with ether. The ether extract was washed with water, dried over sodium sulfate, and distilled. The residue was dried for a short time *in vacuo* at 150°; it weighed 2.03 g. (89%). Distillation at 0.06 mm. (air-bath 130–160°) yielded a nearly colorless liquid of n^{20}_{D} 1.5809. The picrate melted at 171–172.5° (dec.); recrystallization from ethanol raised the melting point to 175–175.5° (dec.), and the mixed melting point with material obtained from methylindole was the same. The methiodide melted at 146–147.5° (dec.) and gave no depression of the melting point when mixed with the analytical sample obtained as described above.

From 1-Methylgramine Hydrochloride.—A mixture of 2.25 g. (0.01 mole) of methylgramine hydrochloride, 4.25 g. (0.05 mole) of piperidine, and 25 ml. of *n*-hexanol was refluxed for twenty-four hours. On cooling, the solution deposited crystals. Ether was added and the suspension was extracted several times, first with 3 *N* and then with 1 *N* hydrochloric acid. The combined acid extract was made alkaline with 40% aqueous sodium hydroxide and extracted with ether. The ether layer was dried and distilled. The residue was distilled at 0.08 mm. (air-bath 130–175°) to yield a nearly colorless oil of n^{20}_{D} 1.5798; yield 1.38 g. (60.5%). The picrate melted at 168.5–170.5° (dec.); one recrystallization raised the melting point to 174.5–175.5° (dec.). The mixed melting point with samples obtained as described above was the same. The methiodide, after recrystallization from absolute ethanol, melted at 147–149 (dec.) and showed no depression in melting point when mixed with samples obtained by the methods described above.

Attempted Reaction of 1-Methylgramine with Piperidine.—This reaction was carried out under exactly the same conditions as described for the hydrochloride, except that 1.9 g. (0.01 mole) of methylgramine was employed instead of the methylgramine hydrochloride. The reaction mixture was worked up as described above. The oil obtained after distillation of the solvents distilled at a bath temperature of 90–115° (0.1 mm.) and had n^{20}_{D} 1.5740. It weighed 1.7 g. The picrate, without recrystallization, melted at 144.5–145.5°; the mixed melting point with 1-methylgramine picrate was 145–146°. Hence the product was practically pure 1-methylgramine, recovered in 90% yield.

Methylgramine was also recovered when refluxed with ten times its weight of piperidine for twenty-four hours.

Reaction of 1-Methylgramine with Piperidine in the Presence of Boron Trifluoride.—This reaction was carried out in the same way as the experiment just described, except that 2 g. (0.014 mole) of boron trifluoride etherate was added before the beginning of the reflux period. The product, isolated as previously described, distilled at an air-bath temperature of 150–180° at 0.1 mm. and had n^{20}_{D} 1.5802. The picrate melted at 171–173° (dec.); recrystallization from 95% ethanol–acetone raised the melting point to 175–176.5° (dec.), and the mixed melting point with samples of the picrate obtained by other routes was 175–176.5° (dec.). Hence the product was II and amine exchange had taken place. The yield was about the same as in the reaction of the hydrochloride of I with piperidine.

Summary

1-Methylgramine hydrochloride undergoes an amine exchange reaction with piperidine in refluxing hexanol, whereas 1-methylgramine does not react under the same conditions. Boron trifluoride, an acid in the Lewis sense, also catalyzes the amine exchange.

3-Piperidinomethyl-1-methylindole, the product of the amine exchange reaction, was also obtained from 1-methylindole, aqueous formaldehyde and piperidine in the presence of glacial acetic acid, and from 1-methylgramine methiodide and piperidine at the reflux temperature.

URBANA, ILLINOIS RECEIVED JULY 26, 1948

[CONTRIBUTION FROM THE UNITED STATES DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH ADMINISTRATION, BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE]

Herculin, A Pungent Insecticidal Constituent of Southern Prickly Ash Bark[1]

BY MARTIN JACOBSON

Various species of the genus *Zanthoxylum* (family *Rutaceae*) have been reported to be insecticidal. Manson[2] found a hot water extract of *Z. hamiltonianum* roots to be an effective mosquito larvicide, and concluded that the active material was a saponin. An acetone extract of "prickly ash" berries (*Zanthoxylum sp.*) was found to be effective against mosquito larvae.[3] Extracts of the dried bark of northern prickly ash, *Z. americanum* Mill., were reported to be repellent to the Japanese beetle,[4] but the ground bark was ineffective against southern armyworms, melonworms and bean leaf rollers, while petroleum ether extracts of both the bark and wood of this species showed neither toxicity to house flies nor synergism with the pyrethrins.[5] The pericarp of a species of *Zanthoxylum*, known as "hua chiao" in China, is used in that country as an anthelminthic and anesthetic.[6] The powdered leaves of southern prickly ash, *Z. clava-herculis*, were repellent to cotton caterpillars.[7] Acetone extracts of the bark of this species are reported to be toxic to mosquito larvae, but non-toxic to aphids[8] and cyclamen mites.[9]

Zanthoxylum clava-herculis L. (*Z. carolinianum* Lam., *Fagara caroliniana* Engler), commonly called southern prickly ash, Hercules' club, or toothache tree, is indigenous to the southern United States. The bark is used medicinally as an irritant and stomachic, and is available commercially. Chewing of various parts of the plant, especially the bark, gives a persistent burning, para-

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(1) Report of a study made under the Research and Marketing Act of 1946.

(2) D. Manson, *J. Malaria Inst. India*, **2**, 85 (1939).

(3) A. Hartzell and F. Wilcoxon, *Contrib. Boyce Thompson Inst.*, **12** [2], 127 (1941).

(4) F. W. Metzger and D. H. Grant, U. S. Dept. Agr. Tech. Bul. 299, 1932.

(5) Unpublished reports of this Bureau.

(6) C. W. Wang, Y. Y. Lu and T. H. Chen, *J. Pharm. Soc. China*, **2**, 13 (1944); *C. A.*, **39**, 4717 (1945).

(7) C. V. Riley, *U. S. Ent. Comm. Rept.*, **4**, 185 (1885).

(8) A. Hartzell, *Contrib. Boyce Thompson Inst.*, **13** [5], 243 (1944).

(9) L. D. Goodhue and F. F. Smith, *J. Econ. Ent.*, **37**, 214 (1944).

lyzing sensation on the lips and tongue, an effect also given by *Z. acanthopodium*,[10] fruits of *Z. piperitum*,[11] and the bark of *Z. macrophyllum*,[12] all of which are used as analgesics, particularly in cases of toothache.

In 1942 LaForge, *et al.*,[13] reported the presence in the bark of southern prickly ash of an insecticidal principle, similar to pyrethrum in its action on house flies, and a patent[14] was obtained on the use of the plant (root, bark, leaves, or fruit) as an insecticide. Asarinin, previously isolated from the bark, has been shown to increase the insecticidal effect of pyrethrum solutions.[15]

In an attempt to isolate the active material, authentic southern prickly ash bark[16] was extracted successively with petroleum ether, ethyl ether, chloroform and ethanol. Only the petroleum ether extractive was toxic, as indicated by tests against house flies, mosquito larvae, ticks and several leaf-eating insects, and as a body louse ovicide.[17] Rats fed 500 mg. oral doses per kilogram of body weight showed no toxic symptoms other than excessive salivation.[18]

The insecticidal material was extracted from the hydrocarbon solution with nitromethane, which was then removed and the residue taken up in ethyl ether. The neutral fraction, obtained following extraction with dilute acid and alkali, was extracted repeatedly with hot petroleum ether. Fractional crystallization of the hydrocarbon-soluble portion gave the pure toxic material in 0.21% yield (based on dry bark) as a crystalline solid, m. p. 59–60°.

A trace of the active material, when placed on the tongue, produced an intense burning, paralytic effect on the tongue and on the mucous membranes of the lips and mouth. It proved to have approximately the same order of paralyzing action and toxicity to house flies as the pyrethrins.

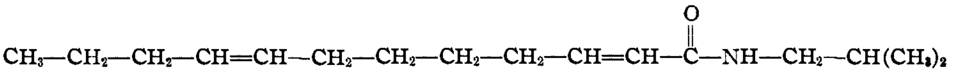
The substance, on standing overnight at room temperature, even in the dark, changed to a dark-colored resin which was neither pungent nor insecticidal. However, the active material may be kept unchanged in the cold for months, and is also stable in solution at room temperature.

The active substance, for which the name "herculin" is proposed, contained nitrogen and rapidly decolorized a dilute carbon tetrachloride solution of bromine with the formation of an insoluble oily addition product. Acid hydrolysis yielded an acid which was too unstable to be characterized, and a nitrogenous base which was identified as isobutylamine by means of melting point and chlorine determination of its hydrochloride, by melting point of the chloroplatinate, and by comparison with authentic materials. Herculin was thus established as the isobutylamide of an unsaturated acid.

Analysis and molecular weight determination indicated the formula $C_{16}H_{29}NO$ for herculin. Hydrogenation with platinum oxide catalyst showed the presence of two double bonds in the molecule, yielding tetrahydroherculin, $C_{16}H_{33}NO$, m. p. 50.5–51.0°.

Acid hydrolysis of tetrahydroherculin yielded isobutylamine and an acid fraction, m. p. 44°, which was identified as lauric acid by analysis and neutralization equivalent, by preparation of the *p*-bromophenacyl ester, m. p. 76°, and by comparison of the acid and ester with authentic specimens. Herculin was thus shown to be the N-isobutylamide of a 12-carbon straight-chain acid containing 2 double bonds, and it remained only to determine the positions of the double bonds.

This determination was accomplished by oxidation of herculin with alkaline permanganate, resulting in the isolation of butyric, adipic and N-isobutyloxamic acids. It was thus concluded that the double bonds occupy the 2- and 8-positions, showing herculin to be N-isobutyl-2,8-dodecadienamide (I).



$$CH_3—CH_2—CH_2—CH{=}CH—CH_2—CH_2—CH_2—CH_2—CH{=}CH—\overset{O}{\overset{\|}{C}}—NH—CH_2—CH(CH_3)_2 \quad (I)$$

The structure of herculin is similar to that of several other pungent isobutylamides isolated from plant materials—N-isobutyl-2,6,8-decatrienamide (II), b. p. 160–165° (0.3–0.5 mm.), isolated from *Heliopsis longipes* roots[19] (previously thought to be *Erigeron affinis*)[20]; spilanthol (N-isobutyl-4,6-decadienamide (III), b. p. 165° (1 mm.), from the flowers of *Spilanthes oleraceae*[21] and *S. acmella*[22]; and pellitorine (N-isobutyl-2,6-decadienamide) (IV), b. p. 162–165° (0.3–0.5 mm.), m.

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(10) K. N. Bagchi and H. D. Ganguly, *Ann. Biochem. Exptl. Med.*, **3** [1], 35 (1943).

(11) Y. Murayama and K. Shinozaki, *J. Pharm. Soc. Japan*, in German, **51**, 33 (1931); in Japanese, **51**, 379 (1931); *Chem. Zentr.*, **102**, II, 1867 (1931); *C. A.*, **25**, 4270 (1931).

(12) J. A. Goodson, *Biochem. J.*, **15**, 123 (1921).

(13) F. B. LaForge, H. L. Haller, and W. N. Sullivan, THIS JOURNAL, **64**, 187 (1942).

(14) F. B. LaForge and H. L. J. Haller, U. S. Patent 2,328,726, Sept. 7, 1943.

(15) (a) H. L. Haller, F. B. LaForge and W. N. Sullivan, *J. Org. Chem.*, **7**, 185 (1942); (b) H. L. Haller, F. B. LaForge and W. N. Sullivan, *J. Econ. Ent.*, **35**, 247 (1942).

(16) Obtained from S. B. Penick and Co., New York, N. Y. This material had been collected in the Mississippi–Louisiana area.

(17) The tests against house flies were made by W. A. Gersdorff; against mosquito larvae and ticks, and as a body louse ovicide by W. V. King; and against leaf-eating insects by A. P. Yerington, all of the U. S. Department of Agriculture.

(18) These tests were made by J. B. DeWitt, Patuxent Research Refuge, U. S. Fish and Wildlife Service, Laurel, Md.

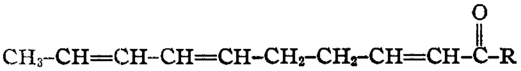
(19) M. Jacobson, F. Acree, Jr., and H. L. Haller, *J. Org. Chem.*, **12**, 731 (1947).

(20) (a) F. Acree, Jr., M. Jacobson and H. L. Haller, *J. Org. Chem.*, **10**, 236 (1945); (b) **10**, 449 (1945).

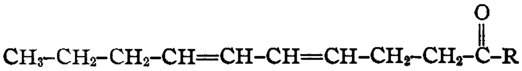
(21) (a) E. Gerber, *Arch. Pharm.*, **241**, 270 (1903); (b) M. Asano and T. Kanematsu, *Ber.*, **65B**, 1602 (1932).

(22) (a) G. S. Pendse, *et al.*, *Current Sci.* (India), **14**, 37 (1945); (b) V. G. Gokhale and B. V. Bhide, *J. Indian Chem. Soc.*, **22**, 250 (1945).

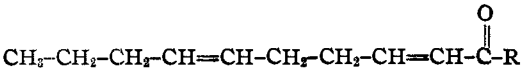
p. 72°, from *Anacyclus pyrethrum* roots.[23,24] The occurrence of a compound of this type in a member of the family *Rutaceae* is of great interest, since compounds II, III and IV have all been isolated from members of a totally unrelated family, *Compositae*. Compound II has been shown[19,20a] to be highly insecticidal, while III has been reported[22a,25] to be an effective mosquito larvicide. Although the value of compound IV as an insecticide has not been reported, preliminary investigation of the roots of *Anacyclus pyrethrum* in the laboratories of this Bureau indicates that pellitorine is insecticidal.



$$\mathrm{CH_3{-}CH{=}CH{-}CH{=}CH{-}CH_2{-}CH_2{-}CH{=}CH{-}}\overset{O}{\overset{\|}{\mathrm{C}}}\mathrm{{-}R} \quad \text{(II)}$$



$$\mathrm{CH_3{-}CH_2{-}CH_2{-}CH{=}CH{-}CH{=}CH{-}CH_2{-}CH_2{-}}\overset{O}{\overset{\|}{\mathrm{C}}}\mathrm{{-}R} \quad \text{(III)}$$



$$\mathrm{CH_3{-}CH_2{-}CH_2{-}CH{=}CH{-}CH_2{-}CH_2{-}CH{=}CH{-}}\overset{O}{\overset{\|}{\mathrm{C}}}\mathrm{{-}R} \quad \text{(IV)}$$

$$\mathrm{R = NH{-}CH_2{-}CH(CH_3)_2}$$

The possible synthesis of compound I and of related compounds is being investigated in this Laboratory.

Experimental[26]

Isolation of Herculin.—For preliminary trial, 110 g. of finely ground bark of southern prickly ash was extracted successively, in a Soxhlet extractor, with petroleum ether, b. p. 30–40° (Skellysolve A), ethyl ether, chloroform and ethanol. Only the petroleum ether extract (6.84 g., 6.2%) was toxic to insects after removal of the solvent.

Therefore, 26.3 kg. of the ground bark was extracted in a percolator with Skellysolve A until the solvent no longer came through colored. The extract was concentrated down to *ca.* 15 liters, and this was separated into five portions of 3 liters each. Each portion was then extracted three times with 300-ml. portions of nitromethane, twice with 200-ml. portions, and finally twice with 100-ml. portions of nitromethane. The combined nitromethane solution was freed of solvent under reduced pressure, the residue taken up in 2 liters of ethyl ether, and the ether solution washed thoroughly with water, 5% hydrochloric acid solution, 5% potassium hydroxide solution, and finally with water. After being dried over sodium sulfate, the ether solution of the neutral fraction was freed of solvent completely, leaving 497 g. (1.9% of the bark) of thick greenish-brown oil.

This oil was extracted repeatedly with boiling petroleum ether, b. p. 60–70° (Skellysolve B), during which time the oil partially solidified. At this point the solid material was separated from the viscous sirupy portion by filtration through silk, and both the solid portion (consisting mostly of asarinin) and the sirup were extracted separately with boiling Skellysolve B. The combined hydrocarbon solution (5 liters) was concentrated down to *ca.* 2 liters on the water pump and left in the ice-box overnight, during which time a thick brown sirup settled out. The solution was decanted and to the sirup was added 300 ml. of Skellysolve B and the mixture cooled in ice-salt with scratching. The sirup solidified and was filtered and washed with a little ice-cold solvent, leaving 60 g. of white solid, which proved to be N-(2-*p*-anisylethyl)-N-methylcinnamamide, m. p. 76°, previously isolated from the bark by LaForge.[27]

The combined Skellysolve B solution (previously decanted solution plus washings) was further concentrated to *ca.* 700 ml. and kept in the icebox overnight. The bulky gelatinous mass which separated was filtered off and washed with ice-cold Skellysolve A. Three crystallizations from Skellysolve B (using norite) gave 53 g. (0.20%) of white needles, m. p. 59–60°. Rapid cooling during crystallization caused the material to separate as a gelatinous mass resembling egg white, but slow cooling gave the substance in crystalline form.

Further concentration and cooling of the main hydrocarbon solution gave an additional 3 g. of pure active material, providing a total yield of 0.21%, based on dry bark.

The substance contained nitrogen and was soluble in all organic solvents except petroleum ether, in which it was soluble when hot, and insoluble in water, acid and alkali. It rapidly decolorized a 5% solution of bromine in carbon tetrachloride with the formation of an insoluble oily product.

Anal. Calcd. for $C_{16}H_{29}NO$: C, 76.44; H, 11.63; N, 5.57; mol. wt., 251.4. Found: C, 76.40; H, 11.42; N, 5.52; mol. wt. (Rast), 252.2.

Hydrolysis of Herculin.—A mixture of 2.13 g. of herculin, 15 ml. of ethanol, and 5 ml. of concentrated hydrochloric acid was heated in a sealed tube at 100° for seventy-two hours and then cooled. The reaction mixture was diluted with three volumes of water and then extracted with ether. The aqueous acid solution was evaporated to dryness on the steam-bath, and the residue (0.91 g.) was stirred with 15 ml. of boiling ethyl acetate and filtered. On cooling, the solution deposited 0.85 g. (92%) of shining colorless plates, m. p. 174–175° after one recrystallization from ethyl acetate. It was identified as isobutylamine hydrochloride by the mixture melting-point determination with authentic material, m. p. and mixed m. p. 174–175°.

Anal. Calcd. for $C_4H_{11}N{\cdot}HCl$: Cl, 32.35. Found: Cl, 32.10.

The chloroplatinate was prepared by the addition of 10 drops of a saturated aqueous solution of chloroplatinic acid to 100 mg. of the base-hydrochloride dissolved in 5 ml. of ethanol. The crystalline product (168 mg.) that precipitated was filtered, washed with water and ethanol, and dried. It melted at 222–223° (dec.), undepressed by admixture with an authentic specimen, 222–223°.

The ether extract of the original reaction mixture was washed free of mineral acid and dried, and the solvent was removed. The residue was refluxed for one and one-half hours with 1 g. of potassium hydroxide in 35 ml. of ethanol; the reaction mixture, after being cooled and acidified, was extracted with ether. The dried ether solution was freed from solvent, leaving a dark oily acid residue (1.5 g., 94%) which was completely soluble in dilute sodium bicarbonate solution, but which could not be characterized at this stage because of its instability.

Preparation of Tetrahydroherculin.—An ethanol solution of 0.9747 g. of herculin was hydrogenated with 50 mg. of reduced platinum oxide catalyst. In forty minutes 181 ml. (cor.) of hydrogen were taken up, and the reaction then ceased. (The theoretical requirement for 2 moles of hydrogen for the above weight of a substance of molecular weight 251 is 174 ml.). The reaction mixture was separated from the catalyst, and the solvent was removed at reduced pressure, leaving a pale yellow oil which rapidly solidified. Two recrystallizations from a small volume of Skellysolve B gave 0.9 g. (93%) of white waxy needles, m. p. 50.5–51.0°.

Anal. Calcd. for $C_{16}H_{33}NO$: C, 75.23; H, 13.02; N, 5.48. Found: C, 75.19; H, 12.97; N, 5.45.

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[23] J. M. Gulland and G. U. Hopton, *J. Chem. Soc.*, 6 (1930).

[24] The points of unsaturation in pellitorine have recently been determined in this Laboratory. This work will be reported in a separate paper.

[25] G. S. Pendse, *et al.*, *J. Univ. Bombay*, **15A**, New Ser. Pt. 3, No. 20, 26 (1946).

[26] All melting points are corrected.

[27] F. B. LaForge and W. F. Barthel, *J. Org. Chem.*, **9**, 250 (1944).

The product was found to be identical with N-isobutyllauramide, m. p. 51.5–52.0°, by mixed m. p. (51.0–51.5°) with an authentic specimen prepared in 91% yield by the following procedure. To an ice-cold solution of 5.0 g. of lauroyl chloride (Kahlbaum) in dry ether was added slowly with stirring an anhydrous ether solution of 6.7 g. (100% excess) of isobutylamine. After the mixture had stood at room temperature for two hours the precipitated amine hydrochloride was dissolved by the addition of dilute hydrochloric acid, and the ether layer was washed with water, 5% potassium hydroxide solution and water, then dried and evaporated. The residue, after two crystallizations from Skellysolve B, melted at 51.5–52.0°, literature[28] m. p. 51–52°.

Hydrolysis of Tetrahydroherculin.—Tetrahydroherculin (0.57 g.) was dissolved in 10 ml. of ethanol, 2 ml. of hydrochloric acid was added, and the mixture was heated in a sealed tube at 100° for seventy-two hours. After the reaction mixture had cooled, it was diluted with water and extracted with ether. From the aqueous acid solution there was obtained, by the procedure described under hydrolysis of herculin, 200 mg. of isobutylamine hydrochloride, m. p. 174–175°.

The ether solution was washed and dried, and the residue, following removal of solvent, was refluxed for one hour with 0.5 g. of potassium hydroxide in 10 ml. of ethanol. After the mixture had cooled, water was added and the solution was acidified and extracted with ether. The ether solution was then washed with water and dried. Removal of the solvent left a pale yellow oil that solidified on cooling. Recrystallization from dilute ethanol yielded 0.39 g. (87%) of colorless needles, m. p. 44°.

Anal. Calcd. for $C_{12}H_{24}O_2$: C, 71.95; H, 12.08; neut. equiv., 200. Found: C, 71.89; H, 11.99; neut. equiv., 201.

The acid was identified as lauric acid by mixed m. p. with an authentic specimen, m. p. 44°, and by preparation of the *p*-bromophenacyl ester, m. p. and mixed m. p. with an authentic sample 76°.

Oxidation of Herculin.—To a stirred suspension of 5 g. of herculin in 500 ml. of water, maintained at 60°, 16.8 g. of finely powdered potassium permanganate (equivalent to 4 moles of oxygen) was added in small portions. When the reaction mixture had become colorless, the manganese dioxide was filtered and washed thoroughly with warm water. The combined aqueous filtrates (*ca.* 800 ml.) were concentrated down to 50 ml. and made acid to congo red with sulfuric acid. The solution was steam-distilled to remove the volatile acids and then extracted with ether in a continuous extractor. The ether solution was freed of solvent, and the residue was extracted with three 10-ml. portions of boiling Skellysolve B. Cooling of the hydrocarbon solution caused the separation of 2.1 g. (75%) of colorless feathery needles, m. p. 106–107°, containing nitrogen.

Anal. Calcd. for $C_6H_{11}NO_3$: C, 49.64; H, 7.64; N, 9.66; neut. equiv., 145. Found: C, 49.59; H, 7.60; N, 9.71; neut. equiv., 145.

The substance was identified as N-isobutyloxamic acid by a mixture melting point determination with a synthetic sample, m. p. 107°.

The insoluble residue from the Skellysolve B extraction above was recrystallized twice from ethyl acetate to give 1.7 g. (59%) of colorless prisms melting at 151–152°.

Anal. Calcd. for $C_6H_{10}O_4$: C, 49.31; H, 6.89; neut. equiv., 73. Found: C, 49.22; H, 6.91; neut. equiv., 74.

The product was identified as adipic acid by a mixed m. p. with an authentic specimen, m. p. 152°, and by preparation of the *p*-phenylphenacyl ester, m. p. 148°.

The solution of steam-volatile acids obtained above was neutralized with sodium hydroxide solution, concentrated to a small volume on the steam-bath, and acidified to congo red with sulfuric acid. Steam distillation gave Duclaux values of 17.7, 15.9 and 14.3, checking closely with those given for butyric acid, 17.9, 15.9 and 14.6.[29]

The acid was shown to be identical with butyric acid by evaporating the neutral solution to dryness and then preparing the *p*-phenylphenacyl ester, m. p. and mixed m. p. with an authentic sample, 81–82°.

Summary

A pungent isobutylamide of an unsaturated C_{12} acid has been isolated from the bark of southern prickly ash, *Zanthoxylum clava-herculis* L. The substance, for which the name "herculin" is proposed, has approximately the same order of paralyzing action and toxicity to house flies as the pyrethrins, and is also toxic to several other species of insects.

Hydrogenation of the amide gave N-isobutyllauramide, and on oxidation it yielded butyric, adipic and N-isobutyloxamic acids.

Herculin was therefore shown to be N-isobutyl-2,8-dodecadienamide, and is closely related to several other pungent isobutylamides previously isolated from plant materials.

BELTSVILLE, MD. RECEIVED AUGUST 27, 1948

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[28] W. Deichmann-Gruebler, *J. Ind. Hyg. Toxicol.*, **21**, 48 (1939).

[29] S. M. McElvain, "The Characterization of Organic Compounds," The Macmillan Co., New York, N. Y., 1945, p. 141.