N, 7.03%. Found: N, 6.82%.

1-Chloroacetylamino-2-naphthol.—24 g. 1-amino-2-naphthol were dissolved in 180 cc. of dry acetone, chilled, and treated with 6.6 cc. chloroacetyl chloride, subsequently adding 57 cc. 2 *N* NaOH and than another 6.6 g. chloroacetyl chloride as in the case of the *o*-chloroacetylaminophenol. The mixture was finally acidified to congo-red with hydrochloric acid and diluted with water. The dark, crystalline precipitate was washed with water and recrystallized from 95% alcohol, using boneblack. The yield was 23 g. of pure material, while an additional 6.0 g. of less pure substance were recovered by concentrating the alcoholic solution and recrystallizing the product so obtained. A portion of the main fraction was recrystallized again from a small volume of 95% alcohol, separating as thin, slightly yellowish, nacreous platelets which dissolve very sparingly in boiling water. The substance is somewhat soluble in alcohol at room temperature, more easily in acetone or hot chloroform. When rapidly heated to 190°, then slowly, it melts and decomposes at 192–3°, with slight preliminary softening. In alkaline solution hydrochloric acid is readily eliminated, with formation of the anhydride of 1-amino-2-naphthoxyacetic acid, which is precipitated on acidification.

0.2100 g. subst. (Kjeldahl); 8.95 cc. 0.1 *N* HCl.
Calc. for $C_{12}H_{10}O_2NCl$: N, 5.95%. Found: N, 5.97%.

1-Chloroacetylamino-4-naphthol.—47 g. 1-amino-4-naphthol were dissolved by warming gently in a mixture of 5 parts of glacial acetic acid and 5 parts of saturated soldium acetate solution. After chilling rapidly 30.5 cc. chloroacetyl chloride were dripped in with continued cooling. The solution was then acidified to congo-red and diluted with a large volume of water, 25 g. of the chloroacetyl derivative separating. Recrystallized successively from 50% alcohol, 50% acetic acid, and 95% alcohol it forms long, faintly purplish, silky needles which soften markedly at 175–80° and melt at 199.5–201.5° to a reddish liquid. The compound dissolves in boiling water, and is quite soluble at room temperature in alcohol or acetone, somewhat less easily in chloroform. An aqueous suspension gives a violet-blue color with ferric chloride.

0.2990 g. subst. (Kjeldahl); 12.4 cc. 0.1 *N* HCl.
Calc. for $C_{12}H_{10}O_2NCl$: N, 5.95%. Found: N, 5.99%.

2,4-Dichloro-5-acetaminophenol.—53 g. *m*-acetaminophenol (from the aminophenol and acetic anhydride in dilute acetic acid solution) were dissolved by warming gently with 10 parts of glacial acetic acid. Chlorine was then passed in with constant agitation, keeping the temperature at 15–20° until the increase in weight equaled 51 g. After standing for 15

minutes the thick, crystalline slurry was diluted with an equal volume of water and the dichloro compound filtered off. The yield was 46 g. Recrystallized first from 95% alcohol, then from acetic acid it forms long, silky needles which melt at 233–6° with preliminary softening. An aqueous suspension dissolves on adding dilute sodium carbonate, while the substance also dissolves in cold alcohol or acetone, less easily in boiling chloroform or acetic acid, and quite sparingly in boiling water.

0.1630 g. subst. (Kjeldahl); 7.6 cc. 0.1 *N* HCl.
Calc. for $C_9H_9O_2NCl_2$: N, 6.37%. Found: N, 6.52%.

2,4-Dichloro-5-aminophenol.—16.5 g. of the acetamino compound were boiled for about one and one-half hours with 5 parts of 1 : 1 hydrochloric acid. Solution occurred gradually, followed by precipitation of the hydrochloride of the amino compound. This was filtered off, washed with 1 : 1 hydrochloric acid, boneblacked in the minimum amount of hot water, and the base precipitated by adding sodium hydroxide to the filtrate. 10 g. of pure material were so obtained. Recrystallized from water, the aminophenol forms large, striated, barely cream-colored prisms which soften at 134°, melt slowly at 135–6°, and have a marked, unpleasant odor recalling that of *o*-nitrophenol. The base dissolves readily in alcohol, chloroform, or benzene; very easily in acetone or ether, and rather sparingly in cold water.

0.2305 g. subst. (Kjeldahl); 13.35 cc. 0.1 *N* HCl.
Calc. for $C_6H_5ONCl_2$: N, 7.87%. Found: N, 8.11%.

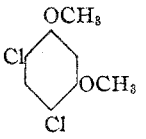
When the aminophenol is dissolved in hot 10% aqueous hydrochloric acid the hydrochloride separates on cooling as thick plates and rhombic prisms.

2,4-Dichloro-5-chloroacetylaminophenol.—This substance was prepared by the usual method,[1] using double the usual amount of 50% acetic acid and warming until the aminophenol dissolved before proceeding. The product separated immediately and was filtered off and washed with water. Recrystallized from 50% alcohol it separates as delicate, interlaced needles which melt slowly at 185.5–6.5° with preliminary softening. The compound dissolves readily in the cold in alcohol or acetone, less easily in ether or hot chloroform, and sparingly in the cold in acetic acid or toluene, dissolving readily in these solvents on boiling.

0.1748 g. subst. (Kjeldahl); 6.95 cc. 0.1 *N* HCl.
Calc. for $C_8H_6O_2NCl_3$: N, 5.50%. Found: N, 5.57%.

That the chlorine atoms in the three preceding compounds actually occupied the positions assigned to them is indicated by the series of reactions described below, by which a substance agreeing in its melting point and other properties with 4,6-dichlororesorcin dimethyl ether,

[1] *Loc. cit.*



was obtained.

2,4-Dichloro-5-acetanisidide (2,4-Dichloro-5-acetaminoanisol).—22 g. of 2,4-dichloro-5-acetaminophenol were dissolved in 100 cc. of normal potassium hydroxide solution and shaken with 10 cc. methyl sulfate, added in small portions. The solution became opalescent with the first portion and the ether suddenly crystallized out. The process was repeated with one-half the amounts of potassium hydroxide and methyl sulfate, after which the mixture was warmed and treated with ammonia to destroy the excess of methyl sulfate. After cooling and washing with water 18 g. of the ether were obtained. Recrystallized first from alcohol, then from toluene, it forms tufts of delicate needles which melt at 157.5–9.0° with slight preliminary softening. The substance dissolves in ether or benzene, less easily in toluene or alcohol in the cold. It is very easily soluble in chloroform and very difficultly so in boiling water.

0.2287 g. subst. (Kjeldahl); 9.85 cc. 0.1 *N* HCl.
Calc. for $C_9H_9O_2NCl_2$: N, 5.99%. Found: N, 6.03%.

2,4-Dichloro-5-anisidine (2,4-Dichloro-5-aminoanisol).—16.8 g. of the acetamino compound were boiled for one-half hour under a reflux with 120 cc. 1 : 1 hydrochloric acid, the sparingly soluble acetyl derivative going partly into solution and then being replaced by the amino hydrochloride. After cooling in the ice-box the salt was filtered off, suspended in water, and the base precipitated with sodium carbonate, separating as an emulsion which immediately crystallized. The product was filtered off, ground up in a mortar with dilute sodium carbonate solution, filtered, and washed with water. As sodium chloride was still present the crude base was dissolved in boiling 85% alcohol, boneblacked, and the filtrate cooled and diluted with cold water until the turbidity first formed just redissolved. On seeding the base slowly crystallized as cream-colored rhombs and prisms. By further dilution of the mother-liquors 11.3 grams were obtained in all. Recrystallized from ligroin (b. 80–90°) it melts at 50.5–1.5° (corr.) with slight preliminary softening. The base has a pronounced odor, greatly resembling that of α-naphthylamine. It is somewhat soluble in boiling water and dissolves readily in ether, benzene, chloroform, or alcohol at room temperature. When diazotized the compound couples with R-salt to form a sparingly soluble red dye.

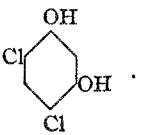
0.1502 g. subst. (Kjeldahl); 8.0 cc. 0.1 *N* HCl.
Calc. for $C_7H_7ONCl_2$: N, 7.30%. Found: N, 7.47%.

Constitution of 2,4-Dichloro-5-aminoanisol and Related Compounds—3 g. of the pulverized base were added to a warm mixture of 7.8 cc. water

and 5.2 cc. of concentrated sulfuric acid. The mixture was then diazotized at 10–15°, adding enough water to form a clear solution at the end. The solution was poured into a mixture of 60 cc. each of concentrated sulfuric acid and water and boiled for one hour under reflux. After standing overnight an equal volume of water and ice was added and the solution shaken with ether. The ether extract was dried over sodium sulfate and the solvent distilled off. The oily residue was then taken up in 20 cc. of normal aqueous potassium hydroxide, boneblacked, and the filtrate shaken with 1.6 cc. methyl sulfate. After the crystalline methyl ether had precipitated, an additional 10 cc. of normal potassium hydroxide solution and 8 cc. methyl sulfate were added and the mixture again shaken and finally warmed and treated with aqueous ammonia in order to decompose the excess of methyl sulfate. The yield of crude methyl ether was 1.2 grams. Recrystallized from ligroin and then from 85 per cent. alcohol it forms faintly yellowish needles and leaflets which melt at 117–8°.

0.1025 g. subst. (Carius); 0.1409 g. AgCl.
Calc. for $C_8H_8O_2Cl_2$: Cl, 34.25%. Found: Cl, 34.02%.

There is therefore little doubt that the substance is identical with the dichlororesorcin dimethyl ether melting at 118° obtained by Auwers and Pohl[1] both by chlorinating resorcin dimethyl ether and by methylating dichlororesorcin. The latter was prepared from resorcin and sulfuryl chloride, a method stated by Mettler[2] to give *para* derivatives only, and since this dichlororesorcin does not react with phthalic anhydride to give a fluorescein, *both para* positions are occupied, and the constitution is



From this follows the formula of the dimethyl ether, and the structure assigned above to the dichloro derivatives of *m*-aminophenol and *m*-anisidine.

2,4,6-Trichloro-3-acetaminophenol.—In the preparation of 2,4-dichloro-5-acetaminophenol it was observed that when the mother liquors were further diluted with about an equal quantity of water and allowed to stand overnight a deposit of rhombic crystals formed. When care was taken to shake the mixture continually during the addition of the chlorine in order to avoid a local excess of the gas to as great an extent as possible, only 7.4 g. of the rhombs, which proved to be the trichloro compound, were obtained, while if the mixture was not properly agitated, more formed at the expense of the dichloro compound. Recrystallized twice from 50% alcohol containing a few drops of acetic acid the trichloro derivative forms

[1] *Ann.*, **405**, 279 (1914).
[2] *Ber.*, **45**, 802 (1912).

grayish, rhombic plates containing one-half molecule of water of crystallization. The anhydrous substance melts at 184–6.5° with preliminary softening and dissolves in alcohol, acetone, or ethyl acetate and only sparingly in boiling toluene or chloroform. The compound is appreciably soluble in boiling water and the suspension formed on cooling gives a violet color with ferric chloride. A small portion was recrystallized again from toluene and separated as rosets and sheaves of minute, flat needles, which melt slowly at 185–6.5°, with preliminary softening.

0.8485 g. air-dry subst. *in vacuo* 1st at 80°, then 100° over H_2SO_4; loss, 0.0286 g.
Calc. for $C_8H_6O_2NCl_3.{}^1/_2H_2O$: H_2O, 3.41%. Found: H_2O, 3.37%.
0.4518 g. anhydrous subst. (Kjeldahl); 17.65 cc. 0.1 *N* HCl.
Calc. for $C_8H_6O_2NCl_3$: N, 5.51%. Found: N, 5.47%.

When hydrolyzed with boiling 1 : 1 hydrochloric acid and neutralized with sodium acetate the compound yields 2,4,6-trichloro-3-aminophenol, which separates from ligroin as cream-colored leaflets melting at 95–6°. The compound has a bromine-like odor and crystallizes from water in colorless, hair-like needles which have the properties ascribed to the substance by Daccomo.[1]

2-Bromo-5-aminophenol.—Heller[2] prepared this substance by a devious method involving the decomposition of *p*-nitrodiazobenzeneimide with sulfuric acid, conversion of the resulting 5-nitro-2-aminophenol into the 2-bromo compound by the Sandmeyer method, reduction of this with stannous chloride, isolation of the crude base by acetylation, and final saponification of the acetyl derivative. The following direct method renders both the acetyl derivative and the base easily available. 44 g. *m*-acetaminophenol are dissolved in 260 cc. of glacial acetic acid and slowly treated with a solution of 52 g. bromine in 52 cc. acetic acid, chilling with ice. The mixture is then diluted with an equal volume of water and the resulting precipitate filtered off, washed with water, and recrystallized from 50% alcohol. 38 g. 2-bromo-5-acetaminophenol are obtained in this way, melting at 209–13° with preliminary softening. Hydrolyzed by boiling with 1 : 1 hydrochloric acid, neutralizing the hot liquid at the end with saturated sodium acetate solution, the acetamino compound gives an almost quantitative yield of the aminophenol. We have nothing to add to the descriptions of the two compounds as given by Heller.

2-Bromo-5-chloroacetylaminophenol.—18.5 g. 2-bromo-5-aminophenol were dissolved by warming in a mixture of 5 parts of saturated sodium acetate solution and 7 parts of glacial acetic acid. The solution was rapidly chilled and treated with 11.5 cc. chloroacetyl chloride, keeping the temperature below 10°. The chloroacetyl derivative separated immediately and was filtered off after dilution with water and washed with water and

[1] *Ber.*, **18**, 1166 (1885).
[2] *Ibid.*, **42**, 2196 (1909).

dried. The yield was 24 g. Recrystallized from alcohol it separates as rhombs which melt to a dark liquid at 191–3° with preliminary softening. It is only sparingly soluble in boiling water or chloroform and in the cold in alcohol or acetic acid, but dissolves quite readily in the latter solvents on boiling. The compound is easily soluble in acetone and dissolves in dilute aqueous ammonia or sodium carbonate. In alkaline solution it couples readily with diazotized sulfanilic acid.

0.2195 g. subst. (Kjeldahl); 8.35 cc. 0.1 *N* HCl.
Calc. for $C_8H_7O_2NClBr$: N, 5.30%. Found: N, 5.33%.

In synthesizing the following three phenoxyacetic derivatives the method here given for the preparation of *m*-aminophenoxyacetic acid was adopted in preference to our older method[1] because *m*-nitrophenol could no longer be purchased and a supply of *m*-aminophenol was at hand.

***m*-Acetaminophenoxyacetic Acid,** *m*-$CH_3CONHC_6H_4OCH_2CO_2H$.—25 grams of *m*-acetaminophenol were suspended in 100 cc. of water and boiled for one hour in an open flask with 26.5 g. of 50 per cent. sodium hydroxide (2 mols) and 15.5 g. of chloroacetic acid. The solution was then diluted, treated with one-half the original amount of alkali and chloroacetic acid, and boiled until the reaction became acid. On acidifying strongly with hydrochloric acid the acetaminophenoxyacetic acid separated as an oil which quickly solidified when rubbed. The yield was good. Recrystallized from water it forms delicate needles containing one molecule of water of crystallization. When plunged into a bath at 165° the air-dry substance melts with effervescence; the anhydrous compound melts slowly at 170.5–2.5° with preliminary softening, the figures being unaffected by a subsequent recrystallization from acetic acid. The air-dry acid is sparingly soluble in cold water, readily on boiling; the anhydrous substance dissolves readily in dry methyl alcohol, less easily in absolute alcohol or dry acetone, and very sparingly in boiling toluene. It dissolves readily in boiling acetic acid, separating on cooling as spherules of microcrystals.

0.3966 g. air-dry subst. *in vacuo* at 100° over H_2SO_4; loss, 0.0322 g.
Calc. for $C_{10}H_{11}O_4N.H_2O$: H_2O, 7.93%. Found: H_2O, 8.12%.
Anhydrous: 0.1508 g. subst. (Kjeldahl); 7.2 cc. 0.1 *N* HCl.
Calc. for $C_{10}H_{11}O_4N$: N, 6.70%. Found: N, 6.69%.

When boiled for one and one-half hours with 1 : 1 hydrochloric acid and cooled the acetamino compound readily yields *m*-aminophenoxyacetic acid hydrochloride, which separates from the solution. The free acid obtained from this after dissolving in hot water, boneblacking, and neutralizing with sodium acetate agreed in melting point and all its other properties with the *m*-aminophenoxyacetic acid prepared by the reduction of the nitro compound.[2]

[1] THIS JOURNAL, **39**, 2192 (1917).
[2] *Loc. cit.*

***m*-Chloroacetylaminophenoxyacetic Acid,** *m*-$ClCH_2CONHC_6H_4OCH_2CO_2H$.—25 grams of *m*-aminophenoxyacetic acid were dissolved in a warm mixture of 250 cc. of glacial acetic acid and 250 cc. of saturated sodium acetate solution. After rapid chilling the solution was treated with 18 cc. of chloroacetyl chloride, stirring vigorously, and keeping the temperature about 0°. The resulting clear solution was concentrated *in vacuo* to a syrup. taken up in water and treated with hydrochloric acid (1 : 1) until acid to congo-red. The chloroacetyl compound separated on scratching, and after standing in the ice-box overnight, was filtered off and washed with water. The crude product was recrystallized from water with the aid of boneblack, separating as an oily suspension which readily crystallized on rubbing. After thorough cooling the acid was filtered off, washed and dried. The yield was 31 grams. A portion was recrystallized from acetic acid, adding an equal volume of water to the solution, cooling, seeding, and letting stand in the ice-box. The acid separated slowly as spherular aggregates of microscopic crystals which are soluble in the cold in alcohol or acetone, less easily in acetic acid, and dissolve very sparingly in cold water but readily on boiling. The substance melts with preliminary softening at 159–60° to a turbid liquid which clears at 162°.

0.2040 g. subst. (Kjeldahl); 8.2 cc. 0.1 *N* HCl.
Calc. for $C_{10}H_{10}O_4NCl$: N, 5.75%. Found: N, 5.63%.

In the following synthesis of 4-aminopyrocatechol, the hydrochloride of which has been prepared by Benedikt[1] by a different method, 4-aminoguaiacol was required in considerable amount. Of the methods available for the preparation of this substance that of Rupe,[2] namely, coupling diazotized sulfanilic acid with guaiacol and reducing the sodium salt of the dye with tin and hydrochloric acid, seemed best suited for preparative purposes, although Rupe states that the method did not result in a pure product. It was found that by isolating the free sulfonic acid and reducing this with hydrogen sulfide in ammoniacal solution 4-aminoguaiacol could easily be obtained pure and in quantity.

***p*-Sulfophenylazoguaiacol.**—104 g. sulfanilic acid (dry weight) were dissolved in 600 cc. of normal aqueous sodium hydroxide and diluted with ice and water to about 2.5 liters. After adding 45 g. sodium nitrite the solution was turbined and treated slowly with 360 cc. of 1 : 1 hydrochloric acid. When diazotization was complete the resulting slurry was slowly poured into a solution of 77 g. guaiacol in 2400 cc. of normal sodium hydroxide containing ice. After stirring for three-quarters of an hour about one-quarter volume of concentrated hydrochloric acid was added,

[1] *Ber.*, **11**, 363 (1878).
[2] *Ibid.*, **30**, 2447 (1897).

whereupon the dye separated on rubbing and letting stand. The product was filtered off and washed with 1 : 1 hydrochloric acid and acetone. The yield of crude dye, sufficiently pure for the subsequent reduction, was 140 g. Recrystallized from water the sulfonic acid separates as glistening, metallic green needles and long, thin plates, appearing orange under the microscope. When heated, decomposition begins above 220° and becomes rapid at about 245°. The dye dissolves in water with an orange-yellow color, deepening to brown on adding ferric chloride. It is insoluble in chloroform and almost so in acetic acid or acetone, but turns deep red on boiling with acetic acid, possibly due to elimination of water of crystallization, although there was no loss on heating the air-dry substance at 100° *in vacuo* over sulfuric acid.

0.1423 g. subst.; 10.4 cc. N (22.0°, 768 mm.)
Calc. for $C_{13}H_{12}O_5N_2S$: N, 9.09%; +1 H_2O: N, 8.56%. Found: N, 8.54%.

4-Aminoguaiacol.—140 g. of the crude sulfo dye were dissolved in 1400 cc. of 10% aqueous ammonia and saturated with a rapid stream of hydrogen sulfide. The solution became hot, the color suddenly changed to yellow, and crystals of the aminoguaiacol soon separated. After letting stand for an hour and chilling, the substance was filtered off and washed with water. The yield was 48 g., melting at 177–8° with preliminary darkening, and corresponding to the recorded properties of this base.

4-Aminopyrocatechol Hydrobromide.—85 g. 4-aminoguaiacol were boiled under a reflux condenser with 5 parts of hydrobromic acid (d. 1.49) for 6 hours. The crystals which separated on cooling were boiled again for 3 hours with fresh hydrobromic acid (b. 123°), while the mother-liquors were also boiled an additional 3 hours. On chilling a total of 90 g. of dark crystals were obtained. A portion of the salt was purified by dissolving in water to which a few drops of hydrobromic acid had been added, adding a little stannous chloride to the deep green solution, and passing in hydrogen sulfide. The precipitate was filtered off and the solution concentrated *in vacuo* to small bulk and let stand in the ice-box. The almost colorless crystals which separated were recrystallized from 85% alcohol, adding a little concentrated hydrobromic acid before cooling. On seeding, the hydrobromide separated slowly as flat needles or long, narrow plates. The salt was washed with 95% alcohol containing a little hydrobromic acid and dried *in vacuo* over sulfuric acid and crushed potassium hydroxide. The compound darkens somewhat above 150° and melts with decomposition at about 255–60°, with preliminary softening and darkening. It is readily soluble in water, the solution giving a cherry-red color with ferric chloride, changing to red-brown and finally forming a violet-black precipitate. It is easily soluble at room temperature in alcohol of various strengths, but is less soluble in alcohol at 0° in the presence of hydrobromic acid.

0.1675 g. subst. (Kjeldahl); 8.25 cc. 0.1 *N* HCl.
0.1186 g. subst. (Carius); 0.1074 g. AgBr.
Calc. for $C_6H_7O_2N.HBr$: N, 6.81; Br, 38.79%. Found: N, 6.90; Br, 38.55%.

4-Aminopyrocatechol(3,4-dihydroxyaniline).—A portion of the recrystallized hydrobromide was placed in a bottle and the air displaced by a current of carbon dioxide. A little water was added through a dropping funnel, followed, when the salt had dissolved, by a saturated sodium bicarbonate solution. On rubbing for a moment the base separated from the pink solution as colorless prisms, often with key-like ends. The aminophenol was filtered off, directing a stream of carbon dioxide on to the funnel, and rapidly washed with several small portions of ice-water, but these precautions were not sufficient entirely to prevent darkening of the sensitive base. After rapidly transferring to a dish, keeping a stream of carbon dixoide playing on the substance, it was dried in a high vacuum. As so obtained the aminophenol melts at 122–3° with preliminary softening and darkening, evolving gas and forming a dark purple mass. It is quite soluble in water at room temperature, except for a slight, dark, amorphous residue of oxidation products which increases as the solution is allowed to stand. It dissolves in 95% alcohol, less easily in acetone, and very sparingly in boiling benzene or toluene. When recrystallized again by dissolving in a little boiling absolute alcohol, adding an equal volume of benzene, and rubbing, the substance separates quickly as gray plates and clusters of short prisms which melt at 124–5° with the same phenomena as described above.

0.1415 g. subst. (Kjeldahl); 11.45 cc. 0.1 *N* HCl.
Calc. for $C_6H_7O_2N$: N, 11.21%. Found: N, 11.33%.

4-Chloroacetylaminopyrocatechol.—50 g. of the crude aminopyrocatechol hydrobromide were dissolved in 300 cc. water and treated with 92 g. of crystalline sodium acetate. The mixture, from which a portion of the free aminopyrocatechol had separated, was chilled in ice-water, vigorously stirred, and treated, drop by drop, with 30 cc. chloroacetyl chloride. Deposition of the chloroacetyl derivative began before the base had entirely dissolved. At the end the mixture was made strongly acid to congo-red with hydrochloric acid and the precipitate filtered off, washed with water, and dried. The yield of crude product was 38 g. Recrystallized successively from water, acetic acid, and ethyl acetate, it forms flat, delicate needles which melt at 156–7.5° with preliminary softening. The compound is sparingly soluble in cold water, readily on boiling; the aqueous solution giving an olive-brown color with ferric chloride. It dissolves easily in alcohol and sparingly in the cold in acetic acid or ethyl acetate, easily on boiling.

0.1647 g. subst. (Kjeldahl); 8.40 cc. 0.1 *N* HCl.
Calc. for $C_8H_8O_3NCl$: N, 6.95%. Found: N, 7.14%.

p-**Chloroacetylaminoacetophenone.**—A well chilled solution of 16 g. *p*-aminoacetophenone in 160 cc. of dry acetone was treated slowly with 10 cc. of chloroacetyl chloride, following this slowly with 50 cc. of 10% sodium hydroxide solution. After acidification with hydrochloric acid the mixture was diluted with water, causing the separation of the chloroacetyl compound. After recrystallization from 50% alcohol it was obtained as a woolly mass of needles. The yield was 16 g. Recrystallized again from toluene the compound forms arborescent aggregates of plates which melt at 152–3° (corr.) with slight preliminary softening. It is sparingly soluble in ether or hot benzene and readily so in alcohol or hot toluene.

0.2663 g. subst. (Kjeldahl); 12.45 cc. 0.1 *N* HCl.
Calc. for $C_{10}H_{10}O_2NCl$: N, 6.62%. Found: N, 6.55%.

p-**Chloroacetylaminophenylacetic Acid,** *p*-$ClCH_2CONHC_6H_4CH_2CO_2H$.—8.5 g. *p*-aminophenylacetic acid were suspended in 100 cc. of 20% sodium acetate solution and treated with dilute sodium hydroxide until solution was complete. After adding ice, 8 cc. chloroacetyl chloride were dropped in, with shaking. The solution was acidified with hydrochloric acid and the chloroacetylamino acid filtered off, washed, and dried. The yield was 10 g. Recrystallized successively from water, toluene, and acetic acid it separates as faintly yellow, glistening leaflets which melt at 158–60° to a yellow liquid, with preliminary softening. A solution of the acid in boiling water deposits the substance on cooling as snowy, arborescent masses of delicate needles. It dissolves in alcohol, more easily in acetone, and also dissolves in boiling acetic acid and only sparingly in boiling toluene.

0.2109 g. subst. (Kjeldahl); 9.45 cc. 0.1 *N* HCl.
Calc. for $C_{10}H_{10}O_3NCl$: N, 6.16%. Found: N, 6.28%.

Ethyl Chloroacetylanthranilate, *o*-$ClCH_2CONHC_6H_4CO_2C_2H_5$.—20 g. ethyl anthranilate hydrochloride, 100 cc. toluene, and 100 cc. of normal sodium hydroxide solution were shaken together until all the ester had gone into solution in the toluene. 100 cc. of 10% sodium hydroxide solution were then added, followed by 14 cc. chloroacetyl chloride, drop by drop, with shaking and cooling, adding more alkali to maintain the alkalinity toward the end. The toluene layer was dried over calcium chloride, evaporated on the water bath, and the residue recrystallized from 95% alcohol. The yield was 23 g. Recrystallized from 85% alcohol the chloroacetyl ester forms glistening needles which melt at 79.5–80° (corr.) and dissolve readily in benzene, toluene, or chloroform, somewhat less so in 95% alcohol.

0.3452 g. subst. (Kjeldahl); 13.6 cc. 0.1 *N* HCl.
Calc. for $C_{11}H_{12}O_3NCl$: N, 5.80%. Found: N, 5.52%.

Ethyl Iodoacetylanthranilate.—10 g. of the chloroacetyl ester were suspended in 25 cc. acetone, treated with 50 cc. of a normal solution of sodium iodide in dry acetone,[1] and the mixture warmed until solution was complete. Deposition of sodium chloride soon commenced, and after standing overnight water was added, precipitating the iodoacetyl compound. The yield was 13 g. after recrystallizing from 95% alcohol with the aid of a freezing mixture. Recrystallized again from 85% alcohol, in which it is less soluble, it formed glistening, transparent prisms which soften at 78° and melt at 78.5–9.0° (corr.). The compound is easily soluble in the cold in chloroform or toluene.

0.4483 g. subst. (Kjeldahl); 13.05 cc. 0.1 *N* HCl.
Calc. for $C_{11}H_{12}O_3NI$: N, 4.21%. Found: N, 4.08%.

Chloroacetyl-*N*-methylanthranilic Acid, *o*-$HOOCC_6H_4N(CH_3)COCH_2Cl$.—4.5 g. methylanthranilic acid were dissolved in 40 cc. of normal aqueous hydroxide, 10 cc. of saturated sodium acetate solution added, and then 4 cc. chloroacetyl chloride, with chilling and shaking. The reaction mixture was next acidified to congo-red with hydrochloric acid. The oil which separated crystallized on rubbing, and the yield was practically quantitative. Recrystallized from toluene the substance forms colorless spears which melt at 167–8° (corr.) with slight preliminary sintering. It is readily soluble in alcohol, acetone, or hot water.

0.3107 g. subst. (Kjeldahl); 13.55 cc. 0.1 *N* HCl.
Calc. for $C_{10}H_{10}O_3NCl$: N, 6.16%. Found: N, 6.11%.

Ethyl Chloroacetylmethylanthranilate, *o*-$ClCH_2CON(CH_3)C_6H_4CO_2C_2H_5$.—This substance was prepared from ethyl methylanthranilate (from the acid with alcohol and sulfuric acid) by the method used for the preparation of ethyl chloroacetylanthranilate. The residue from the evaporation of the toluene slowly crystallized and when dissolved in boiling petroleum ether it separated on cooling as stout, colorless prisms which melt at 50–1° (corr.) and are easily soluble in the usual organic solvents except petroleum ether. 16 g. ethyl methylanthranilate yielded 15 g. of the purified acyl derivative.

0.2940 g. subst. (Kjeldahl); 11.25 cc. 0.1 *N* HCl.
Calc. for $C_{12}H_{14}O_3NCl$: N, 5.48%. Found: N, 5.36%.

Sodium Chloroacetylsulfanilate, *p*-$NaO_3SC_6H_4NHCOCH_2Cl$.—49 g. sodium sulfanilate were dissolved in 10 parts of water, 25 g. sodium carbonate were added, and the solution chilled in a freezing mixture and stirred. When the temperature had dropped to —2° the dropwise addition of 30 cc. chloroacetyl chloride was commenced. Toward the end the mixture set to an almost solid mass, after which the freezing mixture was removed and the turbining continued until the mixture again became fluid. The

[1] Finkelstein, *Ber.*, **43**, 1528 (1910).

rest of the chloroacetyl chloride was then added drop by drop without further cooling. 150 g. salt were then added, with continued stirring, causing the sudden precipitation of the chloroacetylsulfanilate. The product was filtered off, washed with 85% alcohol, and recrystallized from this solvent, giving 23 g. of crude substance still containing appreciable amounts of sodium chloride. A pure product was obtained for analysis, however, by washing the product with small portions of ice-water, then with 50% alcohol, and finally dissolving in a little warm water, filtering, and adding several volumes of alcohol. As so obtained the salt separates as radiating masses of hair-like needles which contain no water of crystallization when air-dried and which dissolve readily in water. The aqueous solution gives only a faint turbidity with silver nitrate in the cold, but if the salt is dried at 100° partial decomposition sets in and a copious precipitate of silver chloride is obtained. The free acid was not isolated in a state of purity.

0.1543 g. subst. (Kjeldahl); 5.65 cc. 0.1 *N* HCl.
Calc. for $C_8H_7O_4NClSNa$: N, 5.16%. Found: N, 5.13%.

4-Chloroacetylamino-6-hydroxybenzenesulfonic Acid and Its Sodium Salt.—4-Amino-6-hydroxybenzenesulfonic acid (*m*-aminophenolsulfonic acid) was easily obtained in good yield by gradually adding *m*-aminophenol to 4 parts of concentrated sulfuric acid, with occasional cooling, and heating the solution on the water bath for one hour. The precipitate obtained by pouring on to ice was collected, washed well with water, suspended in hot water, and dissolved by adding sodium acetate. The hot solution was boneblacked and the free acid precipitated from the filtrate by means of hydrochloric acid. 36 g. of the 4-amino-6-hydroxybenzenesulfonic acid were dissolved in a mixture of 190 cc. of normal sodium hydroxide solution, 190 cc. water, and 19 g. sodium carbonate. The solution was stirred, chilled to 5°, and treated with 22.5 cc. chloroacetyl chloride. About 100 g. sodium chloride were then added, causing the precipitation of the sodium salt of the acyl sulfonic acid. After stirring for 10 minutes the salt was filtered off, washed with a little ice-water, then with 85% alcohol, and dried *in vacuo* over sulfuric acid. The yield was 47 g. A portion was dissolved in the minimum amount of hot water, and the solution filtered and treated with several volumes of alcohol. On seeding, the salt separated rapidly as a voluminous mass of plumes of minute, hair-like needles which contain one-half molecule of water of crystallization. The salt is quite readily soluble in water, the solution giving a purple color with ferric chloride. An alkaline solution couples readily with diazotized sulfanilic acid.

0.4926 g. air-dry subst. *in vacuo* at 80° over H_2SO_4; loss, 0.0134 g.
Calc. for $C_8H_7O_5NClSNa.{}^1/_2H_2O$: H_2O, 3.04%. Found: H_2O, 2.74%.

0.1441 g. anhydrous subst. (Kjeldahl); 5.1 cc. 0.1 *N* HCl.
Calc. for $C_8H_7O_5NClSNa$: N, 4.87%. Found: N, 4.96%.

The *free acid* was obtained by dissolving a portion of the salt in hot 10% hydrochloric acid, filtering, and cooling, rapid manipulation being necessary in order to avoid saponification of the acyl group. On seeding with crystals obtained from a similarly treated preliminary experiment (1 : 1 acid was used) which had been allowed to stand in the ice-box, the acid separated slowly at 0° as minute platelets and flat needles which apparently contain no water of crystallization. When heated, the acid darkens slightly, but does not melt below 275°. It is sparingly soluble in cold water, but dissolves quite easily on boiling. Boiling absolute alcohol or acetic acid dissolve only traces.

0.1548 g. subst. (Kjeldahl); 5.95 cc. 0.1 *N* HCl.
0.2370 g. subst. (hydrolysis with NaOH); 0.1258 g. AgCl.
Calc. for $C_8H_8O_5NClS$: N, 5.28; Cl, 13.35%. Found: N, 5.39; Cl, 13.13%.

With the exception of the hexamethylenetetramine compound, which was used in another connection, the aliphatic substances discussed below also figured as intermediates in the work on arsenic compounds mentioned in the introduction.

Chloroacetmethylamide, $ClCH_2CONHCH_3$.—Since the original description of this substance[1] it has been found that in working up larger amounts of material it is advantageous to use a mechanical stirrer and to add only one-half of the required amount of alkali at the beginning, deferring the addition of the remainder until almost one-half of the chloroacetyl chloride has been added. At the end, after neutralization, the solution is partially saturated with salt to diminish the solubility of the chloroacetmethylamide and shaken out 8 times with chloroform. After drying this over sodium sulfate and concentrating to small bulk the amide is recovered by distillation *in vacuo*, the slight loss due to the volatility of the compound being more than offset by the time saved. In this way, starting with 78 g. methylamine hydrochloride, 70 g. of the chloroacetmethylamide were obtained, boiling at 112–3° under 22 mm. pressure and solidifying at once in the receiver.

Chloroacet-*n*-propylamide, $ClCH_2CONHC_3H_7$.—10 g. *n*-propylamine were added to 125 cc. of 10 per cent. sodium hydroxide solution. To this mixture, which was turbined and chilled in a freezing mixture, were added drop by drop, 13.3 cc. chloroacetyl chloride dissolved in 30 cc. toluene. The mixture was finally acidified to congo-red with hydrochloric acid and extracted with chloroform. The chloroform extract was dried over calcium chloride and concentrated, the oily residue being fractionated

[1] *J. Biol. Chem.*, **21**, 147 (1915).

in vacuo. The main fraction (12 grams) boiled at 107–8° at 13 mm. On redistillation it boiled at 105–6° (corr.) at 10.5 mm. It is a rather viscous oil which dissolves in water but does not mix with it in all proportions. It is miscible with alcohol, acetone, chloroform and ether.

0.1828 g. subst. (Kjeldahl); 13.35 cc. 0.1 *N* HCl.
Calc. for $C_5H_{10}ONCl$: N, 10.33%. Found: N, 10.23%.

Hexamethylenetetramonium Salt of Chloroacet-*n*-propylamide.—2.5 g. each of chloroacetpropylamide and hexamethylenetetramine were boiled with dry chloroform for one hour. The resulting solution was filtered from a trace of precipitate and treated with 2–3 volumes of dry acetone, whereupon the salt separated as thick, hexagonal platelets and relatively few delicate needles. The yield was 3.2 g. The salt dissolves readily in water, alcohol, methyl alcohol, or chloroform, and is practically insoluble in dry acetone. When rapidly heated to 145°, then slowly, it melts to a dark liquid at 147–9°.

0.1566 g. subst.; 10.98 cc. $AgNO_3$ soln. (1 cc. = 0.001794 g. Cl).
Calc. for $C_{11}H_{22}ON_5Cl$: Cl, 12.86%. Found: Cl, 12.58%.

Chloroacetylethylurea, $ClCH_2CONHCONHC_2H_5$.—10 g. ethylurea and 14 g. chloroacetyl chloride (1.1 mols.) were boiled in 100 g. of dry benzene for one hour. Water was added to the mixture, which was then filtered. The solid was recrystallized from 50% alcohol, 14 g. of the ureide being obtained. For analysis a portion was recrystallized from benzene, forming long needles which melt at 141.5–2.5° (corr.). The compound dissolves in acetone, chloroform, or alcohol, and only sparingly in cold benzene.

0.1820 g. subst. (Kjeldahl); 22.2 cc. 0.1 *N* HCl.
Calc. for $C_5H_9O_2N_2Cl$: N, 17.02%. Found: N, 17.09%.

Chloroacetpiperidide, $ClCH_2CONC_5H_{10}$.—In the original method given for the preparation of this substance[1] a poor yield was obtained owing to its not having been foreseen that the piperidide would be soluble in water. A satisfactory yield may be achieved as follows: 25 g. piperidine are dissolved in 150 cc. of dry, alcohol-free ether and cooled to about —5°. The solution is shaken vigorously and kept below 0° while a solution of 12 cc. chloroacetyl chloride in dry, alcohol-free ether is dropped in. After letting stand for a short time the precipitate of piperidine hydrochloride is filtered off, washed with dry ether, and the filtrate and washings concentrated to small bulk. 16.3 g. chloroacetpiperidide are recovered from the residue, the boiling point being 149–53° under a pressure of 17 mm. Most of the substance boils at 151°.

The following table of compounds is appended in the order described:

[1] *J. Biol. Chem.*, **21**, 150 (1915).

Name.	Formula.	Melting point. °C.
o-Chloroacetylaminophenol	$C_8H_8O_2NCl$	138–40
o-Chloroacetylaminophenyl acetate	$C_{10}H_{10}O_3NCl$	113.5–4.5
2-Methyl-5-chloroacetylaminophenol	$C_9H_{10}O_2NCl$	154–5
4-Methyl-5-chloroacetylaminophenol	$C_9H_{10}O_2NCl$	151–2.5
1-Chloroacetylamino-2-naphthol	$C_{12}H_{10}O_2NCl$	192–3
1-Chloroacetylamino-4-naphthol	$C_{12}H_{10}O_2NCl$	199.5–201.5
2,4-Dichloro-5-acetaminophenol	$C_8H_7O_2NCl_2$	233–6
2,4-Dichloro-5-aminophenol	$C_6H_5ONCl_2$	135–6
2,4-Dichloro-5-chloroacetylaminophenol	$C_8H_6O_2NCl_3$	185.5–6.5
2,4-Dichloro-5-acetaminoanisol	$C_9H_9O_2NCl_2$	157.5–9.0
2,4-Dichloro-5-anisidine	$C_7H_7ONCl_2$	50.5–1.5
2,4-Dichlororesorcin dimethyl ether	$C_8H_8O_2Cl_2$	117–8
2,4,6-Trichloro-5-acetaminophenol	$C_8H_6O_2NCl_3$	185.5–6.5
2,4,6-Trichloro-5-aminophenol	$C_6H_4ONCl_3$	95–6
2-Bromo-5-aminophenol	C_6H_6ONBr	
2-Bromo-5-chloroacetylaminophenol	$C_8H_7O_2NClBr$	191–3
m-Acetaminophenoxyacetic acid	$C_{10}H_{11}O_4N$	170.5–2.5
m-Aminophenoxyacetic acid	$C_8H_9O_3N$	
m-Chloroacetylaminophenoxyacetic acid	$C_{10}H_{10}O_4NCl$	159–62
p-Sulfophenylazoguaiacol	$C_{13}H_{12}O_5N_2S$	
4-Aminoguaiacol	$C_7H_9O_2N$	177–8
4-Aminopyrocatechol hydrobromide	$C_6H_7O_2N.HBr$	255–60
4-Aminopyrocatechol	$C_6H_7O_2N$	124–5
4-Chloroacetylaminopyrocatechol	$C_8H_8O_3NCl$	156–7.5
p-Chloroacetylaminoacetophenone	$C_{10}H_{10}O_2NCl$	152–3
p-Chloroacetylaminophenylacetic acid	$C_{10}H_{10}O_3NCl$	158–60
Ethyl chloroacetylanthranilate	$C_{11}H_{12}O_3NCl$	79.5–80
Ethyl iodoacetylanthranilate	$C_{11}H_{12}O_3NI$	78.5–9.0
Chloroacetyl-*N*-methylanthranilic acid	$C_{10}H_{10}O_3NCl$	167–8
Ethyl chloroacetylmethylanthranilate	$C_{12}H_{14}O_3NCl$	50–1
Sodium chloroacetylsulfanilate	$C_8H_7O_4NClSNa$	
4-Chloroacetylamino-6-hydroxybenzenesulfonic acid	$C_8H_8O_5NClS$	
Sodium 4-chloroacetylamino-6-hydroxybenzenesulfonate	$C_8H_7O_5NClSNa$	
Chloroacetmethylamide	C_3H_6ONCl	b_{22} 112–3
Chloroacet-*n*-propylamide	$C_5H_{10}ONCl$	$b_{10.5}$ 105–6
Hexamethylenetetramonium salt	$C_{11}H_{22}ON_5Cl$	147–9
Chloroacetylethylurea	$C_5H_9O_2N_2Cl$	141.5–2.5
Chloroacetpiperidide	$C_7H_{12}ONCl$	b_{17} 151

NEW BOOKS.

Chemical French. By MAURICE L. DOLT. 23 × 16 cm.; pp. VIII + 398. Easton: The Chemical Publishing Company, 1918. Price, $3.00.

This volume plans to do for the student of French what Phillips' book does for the student of German. Since French is an easier language to pick up than German, the author's task is somewhat less difficult than the one that Phillips set himself. The first four chapters deal with: articles; adjectives and pronouns; verbs, participles, adverbs, pronoun objects;