

about 1.5 cm. of the upper end of the cork will project when snugly pushed down. The corks are bored with borers slightly smaller than the burets they are to carry, and then split longitudinally with a knife into two equal parts. When the two halves of the cork are placed around a buret and wedged snugly down into a hole in the board, the buret will be held securely, but at the same time may be slid up and down much more easily than if held in rubber. There are no screws to rust or strip, and the buret is much easier to insert and remove (through the slot) than in a screw clamp. The burets being held in a regular row at the most convenient intervals, a single stand will hold many more than is convenient with screw clamps.

The arrangement may be improved further by cutting a shallow groove around the cork, before splitting, about 0.5 cm. from its larger end; in this groove are placed two or three light rubber bands. This arrangement adds to the ease of operation, as the cork is held on the buret until deliberately removed, and yet permits the buret to slip up and down easily; one also does not have to be so careful in placing the cork in the slots, as when the bands are not used.

The perforated board is supported by some form of bracket; we use a metal clamp sliding on an ordinary vertical support with a heavy base. A burner fork makes a convenient bracket, it being only necessary to bore two holes horizontally into the back edge of the perforated board at the proper distance apart to receive the prongs of the fork.

The support may also be used with small funnels, and a similar device with larger holes, for larger funnels. The slot in the front makes it possible to remove the funnel from the support without loss while it is still dripping rapidly, the stem of the funnel passing out through the slot while its lower end is kept in the receiving vessel.

NORMAN ROBERTS AND F. ALEX MCDERMOTT.

HYGIENIC LABORATORY,
WASHINGTON, D. C.

[CONTRIBUTION FROM DRUG DIVISION, BUREAU OF CHEMISTRY, U. S. DEPT. OF AGRICULTURE.]

A CHEMICAL INVESTIGATION OF THE OIL OF CHENOPODIUM.

BY E. K. NELSON.

Received June 9, 1911.

Introduction.

American wormseed oil, official in the United States Pharmacopoeia as *Oleum chenopodii*, is distilled from *Chenopodium ambrosioides*, var. *Anthelmintica*. It is used as a remedy for worms, particularly for *Ascarides*, which it seems to narcotize so that they can be eliminated by means of a laxative. The larger part of this oil produced in the United

States is distilled from an herb grown in a section of Carroll County, Md., and is known in the trade as "Baltimore" wormseed oil.

The chemistry of the oil of chenopodium has, until recently, been but little investigated. The first recorded examination of this oil was undertaken by Garrigues,¹ in 1854, who reported the presence of two constituents, one of which he described as a hydrocarbon boiling at 176° C., and the other as a liquid of the formula $C_{10}H_{16}O$.

Kremers² examined chenopodium oil in 1907 from the results of which examination he suspected the presence of a most unstable alcohol. Schimmel & Co.,³ in 1908, reported an extensive investigation of the oil. By fractionating at reduced pressure (the oil explodes on attempting to distil it at atmospheric pressure) they separated a liquid substance, designated by them "ascaridol," which constitutes the major portion of the oil, and to which its peculiar chemical as well as medicinal properties seem to be due. Ascaridole afforded on analysis the formula $C_{10}H_{16}O_2$. It is described as a yellow oil possessing a peculiar, repulsive odor suggesting both camphor and carvone. Toward reagents which would characterize it as an alcohol, an aldehyde, a ketone, or a phenol, ascaridol was found to be absolutely indifferent. Many attempts were made to ascertain the chemical nature of this substance, without results. They found that on heating ascaridole to 150° a molecular rearrangement apparently took place, and that the product of conversion, on combustion, gave values which agreed fairly well with the formula $C_{10}H_{16}O_2$. Ascaridole, when allowed to drop into concentrated sulfuric acid, or when reduced with zinc dust and acetic acid, formed cymene. No cymene was formed from the conversion product, either on treatment with zinc dust and acetic acid or with formic acid.

Besides cymene, Schimmel & Co. found a ketone, probably carvenone, to be formed on reducing ascaridole with zinc dust and acetic acid. The lighter boiling fraction of the oil was found to consist mainly of cymene, mixed, as the optical activity would indicate, with a terpene.

Examination of Authentic Samples.

In October, 1910, authentic samples of chenopodium oil were collected by the writer in the producing section of Maryland for the purpose of making a chemical examination as well as to determine the physical variations. Three samples were collected from a large steam still representing three different crops of the herb. A fourth sample was collected from one of the old-fashioned "pot" stills. The following are the results of a physical examination of these samples:

¹ *Am. J. Pharm.*, 26, 405 (1854).

² *Pharm. Rev.*, 25, 155 (1907).

³ Schimmel & Co., *Report*, April, 1908.

PHYSICAL TEST ON FOUR AUTHENTIC SAMPLES OF CHENOPODIUM OIL.

Determinations.	Steamed distilled samples.			Pot-distilled samples, No. 4.
	No. 1.	No. 2.	No. 3.	
Specific gravity 25°/25°.....	0.9691	0.970	0.955	0.9584
n_D at 25°.....	1.4726	1.4723	1.4726	1.4725
α_D at 25°.....	-5.4°	-6.2°	-8.8°	-6.3°
Solubility in 70 per cent. alcohol	1 : 3	1 : 3	1 : 7	1 : 6

For a preliminary chemical examination of chenopodium oil a sample was purchased on the market prior to the distillation of the fall crop. This sample, which must have been at least a year old, afforded the following results: Specific gravity (25° C.) = 0.9694; n_D at 20° = 1.4780; α_D at 20° C. = -0.35°; solubility in 70 per cent. alcohol = 1 : 3; acid number = 0; ester number = 5.0.

On fractionating at 8 mm., about 15 per cent. of a hydrocarbon was separated. After distilling this over sodium a pleasant smelling liquid was obtained having a boiling point of 176° C. (766 mm.); a sp. gr. of 0.8513 at 20°; n_D at 20° C., 1.4828; and α_D at 20° C., -18.5°. Cymene was identified in this fraction.

Dextro camphor was identified in the fractions coming over before the ascaridol by means of its semicarbazone and its oxime. The proportion of camphor in the sample was estimated to be at least 4 per cent. This was determined by treating a weighed sample of the oil with semicarbazine hydrochloride and sodium acetate in acetic acid solution, allowing the mixture to stand for some time, and distilling the oil, after freeing from acetic acid, with steam. As camphor semicarbazone is scarcely volatil with steam, it remained behind in a crude form. This was dried on a porous plate and from its weight the amount of camphor was roughly estimated.

The presence of dextro camphor no doubt accounts for the low levo rotation of this sample. Camphor was not found in the fresh authentic specimens, and the question therefore arises whether the camphor may be formed in the oil on aging. The question is to be investigated by an examination of the samples in which no camphor was found after aging a year under varying conditions.

The substance which Schimmel & Co. have designated "ascaridol" was separated as completely as possible by fractionation at 8 mm. Thus purified, it has a constant boiling point, and probably constitutes at least 70 per cent. of the sample.

Boiling point, 8 mm. = 96-97°; specific gravity (20°/20°) = 0.9985; n_D at 20° = 1.4769; α_D at 20° = +0.7°.

Schimmel & Co. found ascaridole to be inactive. The slight optical activity of the ascaridole obtained from this sample is no doubt due to the rather large amount of camphor present, from which the ascaridole was not entirely freed on fractionation.

Experiments to Determin the Nature of Ascaridole.

The following experiments illustrate the instability of ascaridole: On pouring ascaridole on to mercury, heated to 260° , it inflames. It is decomposed with explosive violence on adding sulfuric, hydrochloric, nitric, or phosphoric acids, and on warming gently with zinc chloride. When heated to 140° , with phthalic anhydride, it is violently decomposed. No phthalic acid ester was found in the reaction product. When heated to near its boiling point, ascaridole decomposes with explosive violence. If dropped into sulfuric acid a combustible, saturated gas is evolved. Treated with acetic anhydride in pyridine solution, it does not react, either at the temperature of the steam bath or at the boiling point of pyridine. On boiling with acetic anhydride, however, some ester is apparently formed, but involving a decomposition of the original material. It affords no oxime and no semicarbazone. Phenyl isocyanate does not react.

On shaking ascaridole with a saturated solution of ferrous sulfate, the temperature rises, a combustible gas is evolved, and basic ferric sulfate is precipitated. This reaction indicates that ascaridole may be an unstable oxide. As the reaction with ferrous sulfate appears to go smoothly and is capable of control, its study seemed to promise some light on the chemical nature of ascaridole, and the following experiments were made:

Experiment 1.—Fifty cubic centimeters of ascaridole were shaken with a saturated solution of ferrous sulfate. The mixture became quite hot, and a small amount of gas was evolved which was collected and found to be combustible. Much basic ferric sulfate was precipitated, and the ascaridole first became colorless and finally quite viscous. Thirty-five cubic centimeters of thick oil were drawn off and the filtered, aqueous solution was extracted with ether. On evaporating the ether a viscous, odorless, water-soluble substance remained, which had a burning taste. Accordingly, the thick oil drawn off at first was shaken out with water, the aqueous extract shaken out with ether, and an additional quantity of the water-soluble substance obtained.

Experiment 2.—Ascaridole, 20 cc., was shaken with ferrous sulfate solution and the entire mixture distilled with steam. The distillate was saturated with sodium chloride and extracted with petroleum ether, the aqueous solution being then distilled into a 50 cc. flask.

The specific gravity ($15.6^{\circ}/15.6^{\circ}$) of distillate is 0.9978, equivalent to 0.57 gram (as ethyl alcohol) or 2.85 per cent. of the ascaridole. The distillate was then fractionated and the concentrated alcohol examined. It gave iodoform in the cold, and on oxidizing with chromic acid afforded acetone, which was identified by means of its condensation product with benzaldehyde, dibenzylidene acetone, melting point 111° – 112° . Therefore, isopropyl alcohol is among the products formed from ascaridole on

treatment with ferrous sulfate; 2 cc. of oil came over with the steam, the greater part being nonvolatil. This was extracted from the retort residue by means of ether and amounted to 15 cc. of a thick, sirupy oil. On acetylation this was found to be alcoholic in nature. The acetyl ester had a decided pennyroyal or pulegone odor, especially upon warming.

Experiment 3.—Treated 20 cc. of ascaridole with ferrous sulfate solution as before, but kept the temperature down by occasional cooling under the tap. Little, if any, gas was evolved and less basic ferric salt was precipitated than in the previous experiments. The ascaridole, as before, became first colorless, then viscous, and part of it went into solution. In all cases the chenopodium odor almost entirely disappeared, and the viscous, soluble substance seemed to be the chief product of the reaction.

Experiment 4.—In order to study further this conversion product of ascaridole, a large amount of the latter was prepared from authentic samples of the oil.

Three hundred cubic centimeters of ascaridole were shaken violently with a nearly saturated solution of 100 grams of ferrous sulfate, keeping the temperature below 35° by occasional cooling. When the temperature ceased to rise and the mixture had become quite viscous, the reaction was considered at an end. The reaction product was recovered from the mixture by means of ether. On shaking it with benzoyl chloride and sodium hydroxide solution (Schotten-Baumann method), a solid crystallin ester was separated. This was filtered off and dried on a porous plate. Recrystallized from alcohol it melted at from 136°–137° C. From this ester the pure alcohol was obtained as an odorless, colorless, viscous oil, which crystallizes on long standing in a vacuum desiccator, the crystals rotating like camphor when dropped on water. The alcohol possesses the following physical characteristics: Boiling point, 271°–272°; melting point, 62.5°–64.0°; specific gravity (20°/20°), 1.0981; n_D at 20° C. = 1.4796; $\alpha_D = 0$; molecular refraction, 48.63 (calculated for a saturated compound with two hydroxyls = 48.65). On analysis the formula was found to be $C_{10}H_{18}O_3$.

Calculated for $C_{10}H_{18}O_3$: C, 64.46, ; H, 9.74.
Found: C, 64.19, 64.20; H, 9.76, 9.66.

This alcohol, as will be shown, contains two hydroxyl groups and therefore is designated as ascaridole glycol.

Monobenzoate of Ascaridole Glycol.

The product of the Schotten-Baumann reaction proved to be a monobenzoate.

0.5183 gram required 3.6 cc. of half-normal potassium hydroxide to saponify = 36.46 per cent. of C_6H_5CO ; calculated for $C_6H_5COC_{10}H_{17}O_3$ = 36.21 per cent. C_6H_5CO . Crystallizes from warm alcohol in prisms; melting point = 136°–137°.

Calculated for $C_6H_5COC_{10}H_{17}O_3$: C, 70.34, ; H, 7.58.
 Found: C, 70.62, 70.00; H, 7.16, 7.51.

Dibenzoate of Ascaridole Glycol.

The second hydroxyl group in ascaridole glycol was shown by the preparation of the dibenzoate. This is formed when the glycol is heated with benzoic anhydride to 150° for two hours. The ester recovered was purified by recrystallizing from alcohol, yielding white, glistening needles. Melting point, 116.5° – 117.5° .

Calculated for $(C_6H_5CO)_2C_{10}H_{16}O_3$: C, 73.05, H, 6.64.
 Found: C, 72.62; H, 6.77.

One gram = 10.21 cc. half-normal potassium hydroxide = 53.62 per cent. C_6H_5CO ; calculated for $(C_6H_5CO)_2C_{10}H_{16}O_3$ = 53.28 C_6H_5CO .

The glycol was recovered from this dibenzoate by saponification with potassium hydroxide, unchanged by the conditions of reaction. The boiling and melting points of the recovered glycol were the same as of that prepared through the monobenzoate. A peculiarity of the hydroxyls of ascaridole glycol is shown by the fact that only one reacts under the conditions of the Schotten-Baumann method while both react on heating to 150° with benzoic anhydride.

The Relation of the Glycol to Ascaridole.

Ascaridole glycol does not react with reagents which would characterize it as a ketone or aldehyde, nor does it afford a methoxyl number on subjecting it to the Zeisel method. The third oxygen is therefore, in all probability, an oxide oxygen. In that case ascaridole glycol is quite analogous to pinene glycol, and is the product of hydrating a dioxide. In case ascaridole did not suffer a molecular rearrangement on treatment with ferrous sulfate, or if the reagent merely acted catalytically, resulting in simple hydration, the conclusion would be reached that ascaridole is a glycol anhydride. In such a case it would seem that hydration should result on treatment with very dilute sulfuric acid, or with ferric salts. Both were tried and were found to produce no glycol whatever. As this seemed to indicate that a molecular rearrangement must take place when ascaridole is treated with solutions of ferrous sulfate, attention was then directed to the product of conversion described by Schimmel & Co., which they obtained on heating ascaridole to 150° and which they found to have the same composition as that of the original material. This product was prepared and was found to be the anhydride of the same glycol obtained by the action of ferrous sulfate on ascaridole, for, on treatment with 2 per cent. sulfuric acid, it took up water with rise in temperature, and the hydrate thus formed gave a plentiful yield of the monobenzoate with a melting point of from 136° to 137° when subjected to the Schotten-Baumann reaction. On heating this monobenzoate at

150° with benzoic anhydride the dibenzoate (melting point 116.5°–117.5°) was obtained.

The method of preparing the conversion product is as follows:

Cymene, 15 cc., was heated in a glycerol bath to 150° and the ascaridole added in 5 cc. portions, not allowing the temperature to rise above 165° until 25 cc. had been added. The mixture was cooled and hydrated by shaking with 100 cc. of 2 per cent. sulfuric acid. To the solution 100 cc. of 20 per cent. sodium hydroxide were added, then 35 cc. of benzoyl chloride. The mixture was shaken until the odor of benzoyl chloride had disappeared, when it was allowed to stand in the refrigerator overnight. Seventeen grams of the monobenzoate were recovered, a yield of 40 per cent. It is probable this yield can be increased by altering the method given.

Therefore, ascaridole suffers a molecular rearrangement with the formation of a glycol anhydride, one oxygen apparently remaining combined with two carbons, as an oxide. By fusion with potassium hydroxide or by boiling with a small amount of sodium, ascaridole glycol is changed, in part, into a substance which oxidizes to a greenish violet color in the air. On acidifying the product from such treatment, adding ferric chloride and distilling with steam a yellow solution comes over, which gives up its color to ether. On shaking the ether with potassium hydroxide solution the latter is colored a beautiful violet. This alkaline solution was acidified, extracted with ether, and on evaporation of the solvent, orange-yellow crystals were obtained (melting point 164°–166°). These crystals afford a purple-red color with concentrated sulfuric acid. The aniline derivative was prepared and crystallized in violet-black needles. This substance therefore is evidently α -hydroxythymoquinone, but the amount recovered was very small.

Oxidation of Ascaridole Glycol.

When ascaridole glycol is oxidized with a neutral solution of potassium permanganate, a difficultly soluble, crystallin acid is formed in preponderating amount. This separates at once in acidifying the concentrated solution filtered from manganese dioxide. The acid is quite soluble in hot water, but is difficultly soluble in cold water. It crystallizes from water in fine glistening needles; melting point, 116.5°–117°; $\alpha_D = 0$ (2 per cent. alcoholic solution).

The formula indicated by analysis is $C_{10}H_{16}O_5$. It is, therefore, isomeric with cineolic acid.

Calculated for $C_{10}H_{16}O_5$:	C, 55.52,	H, 7.46.
Found:	C, 55.48, 55.28;	H, 7.43, 7.62.

This acid, which is the chief oxidation product, will be designated ascaridic acid. It is dibasic. The silver salt, prepared by precipitation,

is almost insoluble in water; 0.0637 gram silver salt gave 0.0317 gram Ag = 49.76 per cent.; calculated for $C_{10}H_{14}O_5Ag_2$ = 50 per cent. Ag.

Ascaridic acid reacts neither with hydroxylamine nor with semicarbazine and is evidently, therefore, not a ketonic acid. After boiling with acetic anhydride and rehydrating by boiling with water, the acid was recovered unchanged, which would not have been the case had it contained a hydroxyl group. That it is not a lactone or anhydrid is shown by its behavior on titration.

When heated above its melting point, a lighter boiling substance is formed, which has an odor suggestive of amyl acetate. Methyl heptenone, is, therefore, probably formed, but sufficient material is not available at present to positively identify it by the preparation of derivatives. This acid is probably closely related to cineolic acid, which breaks down into methyl heptenone on dry distillation.

After separating the ascaridic acid, the solution was distilled with steam and a small amount of a mixture of volatil acids recovered. These have not been separated, but apparently acetic and butyric acids are present.

The residue, freed from most of the volatil acid, on cooling, deposited crystallin crusts. This was recrystallized from water and proved to be another acid. It is soluble in hot water, but difficultly soluble in cold water. The crystals are brilliant rhombohedra, melting at 186° - 187° (with decomposition).

Calculated for $C_{10}H_{16}O_8$: C, 51.69; H, 6.95.
Found: C, 51.00; H, 7.11.

As 0.2066 gram = 17.6 cc. tenth-normal potassium hydroxide, the neutralizing equivalent is 117.3.

The silver salt was prepared by precipitation; 0.3084 gram gave 0.1486 gram Ag = 48.18 per cent.; calculated for $C_{10}H_{14}O_6, Ag_2$ = 48.20 per cent. Ag. The acid, therefore, is dibasic, and its formula is evidently $C_{10}H_{16}O_6$. On heating above its melting point, no odor of methyl heptenone was observed. The amount of these acids available was too small for further examination. Their study is, therefore, reserved for a future communication.

The Chemical Nature of Ascaridole.

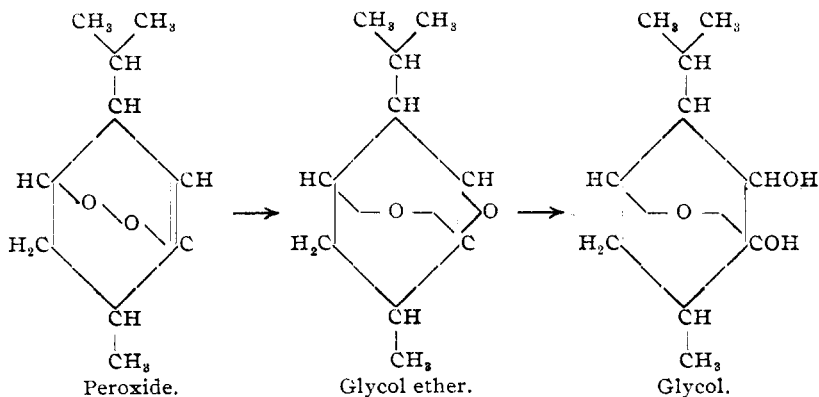
The indifference of ascaridole toward reagents, which would characterize it as an aldehyde, ketone, phenol, or alcohol, taken with the fact that it rearranges to form a glycol anhydride, analogous to pinene oxide, seems to warrant the conclusion that it is an unstable dioxide.

Its property of exploding when heated and of giving off a combustible gas under certain conditions (which was also observed by Freer¹ in his

¹ *Am. Chem. J.*, 27, 161 (1902).

work on acetyl-benzoyl peroxide), as well as the violence of the reaction brought about when treated with ferrous sulfate and other reducing agents, seem to indicate that ascaridole is an organic peroxide.

If so, the following tentative structural formulas, which are intended to show a relationship to hydroxythymoquinone, will indicate the course of the reactions involved.



[CONTRIBUTION FROM THE LABORATORY OF SOIL FERTILITY INVESTIGATIONS.]

DIHYDROXYSTEARIC ACID IN GOOD AND POOR SOILS.¹

BY OSWALD SCHREINER AND ELBERT C. LATHROP.

Received May 29, 1911.

The presence of dihydroxystearic acid in certain infertile soils was reported² from this laboratory in 1908 and was followed by a more extensive study of the effects of this substance on plant growth.³ Since then dihydroxystearic acid has been found so often in the examination of infertile soils brought to the attention of this laboratory as to lead to the conclusion that it is one of the principal factors of infertility in such soils, or at least a contributory factor that is easily determined and thus becomes an indicator of the poor soil conditions which lead to infertility. More accurate knowledge concerning the other organic soil constituents associated with and accumulating under the same conditions as dihydroxystearic acid will doubtless be necessary before this question can be definitely answered, but attention should here be called to the fact that even the knowledge that this one constituent is present leads to a recognition of the fact that poor soil conditions exist and this suggests

¹ Published by permission of the Secretary of Agriculture.

² Schreiner and Shorey, *THIS JOURNAL*, 30, 1599 (1908); "The Isolation of Harmful Organic Substances from Soils," *Bull.* 53, Bureau of Soils, U. S. Dept. Agr. (1909).

³ Schreiner and Skinner, *Botan. Gaz.*, 50, 161 (1910); "Some Effects of a Harmful Organic Soil Constituent," *Bull.* 70, Bureau of Soils, U. S. Dept. Agr. (1910).