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CHEMICAL EXAMINATION OF IPOMŒA PURPUREA.

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A Contribution from the Wellcome Chemical Research Laboratories, London.

Ipomœa purpurea, Roth (syn. *Ipomœa congesta*, R. Br., *Convolvulus purpureus*, Linné, *Pharbitis hispida*, Choisy), Fam. *Convolvulaceæ*, is indigenous to the tropical regions of both hemispheres. It is largely cultivated in temperate climates on account of the beauty of its flowers, being known as the common Morning Glory (compare Gray's "Manual of Botany," sixth edition, p. 369).

The above-mentioned plant was brought to the notice of Messrs. Burroughs, Wellcome & Co., London, a few years ago by Mr. J. Medley Wood, A.L.S., Director of the Natal Botanic Gardens, Durban, South Africa, and to the kindness of Mr. Wood we are indebted for the material employed in this investigation, which was specially collected under his supervision for the purpose.

The interest pertaining to this subject depends upon the fact that the stems and roots of the respective plant, called by the natives of South Africa "i-Jalapa," are used by them as an aperient medicine, and are believed to be as valuable for this purpose as true jalap. It is, however, well known that among the 300–400 species of the genus *Ipomœa*, which are distributed throughout tropical and temperate countries, there are many which possess purgative properties similar to those of jalap, and a number of these plants, or the resins obtained from them, have in fact been employed to some extent medicinally (compare "The National Standard Dispensatory," p. 836; "United States Dispensatory," nineteenth edition, p. 675; "Pharmacographia Indica," Vol. II, pp. 527 *et seq.*).

With consideration, therefore, of the recognized value of true jalap, and also of the conditions which in recent years have so unfavorably influenced the quality of this drug, it would appear to be very desirable that such plants as are capable of affording products of similar or equal activity should be subjected to a complete chemical and physiological examination. The results of such investigations, apart from the scientific interest they may possess, would doubtless often prove useful in directing attention to the particular value of native remedies, even should their employment remain restricted to the country of their production.

A description of *Ipomœa purpurea* (Roth), with its synonymy and geographical distribution, is contained in the "Flora Capensis," Vol. IV, section 2, p. 59. London, 1904. It is stated in this work that the plant not only occurs in the Kalahari and eastern regions of South Africa, such as the Transvaal and Natal, but also in Central and South America and Australia.

A more detailed description of the same plant, under the name of *Ipomœa congesta*, R. Br., is given in the work entitled "Natal Plants," by J. Medley Wood, A.L.S., and Maurice S. Evans, M.L.A., F.Z.S., Vol. I, Part 2, p. 75. Durban, 1899. This description is accompanied by an uncolored plate, representing a flowering plant with dissections of the flower. It is likewise noted by these authors that the plant is not uncommon in the coast districts of Natal, and that it is also a native of Australia.

The material employed in this investigation evidently consisted chiefly of the ærial stems of the above-mentioned plant. It had the following general characters :—Curved, rope-like pieces, a metre or more in length, and varying in diameter from 8 millimetres in the larger pieces to 1 millimetre or less in the branches. Color, light brown; fracture, short, except in the bark, where fine, long, silky fibres project; odor and taste slight.

Experimental.

As a preliminary experiment for ascertaining the general characters of the drug, fifty grammes of the finely-ground material were extracted successively in a Soxhlet apparatus with various solvents, when the following amounts of extract, dried at 100° C., were obtained.

Petroleum (b. p. 40–60° C.)	extracted	0·17	gramme	= 0·34	per cent.
Ether	"	0·30	"	= 0·60	" "
Chloroform	"	0·34	"	= 0·68	" "
Alcohol	"	3·07	grammes	= 6·14	" "
Water	"	5·25	"	= 10·50	" "
	Total	9·13	"	18·26	" "

Determination of Total Resin.

For the determination of the total resin in the drug the following method was employed :—Fifty grammes of the finely-ground material were thoroughly extracted in a Soxhlet apparatus with hot alcohol (94 per cent). To the liquid thus obtained 25 c.c. of water were added, and the alcohol removed by distillation, after which the residue was brought into a dish and heated on a water-bath in order to remove the last traces of alcohol. The separated resin was then washed three or four times with hot distilled water, and finally dried in a water-oven until of constant weight. Two concurrent determinations yielded 2·4 grammes of resin, corresponding to 4·8 per cent. of total resin in the drug. The proportion of this crude resin which was soluble in ether, as determined by its complete extraction with the latter solvent in a Soxhlet apparatus, corresponded to 15·5 per cent. of its weight.

Optical Rotation of the Crude Resin.

It has been indicated by P. Guigues[1] that the specific optical rotatory power of certain convolvulaceous resins is a factor which may be utilized for discriminating between them, and for the detection of substitutes and adulterants. Thus the resin of scammony, obtained from the root, is said to have a rotation varying from — 18° 30′ to —23° 30′, whereas the upper limit for the resin from the natural gum-resin scammony is — 25°. Resins having a rotation between — 23° 30′ and —25° are considered to be derived from *Ipomœa orizabensis*, Ledanois. The addition to the above products of official jalap resin or that of *Ipomœa turpethum*, R.Br., increases the rotation, while an admixture of colophony, sandarac or mastic would lower it, since the latter are dextrorotatory.

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[1] *Journ. de Pharm. et de Chim.* [6], 22, 241, and *Chem. Centralblatt*, 1907, Bd. I, p. 309.

In order to determine the value of this factor in connection with the resin under investigation, the method suggested by Guigues was employed. About 2·5 grammes of the crude resin were dissolved in 50 c.c. of alcohol, and the solution boiled with successive small portions of animal charcoal until it became practically colorless. The rotation of this liquid was then observed in a 1 dcm. tube, after which 10 c.c. of the liquid were evaporated to dryness, the residue dried at 105—110° C., and weighed. The initial rotation in a 1 dcm. tube having been found to be —42′, and as the amount of solid substance in 10 c.c. of the liquid was 0·1374 gramme, the specific rotatory power of the resin is $[a]_D$ — 50·95°.

Preliminary Extraction of the Crude Resin with Different Solvents.

In order to ascertain the general character of the crude resin, an amount of the latter obtained from 100 grammes of the drug (4·8 grammes) was dissolved in alcohol, mixed with purified sawdust, and the thoroughly dried mixture extracted successively in a Soxhlet apparatus with various solvents. The percentages of extract, dried at 110° C., were as follows:

		Per cent.
Petroleum (b. p. 40–60° C.)	extracted	8.0
Ether	"	7·3
Chloroform	"	9·8
Ethyl acetate	"	23·8
Alcohol	"	49·0
Loss		2·1
		100·0

For the further complete examination of the drug a quantity (43¼ pounds = 19·6 kilograms) of the ground material was completely extracted with hot alcohol. The extract thus obtained, after the removal of the greater portion of the alcohol, was brought into a large flask, some water added, and the mixture distilled in steam until volatile products ceased to pass over. A turbid distillate was thus obtained, from which a few oily drops separated on the surface. After this operation there remained in the distilling vessel a dark-colored, aqueous liquid (*A*), which possessed an agreeable, fruity odor, and a quantity of soft, very dark greenish resin (*B*), which was thoroughly washed with warm water and the washings added to the aqueous liquid.

Examination of the Steam Distillate.

The distillate was extracted with ether, the ethereal liquid being dried with anhydrous sodium sulphate, and the ether removed. A small amount of an essential oil was thus obtained which, when distilled under a pressure of 35 mm., passed over between 90 and 180° C. It had a pale yellow color, a strong characteristic odor, and the following constants: $d\ 20^\circ/20^\circ = 0{\cdot}9085$; $\alpha_D - 4^\circ\ 52'$ in a 1 dcm tube. The amount of this essential oil was 3·5 grammes, corresponding to 0·018 per cent. of the weight of the drug.

Examination of the Aqueous Liquid (A).

The aqueous liquid remaining in the steam distillation flask was separated from the previously mentioned soft resin, and, together with the washings from the latter, evaporated to a small volume. It then formed a very dark, syrupy liquid, which, on standing, deposited a quantity of crystals amounting to about 40 grammes. These were separated, and washed with a little alcohol, when on further examination they were found to be entirely inorganic, and to consist of a mixture of potassium chloride and nitrate.

The syrupy liquid was subsequently diluted with water, and treated with a slight excess of solution of basic lead acetate, when an abundant, deep yellow precipitate was produced. This was collected on a filter and washed with water, the washings being added to the filtrate.

Basic Lead Acetate Precipitate.—This was suspended in water, decomposed with hydrogen sulphide, and the lead sulphide removed by filtration. The filtrate had an orange-yellow color and gave a greenish-brown coloration with ferric chloride, indicating the presence of a small amount of tannic matter. When concentrated, it formed a dark brown syrup. As the latter deposited nothing of a crystalline character on standing, it was extracted with ether, and the ethereal liquid shaken with successive portions of a solution of sodium carbonate. The first two extractions with alkali were of a red color, and, when diluted, showed a blue fluorescence, whereas the subsequent extractions were colorless. The alkaline liquids were then acidified and extracted with ether, but only a trace of an amorphous, reddish substance was obtained. The original ethereal liquid which had been shaken with alkali was dried and the ether removed, but it gave practically no residue.

Filtrate from the Basic Lead Acetate Precipitate.—This was treated with hydrogen sulphide for the removal of the lead, the mixture filtered, and the filtrate concentrated under diminished pressure to the consistency of a thick syrup. The latter, on cooling, deposited a further quantity of the above-mentioned mixture of potassium chloride and nitrate. The syrupy liquid, amounting to about 250 grammes, only reduced Fehling's solution very slowly on heating, and no osazone could be obtained directly from it. It was therefore mixed with purified sawdust, the mixture thoroughly dried in a vacuum, and extracted successively in a Soxhlet apparatus with ethyl acetate, absolute alcohol, and water. The amounts removed by these solvents were about 20, 190 and 40 grammes, respectively. Both the ethyl acetate and alcohol extracts were uncrystallizable syrups, and only reduced Fehling's solution after heating with a dilute mineral acid. They then afforded crystalline osazones, melting at 213–214° C., thus indicating that by the treatment with acid hydrolysis had ensued with the production of glucose. In both cases during the hydrolysis a peculiar, fragrant odor was developed, and on distilling the liquid the aromatic substance was found to be volatile in steam, but it was only small in amount, and did not afford a reaction for furfural or other aldehydes. The final aqueous extract formed a thick syrup, which, in distinction from the above-mentioned ethyl acetate and alcohol extracts, reduced Fehling's solution directly on heating, although slowly. After hydrolysis, however, the reduction was effected immediately, and it then afforded *d*-phenylglucosazone, melting at 210–211° C. With the exception, therefore, of the previously mentioned inorganic salts, nothing of a crystalline character could be isolated from the original aqueous liquid.

Examination of the Resin (*B*).

For the purpose of completely examining the resinous material the previously mentioned, soft, dark-colored mass was thoroughly mixed with prepared sawdust, the mixture dried, and extracted successively in a Soxhlet apparatus with the following solvents: (I) Petroleum (b. p. 40–60° C.), (II) Ether, (III) Chloroform, (IV) Ethyl acetate, (V) Alcohol.

I. *Petroleum Extract of the Resin.*

This was a soft, thick extract, possessing a deep green color. It was hydrolyzed by heating with an alcoholic solution of an excess of potassium hydroxide, the alcohol then removed, and the residual thick, green liquid poured into a large volume of water. The strongly alkaline liquid was extracted six times with ether, the combined ethereal solutions washed with water, dried with calcium chloride, and the ether removed, when a dark-colored liquid was obtained which, on cooling, solidified to a crystalline mass. This was dissolved in alcohol, the solution heated with animal charcoal, and filtered, when, on cooling, a quantity of a solid substance separated, which was collected on a filter and spread on a porous plate. After being again subjected to the same process of purification, it was finally distilled under a pressure of 15 m.m., ween it was obtained as a white, silky mass. This was crystallized from ethyl acetate, from which it separated in small, lustrous leaflets, melting sharply at 74–75° C.

0·0794 gave 0·2480 CO_2 and 0·1042 H_2O. C = 85·2; H = 14·6
$C_{35}H_{72}$ requires C = 85·4; H = 14.6 per cent.

The above described substance was thus identified as pentatriacontane.

The alcoholic mother-liquors from the first crystallization of the pentatriacontane were concentrated and allowed to stand, when a further portion of a solid substance separated. This was collected, dried on a porous plate, and subsequently crystallized several times from a mixture of ethyl acetate and alcohol containing a little water. It was then obtained in colorless laminæ, melting at 132–133° C., and afforded the color reactions characteristic of the phytosterols. On analysis it gave the following results:

0·1912 of the air-dried substance when heated to 105° C. lost 0·0090.
H_2O = 4·7
0·0682 of anhydrous substance gave 0·2094 CO_2 and 0·0722 H_2O
C = 83·7; H = 11·8
$C_{27}H_{46}O, H_2O$ requires H_2O = 4·5 per cent.
$C_{27}H_{46}O$ requires C = 83·9; H = 11·9 per cent.

This substance was thus identified as a phytosterol. Its optical rotatory power was determined with the following result:—
0·2336 of anhydrous substance, dissolved in 25 c.c. of chloroform, gave a_D — 0·36° in a 2 dcm. tube, whence $[a]_D$ — 32·1°.

From the character of this phytosterol it would appear probable that it is identical with sitosterol (compare *Chem. Centralblatt*, 1902, Bd. I, p. 743, and 1903, Bd. I, p. 980).

The strongly alkaline, aqueous liquid resulting from the hydrolysis of the petroleum extract, and from which the pentatriacontane and phytosterol had been extracted by means of ether, was concentrated to a small bulk, acidified with sulphuric acid, and distilled with steam. The distillate had an acid reaction, and in the first portions some oily drops were observed. It was therefore extracted with ether, the ethereal solution being washed with a little water, dried with calcium chloride, and the ether removed, when a small amount of a pale-yellow, oily acid was obtained. This was neutralized with ammonia, and, by fractional precipitation with a solution of silver nitrate, several silver salts were prepared, which were washed, dried in a vacuum over sulphuric acid, and analyzed.

(I) 0·2004 of salt gave on ignition 0·0728 Ag. Ag = 36·3
(II) 0.0760 " " " 0·0300 Ag. Ag = 39.5
(III) 0·0112 " " " 0·0046 Ag. Ag = 41·1
$C_9H_{17}O_2$ Ag requires Ag = 40·8 per cent.
$C_{11}H_{21}O_2$ Ag " Ag = 36·9 " "

The results of these analyses indicate the volatile oily product to be a somewhat complex mixture of acids, and no conclusion can be drawn respecting the identity of the latter.

The aqueous distillate, after extraction with ether, still contained a small amount of acid which was converted into a barium salt. This yielded reactions indicating the presence of both formic and butyric acids.

After the removal of the volatile acids by distillation with steam, the contents of the distillation flask, when allowed to cool, consisted of a yellowish liquid, on the surface of which a quantity of a green solid substance had separated. This was removed, dissolved in ether, and the ethereal liquid extracted with a solution of sodium carbonate. There then remained in the ether but a small quantity of substance which, when purified, was obtained in the form of colorless crystals, melting at 74–75° C. This evidently consisted of pentatriacontane, which had escaped extraction by the treatment of the alkaline product of hydrolysis with ether. The sodium carbonate extract was acidified, when a green product was precipitated, which was treated with light petroleum, a small amount of tarry matter remaining undissolved. The petroleum solution was warmed with a little animal charcoal, filtered, and the solvent removed, when a green colored mass was obtained. This was distilled under 15 mm. pressure, when it passed over for the most part at 230° C. as a pale yellow oil, which solidified on cooling to a nearly white, crystalline mass, and amounted to 4·5 grammes. The solid was dissolved in hot alcohol, from which, on cooling, the greater portion separated, and, after drying, melted at 60–62° C. This portion was converted into a lithium salt, and the acid regenerated from the latter obtained in two fractions. The first of these melted at 66–68° C., and was analyzed with the following result:

0·0730 gave 0·2036 CO_2 and 0·0826 H_2O. C = 76·1 ; H = 12·6.
$C_{18}H_{36}O_2$ requires C = 76·1 ; H = 12·7 per cent.

This substance was evidently stearic acid.

The second fraction of acid melted at 60–62° C., and was also analyzed.

0·0600 gave 0·1660 CO_2 and 0·0696 H_2O. C = 75·4; H = 12·9
$C_{16}H_{32}O_2$ requires C = 75·0; H = 12·5 per cent.
$C_{18}H_{36}O_2$ " C = 76·1 ; H = 12·7 " "

The characters of this second fraction indicated it to consist of a mixture of palmitic and stearic acid.

The alcoholic mother-liquor from the crystallization of the above mentioned acids was tested for the presence of unsaturated acids by treatment with an alcoholic solution of lead acetate, and digesting the precipitated lead salt with ether. The portion of salt dissolved by the ether was decomposed with hydrochloric acid, when a very small amount of an oily acid was obtained. The latter, when dissolved in chloroform, decolorized a solution of bromine in the same solvent, thus indicating the presence of some unsaturated acid.

II. *Ether Extract of the Resin.*

This extract was a hard, dark green, brittle resin.

Fusion with Potassium Hydroxide.—Forty grammes of the resin were fused with 240 grammes of potassium hydroxide in a nickel basin, the temperature of the mixture being kept for some time at 200° C., and finally increased to 260° C., when the mass became thick and pasty. After being allowed to cool, it was dissolved in water, the liquid acidified with sulphuric acid, and distilled with steam. The first portion of the distillate contained a brown-colored oil of disagreeable odor floating on the surface. The entire distillate was therefore first extracted with ether in order to remove the oily acid, the ethereal liquid being washed, dried, and the solvent removed. The product thus obtained was distilled under a pressure of 50 mm., when it passed over as a dark yellow oil, showing no constant boiling-point, and amounted to 1·5 grammes. A portion of the acid was converted into the ammonium salt, and from this, by fractional precipitation with a solution of silver nitrate, two silver salts were prepared, which were analyzed with the following results:

(I) 0·1574 of salt gave on ignition 0·0616 Ag. Ag = 39·1
(II) 0·0982 " " " " 0·0410 Ag. Ag = 41·7
$C_9H_{17}O_2$ Ag requires Ag = 40·8 per cent.
$C_{10}H_{19}O_2$ Ag " Ag = 38·7 " "

It is evident from these results that the oily acids represent a mixture of somewhat indefinite composition.

The aqueous distillate, after extraction with ether, still contained some acid, which was converted into a barium salt, of which about 7 grammes were obtained. This salt afforded reactions indicating the presence of formic and butyric acids. After drying at 110° C. it was analyzed:

0·2866 of the dried salt gave 0·2580 $BaSO_4$. Ba = 52·9.
$(CHO_2)_2$ Ba requires Ba = 60·4 per cent.
$(C_4H_7O_2)_2$ Ba " Ba = 44·1 " "

This salt would thus appear to have consisted of barium formate and butyrate in about equal proportions.

After the removal of the volatile acids by steam, as above described, there remained in the distillation flask a quantity of resin and an aqueous liquid, which were separated by filtration. The aqueous liquid was extracted with ether, and from this ethereal liquid, after the removal of the solvent, a small amount of a dark red syrup was obtained. The latter, when dissolved in water, yielded with ferric chloride the characteristic catechol reaction, and, after treatment with animal charcoal, deposited a very small amount of a substance in the form of small, crystalline plates. This substance melted sharply at 103–104° C., was acid to litmus, and gave no coloration with ferric chloride, but yielded precipitates with solutions of silver nitrate and lead acetate. It appeared to be identical with an acid which was subsequently obtained in larger amount by the fusion of the alcohol extract of the resin with potash, and which proved to be azelaic acid. The mother-liquor from this acid deposited an exceedingly small amount of a crystalline substance which gave the above described coloration with ferric chloride, but it could not be obtained in a pure state.

Treatment with Dilute Alcoholic Sulphuric Acid.—Thirty grammes of the resin were dissolved in alcohol, and such an amount of sulphuric acid added, with a little water, that the total liquid contained about 5 per cent. of its weight of acid. The liquid was then heated in a reflux apparatus on the water-bath for about four hours, after which the alcohol was removed, and the residue subjected to distillation in a current of steam. The distillate, which contained a small amount of oil floating on the surface, was extracted with ether, the ethereal liquid being first washed with a little water, and then shaken with a solution of sodium carbonate in order to remove any acids present. After this treatment the ethereal liquid was dried with calcium chloride and the ether removed, when a small amount of a dark green oil was obtained. This was first distilled under a pressure of 10 mm., and then at the ordinary pressure, but as the range of temperature at which it passed over was very wide, it was evidently a complicated mixture. The amount of neutral oil thus obtained was 1·8 grammes. It was a pale yellow liquid, having a rather agreeable odor.

The alkaline liquid obtained by extraction of the original oily product with sodium carbonate was acidified, and extracted with ether, the ethereal liquid being washed, dried with calcium chloride, and the solvent removed. A small amount of an oily acid was thus obtained, which was converted into an ammonium salt, and from this a silver salt was prepared. The latter was washed, dried in a vacuum over sulphuric acid, and analyzed.

0·1288 of salt gave on ignition 0·0498 Ag. Ag = 38·7

$C_{10}H_{19}O_2$ Ag requires Ag = 38·7 per cent.

The figures obtained by this analysis are seen to be in exact agreement with those required for the silver salt of a decylic acid, although it is probable that the acid was a mixture.

The aqueous distillate which had been extracted with ether still contained a small amount of acid, which was converted into a barium salt, and this yielded reactions indicating the presence of formic and butyric acids.

After the removal of the volatile products of hydrolysis by distillation with steam there remained in the distillation flask a quantity of greenish-black resin and a dark-colored, aqueous liquid, which were separated by filtration. From the resinous substance nothing of a crystalline nature could be obtained. The acid, aqueous liquid was first extracted with ether, which removed only a very small quantity of a syrupy substance, and the sulphuric acid then removed by means of baryta. After filtration the liquid was concentrated, when about 3 grammes of a syrup were obtained which instantly reduced Fehling's solution on heating, and when treated with phenylhydrazine acetate yielded *d*-phenylglucosazone, thus indicating the presence of glucose. This syrupy liquid also contained a small amount of a readily soluble organic acid.

III. *Chloroform Extract of the Resin.*

This extract formed a brown mass, which could readily be powdered. Its solution in chloroform was first repeatedly extracted with a solution of sodium carbonate, but this removed only a very small amount of an amorphous, acidic substance.

Fusion with Potassium Hydroxide.—Twenty grammes of the resin were fused with 120 grammes of potassium hydroxide, the operation being conducted in the same manner as has been described in connection with the ether extract. The cooled mass, when dissolved in water, acidified with sulphuric acid, and distilled with steam, yielded a small amount of oily acid. This was extracted with ether, converted into an ammonium salt, and from the latter three fractions of silver salt were prepared and analyzed:

(I) 0·1364 of salt gave on ignition 0·0516 Ag. Ag = 37·8
(II) 0·0644 " " " 0·0260 Ag. Ag = 40·4
(III) 0·0494 " " " 0·0206 Ag. Ag = 41·7

$C_9H_{17}O_2$ Ag requires Ag = 40·7 per cent.
$C_{11}H_{21}O_2$ Ag " Ag = 36·9 per cent.

The volatile acids remaining in the distillate after extraction with ether were neutralized with baryta, when about 2 grammes of a barium salt were obtained. This afforded reactions indicating the presence of formic and butyric acids, and, after drying at 110° C., was analyzed with the following result:

0·4848 of the dried salt gave 0·4420 $BaSO_4$. Ba = 53·7
$(CHO_2)_2$ Ba requires Ba = 60·4 per cent.
$(C_4H_7O_2)_2$ Ba " Ba = 44·1 per cent.

This salt would thus appear to have consisted of barium formate and butyrate in approximately equal proportions.

The liquid contained in the distillation flask was separated from a quantity of resin and extracted with ether, which removed a very small quantity of substance in the form of a syrup. This gave with ferric chloride the catehol reaction, but nothing of a crystalline nature could be obtained from it.

Treatment with Dilute Alcoholic Sulphuric Acid.—Twenty grammes of the resin were dissolved in alcohol, and such an amount of sulphuric acid added with a little water, that the total liquid contained about 5 per cent. of its weight of acid. After heating for about four hours in a reflux apparatus, the alcohol was removed and the residue distilled with steam. The distillate, which contained some oily drops, was extracted with ether, the ethereal liquid shaken with a solution of sodium carbonate, and the alkaline liquid separated. After the removal of the ether a very small amount (0·5 gramme) of a pale yellow, neutral oil was obtained, which was very similar in character to that described in connection with the ether extract of the resin. The acid extracted from the ethereal solution of the original oily liquid by means of sodium carbonate was converted into an ammonium salt, from which two fractions of silver salt were prepared and analyzed.

(I) 0·0352 of salt gave on ignition 0·0132 Ag. Ag = 37·5
(II) 0·0324 " " " " " 0·0134 Ag. Ag = 41·4
$C_9H_{17}O_2$ Ag requires Ag = 40·7 per cent.
$C_{11}H_{21}O_2$ Ag " Ag = 36·9 " "

The acids remaining in the aqueous distillate after extraction with ether were converted into a barium salt, of which about 1 gramme was obtained. This gave reactions indicating the presence of formic and butyric acids.

After the removal of the above described volatile products by distillation with steam, there remained in the distillation flask a quantity of resinous substance and an aqueous liquid. The latter, after the removal of the sulphuric acid, yielded about 1·5 grammes of a syrup in which, by the formation of *d*-phenylglucosazone, the presence of glucose was determined. This syrupy liquid also contained a small amount of a readily soluble organic acid.

From these results it will be seen that the chloroform extract of the resin, by treatment with dilute sulphuric acid, yielded products very similar in character to those obtained from the ether extract.

IV. *Ethyl Acetate Extract of the Resin.*

This extract, as originally obtained, was allowed to stand for some time without removing the solvent, when it deposited a considerable quantity of a brown, viscid resin, together with a small amount of a slightly colored, flocculent substance. The ethyl acetate liquid was decanted from these products, which were then treated with alcohol, when most of the flocculent substance remained undissolved, and was separated by filtration. The alcoholic filtrate, after being boiled with animal charcoal and again filtered, was concentrated to a small bulk, when a little more of the flocculent substance was obtained. The ethyl acetate liquid, which had been decanted from the above-mentioned products, was concentrated, when a further small amount of the flocculent substance separated, and was removed by filtration. This filtrate was finally mixed with the alcoholic solution of the viscid resin and the solvents removed, the residual product thus representing the total resin extracted by ethyl acetate, deprived so far as possible of the small amount of light colored, flocculent solid.

Isolation of a New Dihydric Alcohol, Ipuranol, $C_{23}H_{38}O_2(OH)_2$.

The several portions of flocculent solid described above were mixed, dissolved in alcohol, and the solution boiled with animal charcoal. After filtering, and concentrating the liquid, the substance separated in a perfectly white condition. The amount obtained was only about 0·2 gramme. When heated on platinum-foil it first charred, and then burned with a smoky flame, leaving finally no residue. It was very sparingly soluble in alcohol or ethyl acetate, and quite insoluble in water, even when hot. Its alcoholic solution was neutral to litmus. The substance was not decomposed by dilute acids or alkalis, even on boiling. It was found to be freely soluble in pyridine, and was therefore dissolved in a hot, aqueous solution of this solvent, from which, on cooling, it separated in its original form. After drying, it was finally dissolved in hot alcohol, and the pure white *substance* which separated on cooling then melted at 285–290° C., and was analyzed:

0·0708 gave 0·1884 CO_2 and 0·0676 H_2O. $C = 72·6$; $H = 10·6$

$C_{23}H_{40}O_4$ requires $C = 72·6$; $H = 10·5$ per cent.

From the remaining portion of the substance an *acetyl derivative* was prepared. The latter, when crystallized from acetic anhydride, was obtained in pearly leaflets, melting sharply at 160° C., but the amount was too small for analysis.

A substance possessing the same empirical formula as that of the above-described compound, namely, $C_{23}H_{40}O_4$, and having the same properties, has recently been isolated in these laboratories from olive bark, and has proved to be a new dihydric alcohol. As the acetyl derivatives of these two preparations have the same melting point, which is not altered when they are mixed, it is evident that the two alcohols are identical. It has thus been possible to establish the correctness of the formula assigned to the above-described substance, and, in view of its being a new alcohol, it is proposed to designate it *ipuranol*.

The resinous portion of the ethyl acetate extract was finally obtained in the form of a yellowish-brown powder. This was subjected to the same treatment as has been described in connection with the ether and chloroform extracts of the resin.

Fusion with Potassium Hydroxide.—Thirty grammes of the resin were fused with 160 grammes of potassium hydroxide, the operation being conducted in the same manner as has been described in connection with the ether extract. The cooled mass, which was very light in color, was dissolved in water, the solution acidified with sulphuric acid, and distilled with steam. The distillate, which contained some dark brown, oily drops, was extracted with ether, the ethereal solution being washed, dried with calcium chloride, and the ether removed. A dark brown, oily liquid was thus obtained, which amounted to 1·5 grammes. This was distilled under a pressure of 40 mm., when it passed over within a wide range of temperature as a light brown oil which darkened in color on standing. A portion of this oily acid was converted into an ammonium salt, from which two fractions of silver salt were prepared and analyzed:

(I) 0·1302 of salt gave on ignition 0·0490 Ag. $Ag = 37·6$
(II) 0·1156 " " " " " 0·0484 Ag. $Ag = 41·9$
$C_8H_{15}O_2$ Ag requires $Ag = 43·0$ per cent.
$C_{10}H_{19}O_2$ Ag " $Ag = 38·7$ " "

The acids remaining in the aqueous distillate after extraction with ether were converted into a barium salt, of which about 8 grammes were obtained. This afforded reactions which established the presence of formic and butyric acids. After drying at 110° C., it was analyzed with the following result:

0·5934 of the dried salt gave 0·5242 $BaSO_4$. $Ba = 52·0$
$(CHO_2)_2$ Ba requires $Ba = 60·4$ per cent.
$(C_4H_7O_2)_2$ Ba " $Ba = 44·1$ " "

This salt would thus appear to have consisted of barium formate and butyrate in about equal proportions.

The liquid remaining in the distillation flask after the removal of the volatile acids with steam was separated by filtration from the resin and extracted with ether, but this yielded only a very small amount of an amorphous substance which gave a green coloration with ferric chloride.

Treatment with Dilute Alcoholic Sulphuric Acid.—Thirty grammes of the resin were dissolved in alcohol, and such an amount of sulphuric acid added, with a little water, that the total liquid contained about 5 per cent. of its weight of acid. After heating for about four hours in a reflux apparatus the alcohol was removed, and the residue distilled with steam. The distillate, which contained some oily drops, was extracted with ether, the ethereal liquid shaken with a solution of sodium carbonate, and the alkaline liquid separated. After the removal of the ether a small amount (0·7 gramme) of an aromatic, neutral oil was obtained, which was very similar in character to that produced under the same conditions from the ether and chloroform extracts of the resin. This oil was distilled under a pressure of 40 mm., when it passed over up to a temperature of 170° C. The acid extracted from the original oily liquid by means of sodium carbonate was obtained as a yellow oil which was converted into an ammonium salt, and from the latter three fractions of silver salt were prepared and analyzed.

(I) 0·1300 of salt gave on ignition 0·0514 Ag. Ag = 39·5
(II) 0·0974 " " " 0·0416 Ag. Ag = 42·7
(III) 0·0464 " " " 0·0198 Ag. Ag = 42·7
$C_8H_{15}O_2$ Ag requires Ag = 43·0 per cent.
$C_{10}H_{19}O_2$ Ag " Ag = 38·7 per cent.

The acids remaining in the aqueous distillate after extraction with ether were converted into a barium salt. This was at first syrupy, but soon solidified almost completely, and amounted to about two grammes. It afforded reactions, indicating the presence of formic and butyric acids. The salt was first brought on to a porous tile to deprive it of a little mother-liquor, then recrystallized three times from water, and, after being heated to 110° C. until of constant weight, was analyzed.

0·4028 of the dried salt gave 0·3574 $BaSO_4$. Ba = 52·2
$(CHO_2)_2$ Ba requires Ba = 60·4 per cent.
$(C_4H_7O_2)_2$ Ba " Ba = 44·1 per cent.

This salt thus appears to have consisted of barium formate and butyrate in about equal proportions. From the above results it is also seen that the volatile acids formed by the treatment of the resin with dilute sulphuric acid are very similar in character to those produced by its fusion with potassium hydroxide.

The dark yellow, aqueous liquid remaining in the distillation flask was filtered from the resin and extracted with ether, the ethereal liquid being dried with calcium chloride and the ether removed. A very small quantity of an acid, oily liquid was thus obtained, which gave a brown coloration with ferric chloride. The aqueous liquid which had been extracted with ether, was treated with baryta for the removal of the sulphuric acid, filtered, and the filtrate concentrated, when a small amount of a syrupy liquid was obtained, which immediately reduced Fehling's solution on heating, and yielded *d*-phenylglucosazone, thus indicating the presence of glucose. This syrupy liquid also contained a readily soluble organic acid.

The resin which was separated from the acid liquid after distillation with steam, as above described, was dried, dissolved in alcohol, and mixed with purified sawdust. The thoroughly dried mixture was then extracted successively in a Soxhlet apparatus with light petroleum and ether, but only relatively small amounts of resinous products of an acidic nature were thus obtained.

V. *Alcohol Extract of the Resin.*

This constituted by far the largest proportion of the total resin, and, when dry, could readily be reduced to a very light brown, mobile powder.

In order to insure the freedom of this resin from substances soluble in water, it was dissolved in alcohol and reprecipitated by the addition of water. Its further purification was effected by heating the alcoholic solution with a little pure animal charcoal. After filtering the liquid and removing the solvent a very light colored product was obtained, which, when dry, could be reduced to a perfectly white powder.

The resin, purified as above described, after being dried at 110° C. was found to soften at 140° C., and to melt somewhat indefinitely between 150 and 160° C. When heated on platinum-foil it fuses, chars, and burns with a smoky flame, leaving finally no visible residue. With cold, concentrated sulphuric acid it gives only a light brown color, whereas with nitric acid no coloration is produced.

The optical rotatory power of this purified resin was determined in the same manner as has been described in connection with the crude resin. An alcoholic solution containing 1·3070 gramme of the resin in 25 c.c. had an initial rotation of — 2·7° in a 1 dcm. tube, whence $[\alpha]_D$ — 51·64°.

With the endeavor to ascertain whether this resin is homogeneous in character, 10 grammes of it were dissolved in 100 c.c. of alcohol, and to this solution was added an alcoholic solution of lead acetate. As no precipitate was produced, an alcoholic solution of ammonia was subsequently added in slight excess, when an abundant precipitate was obtained. This precipitate was collected, well washed with alcohol, then suspended in alcohol, and decomposed by hydrogen sulphide. After the removal of the lead sulphide by filtration, the liquid was concentrated to a small bulk, and ether added to precipitate the resin, which was subsequently dissolved in a little alcohol, the solution evaporated, and the residue dried. The weight of the resin which had thus been precipitated by the basic lead acetate was 6 grammes. The alcoholic filtrate from the basic lead acetate precipitate was deprived of lead by means of hydrogen sulphide, and, after filtration, concentrated to the consistency of a syrup. On the subsequent addition of ether a quantity of resin was precipitated, which, when collected and dried, was found to weigh 3 grammes. This resin, when again dissolved in alcohol and treated with basic lead acetate as before, yielded a further small quantity of a precipitate from which, after treatment with hydrogen sulphide, about 1 gramme of dry resin was obtained. The filtrate from this second precipitation, after removal of the lead, yielded finally 2 grammes of resin, the alcoholic solution of which was no longer precipitated by basic lead acetate.

The result of the above experiment would appear to indicate that the alcohol extract of the resin, notwithstanding the various methods of purification to which it had been subjected, was still not a homogeneous or individual substance.

Destructive Distillation of the Resin under Diminished Pressure.—It was thought of some interest to ascertain the character of the products afforded by the dry distillation of the purified alcohol extract of the resin, especially when this operation was conducted under greatly diminished pressure. For the purpose of this experiment 10 grammes of the dry resin were brought into a small distillation flask, which was connected with a receiver, and the apparatus evacuated to a pressure of 20 mm. On heating gently, the resin first melted, then fumes were evolved, and, on gradually increasing the temperature, a viscid red liquid passed over, until finally, at 280° C./20 mm., the distillation was stopped. The amount of this liquid was 2 grammes, or one-fifth of the weight of resin employed, the remainder having been chiefly converted into a brittle, black mass. The distillate was almost entirely soluble in ether, and on shaking the ethereal liquid with a solution of sodium carbonate the greater portion of the dissolved substance was removed, thus indicating it to be of an acidic nature, while a further small amount was removed by subsequent extraction with a solution of sodium hydroxide, a little finally remaining in the ethereal liquid. The amount of these products was not sufficient for their further examination, and they did not appear to be of sufficient interest to justify the use of larger quantities of the resin in this manner. It may be noted in this connection that Klimenko and Bandalin[1] have recorded an experiment in which they subjected 600 grammes of "jalapin" to dry distillation, and obtained therefrom 285 grammes of a viscid,

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[1] *Ber. d. deutsch. chem. Ges.*, 1893, 26, IV, 591.

reddish-brown liquid. By the fractional distillation of this product they established the presence of acetic, tiglic, and palmitic acids. As, however, there is no indication that the resin employed by them had been freed from substances soluble in petroleum, it is probable that the palmitic acid pre-existed, and was not produced by the destructive distillation.

Fusion with Potassium Hydroxide.—Twenty grammes of the resin were fused with 120 grammes of potassium hydroxide in the manner described in connection with the ether extract of the resin. The reaction was particularly vigorous between 220 and 230° C., the temperature of the mass having been finally raised to 250° C. After allowing the mass to cool, it was dissolved in water, the solution acidified with sulphuric acid, and then subjected to distillation with steam. The distillate, which contained some oily drops, was extracted with ether, the ethereal solution being washed with water, dried with calcium chloride, and the ether removed, when about 2 grammes of oily acid were obtained. This was distilled under 30 mm. pressure, and the distillate collected in the following three fractions: (1) below 110°; (2) 110–120°; (3) above 120° C./30 mm. The fractions (1) and (2) were analzyed.

Fraction below 110° C./30 mm.

0·0996 gave 0·2074 CO_2 and 0.0874 H_2O. $C = 56·8$; $H = 9·7$

Fraction 110–120° C./30 mm.

0·1290 gave 0·2746 CO_2 and 0·1120 H_2O. $C = 58·1$; $H = 9·6$

$C_4H_8O_2$ requires $C = 54·5$; $H = 9·1$ per cent.

$C_5H_{10}O_2$ " $C = 58·8$; $H = 9·8$ " "

From these results it may be concluded that the above two fractions consisted chiefly of mixtures of butyric and valeric acids.

Fraction above 120° C./30 mm.

From this fraction a silver salt was prepared, which, after being well washed with water and dried in a vacuum, was analyzed.

0·1834 of salt gave on ignition 0·0790 Ag. Ag. = 43·1

0·1874 " " " 0·0806 Ag. Ag. = 43·0

$C_8H_{15}O_2$ Ag requires Ag = 43·0 per cent.

Although the results of these analyses are in agreement with the figures required for silver octoate, it is not probable that the fraction consisted of a pure substance.

The acids remaining in the aqueous distillate after extraction with ether were converted into a barium salt, of which 13·5 grammes were obtained. This salt afforded reactions which established the presence of formic and butyric acids. After drying at 110° C. it was analyzed with the following result:

0 5178 of the dried salt gave 0·4532 $BaSO_4$. Ba = 51·5
$(CHO_2)_2$ Ba requires Ba = 60·4 per cent.
$(C_4H_7O_2)_2$ Ba " Ba = 44·1 " "

From these results it may be inferred that this salt consisted of barium formate and butyrate in nearly equal proportions.

The liquid remaining in the distillation flask after the removal of the volatile acids by steam was very light in color, and contained practically no resin. It was extracted with ether, the ethereal liquid being washed, dried with calcium chloride, and the ether removed, when a small amount of an oily liquid was obtained, which, on cooling, solidified to a crystalline mass. The substance was acid to litmus, and also soluble in a solution of sodium carbonate. It was recrystallized from water, from which it separated in small, colorless plates, melting at 103–104° C. On analysis it gave the following result:

0·0956 gave 0·2020 CO_2 and 0·0754 H_2O. C = 57·6; H = 8.8
$C_9H_{16}O_4$ requires C = 57·4; H = 8·5 per cent.

A silver salt of the acid was also prepared and analyzed:

0·0268 of salt gave on ignition 0·0144 Ag. Ag = 53·7
$C_9H_{14}O_4Ag_2$ requires Ag = 53·7 per cent.

It is evident from these results that the above-described substance is a dicarboxylic acid, corresponding in its composition and properties to azelaic acid.

Treatment with Dilute Alcoholic Sulphuric Acid.—Forty grammes of the resin were dissolved in alcohol, and such an amount of sulphuric acid added, with a little water, that the total liquid contained about 5 per cent. of its weight of acid. The liquid was then heated on a water-bath in a reflux apparatus for four hours, after which the alcohol was removed, and the residue subjected to distillation with steam. The distillate was extracted with ether, the ethereal liquid being shaken with a solution of sodium carbonate, then washed with water, dried with calcium chloride, and the ether removed. A very small quantity (0·5 gramme) of a neutral, oily liquid was thus obtained, which was more viscid than the corresponding products from the previously-described extracts of the resin. The sodium carbonate liquid was acidified and extracted with ether, when a very small amount of an oily acid was obtained, from which a silver salt was prepared and analyzed:

0·1208 of salt gave on ignition 0·0600 Ag. Ag = 49·7
$C_5H_9O_2$ Ag requires Ag = 51·7 per cent.
$C_6H_{11}O_2$ Ag " Ag = 48·4 " "

The acids remaining in the aqueous distillate after extraction with ether were converted into a barium salt, of which 1·8 grammes were obtained. This salt afforded reactions which established the presence of formic and butyric acids. After drying at 110° C. it was analyzed with the following results:

0·5588 of the dried salt gave 0·3898 $BaSO_4$. Ba = 41·0
0·8000 " " " " " 0·5584 $BaSO_4$. Ba = 41·0

As this salt contained a considerably lower percentage of barium than that required for barium butyrate (44·1 per cent. Ba), it must also have contained some acid of higher molecular weight.

After the removal of the above-described volatile products by distillation with steam, and allowing the contents of the distillation flask to cool, it was observed that a small quantity of a white solid had separated, and that the resinous matter, which formed a solid cake floating on the surface of the liquid, was very much smaller in amount than in the case of the corresponding products from the previously-described extracts. The white solid substance was separated, dried on a porous plate, and crystallized from hot water, from which it separated in fine, long, interlaced needles, melting at 100–102° C. This substance was evidently identical with a new acid, $C_{14}H_{23}O_4$, which was subsequently isolated from the above-mentioned cake of resinous matter, and will presently be described.

The acid filtrate from the white solid substance and resinous matter was extracted with ether, the ethereal liquid being shaken with a solution of sodium carbonate, then washed with water, dried, and the ether removed. Only a trace of a neutral oily liquid was thus obtained, which gave no coloration with ferric chloride. The sodium carbonate liquid, which had a dark red color, was acidified and extracted with ether, the ethereal liquid being dried and the ether removed. A small amount of a dark red oil was thus obtained which, on standing for some time, became solid. This solid substance was dried on a porous plate and crystallized from hot water, when it separated in fine, long needles, melting at 100–101° C. It consisted of a further small amount of the new acid which is described below.

The above-mentioned acid filtrate, which had been extracted with ether, was treated with baryta for the removal of the sulphuric acid, and the filtrate evaporated under diminished pressure to the consistency of a thick syrup, the amount of which was 18 grammes. This syrup readily reduced Fehling's solution on heating, and yielded *d*-phenylglucosazone, melting at 215° C., thus indicating the presence of glucose. It also contained a readily soluble organic acid, which could not be separated from the sugar.

Isolation of a New Dihydroxymonocarboxylic Acid, Ipurolic Acid, $C_{13}H_{25}(OH)_2 \cdot CO_2H$.

The cake of brown resinous matter obtained by the treatment of the alcohol extract of the resin with dilute sulphuric acid, as above described, was dried on a porous plate, then dissolved in alcohol, the solution mixed with purified sawdust, and the mixture, after being thoroughly dried, extracted successively in a Soxhlet apparatus with light petroleum and ether, after which nothing remained on the sawdust. The petroleum removed about 2 grammes of an oily substance which was soluble in a solution of sodium carbonate and the fixed alkalis, and on acidifying these solutions it separated in its original form. On boiling this oily product repeatedly with large volumes of water, filtering the liquids while hot, and allowing them to cool slowly, a small amount of a colorless, crystalline substance was deposited. This melted at 68° C., and was apparently identical with a hydroxylauric acid, which was subsequently obtained in larger quantity, as will presently be described.

The subsequent extraction of the brown resinous matter with ether yielded about 5 grammes of a viscid liquid, which solidified on cooling. This solid substance was dissolved in a dilute solution of sodium hydroxide, when, after standing for some time, a product separated which appeared to be crystalline. The solution was therefore diluted with water, heated with a little animal charcoal, filtered, and concentrated, when, on cooling, the whole solidified to a crystalline mass. By recrystallizing this salt four times from water it was obtained perfectly white, and then melted at 185–190° C. From the sodium compound the acid was liberated by means of acetic acid. On heating the acidified liquid the solid acid melted, then dissolved, and, on allowing the solution to cool, it separated in long, thin, interlaced needles which melted at 100–101° C. It can also readily be purified by crystallization from warm chloroform. On heating the acid at 100–105° C. there was no loss of weight, and it is therefore anhydrous. When dissolved in absolute alcohol it was found to be devoid of optical activity. It was analyzed with the following result:

0·0686 gave 0·1618 CO_2 and 0·0674 H_2O. $C = 64·3$; $H = 10·9$
$C_{14}H_{28}O_4$ requires $C = 64·6$; $H = 10·8$ per cent.

The *sodium salt* gave, on analysis, the following results:

0·2212 of the air-dried salt, on heating at 110° C., lost 0·0106 H_2O.
$H_2O = 4·8$
0·2106 of the anhydrous salt gave, on ignition, 0·0400 Na_2CO_3.
$Na = 8·2$
$C_{14}H_{27}O_4$ Na, H_2O requires $H_2O = 6·0$ per cent.
$C_{14}H_{27}O_4$ Na requires $Na = 8·2$ per cent.

The somewhat low percentage of water found in this salt indicates that some efflorescence had occurred.

From the sodium salt a *silver salt* was prepared, which also was crystalline, and melted at 160° C. On analysis it gave the following results:

0·1430 gave 0·2382 CO_2, 0·0940 H_2O, and 0·0428 Ag.
$C = 45·4$; $H = 7·3$; $Ag = 29·9$
0·1304 gave on ignition 0·0390 Ag. $Ag = 29·9$
$C_{14}H_{27}O_4$ Ag requires $C = 45·8$; $H = 7·4$; $Ag = 29·4$ per cent.

A *copper salt* was likewise prepared from the sodium salt by precipitation with a solution of copper sulphate. This was obtained in the form of a pale blue, amorphous powder, but on analysis was found to be highly basic and of indefinite composition.

The preceding results prove that the above described substance is a monocarboxylic acid, having the empirical formula, $C_{14}H_{28}O_4$. As it is not identical with any acid hitherto described, it is proposed to designate it *ipurolic acid*.

In order to ascertain whether ipurolic acid could be distilled, a small quantity (5 grammes) of it was heated in a distillation flask under a pressure of 15 mm. During the operation water was eliminated, and between 240 and 250° C. the greater portion passed over as a viscid yellow oil, the temperature being finally increased to 280° C. at 15 mm. As the oily product did not solidify, it was dissolved in ether, and the ethereal liquid extracted with a solution of sodium carbonate. On subsequently removing the ether about 0·5 gramme of a non-acidic substance was obtained, whereas the sodium carbonate had extracted about 4 grammes of acidic substance. Both these products were unsaturated, but their analysis and the determination of their iodine values showed them to be complex mixtures which did not permit of further examination.

Methyl Ipurolate, $C_{13}H_{25}(OH)_2 . CO_2CH_3$.

Five grammes of ipurolic acid were dissolved in hot methyl alcohol, and dry hydrogen chloride passed into the solution until it was saturated. The solution was then poured into water, when the *ester* separated as a white precipitate, and was extracted by means of ether. The ethereal liquid was washed, first with a solution of sodium carbonate to remove any unchanged acid, and then with water, after which it was dried with calcium chloride, and the ether removed. A crystalline mass was thus obtained, which was recrystallized from dilute methyl alcohol, when the ester separated in the form of fine needles, melting sharply at 68–69° C. On analysis it gave the following result:

0·1042 gave 0·2500 CO_2 and 0·1038 H_2O. $C = 65{\cdot}4$; $H = 11{\cdot}1$

$C_{15}H_{30}O_4$ requires $C = 65{\cdot}7$; $H = 10{\cdot}9$ per cent.

For the purpose of ascertaining the presence of hydroxyl groups in ipurolic acid, an attempt was made to prepare its acetyl and benzoyl derivatives. The products, however, could only be obtained in the form of thick syrups, which were not suitable for analysis.

Diphenylurethane of Methyl Ipurolate, $C_{13}H_{25}(O{\cdot}CO{\cdot}NH{\cdot}C_6H_5)_2CO_2CH_3$.—Two grammes of methyl ipurolate were heated with an excess of phenyl *iso*cyanate in a sealed tube in a water-bath for about eight hours. After being allowed to cool, the product was shaken with light petroleum, when a solid was precipitated. This was dissolved in a small quantity of ether and cooled to — 10° C., when a product separated, which was removed and found to be the unchanged ester. The addition of light petroleum to the filtrate caused the separation of a substance which melted at 95–96° C. This was dissolved in ether, and such an amount of light petroleum added that the solid separated slowly. By this means it was obtained in the form of small rosettes, which melted at 96–97° C., and after two recrystallizations the melting point remained unchanged. The compound was then analyzed with the following results:

(I.) 0·1100 gave 0·2572 CO_2 and 0·0798 H_2O. $C = 68{\cdot}2$; $H = 8{\cdot}1$.
(II.) 0·0352 gave 0·0882 CO_2 and 0·0250 H_2O. $C = 68{\cdot}3$; $H = 7{\cdot}9$.
0·1562 gave 7·0 c.c. of moist nitrogen at 759 mm. and 19° C.
$N = 5{\cdot}6$.
$C_{29}H_{40}O_6N_2$ requires $C = 68{\cdot}0$; $H = 7{\cdot}8$; $N = 5{\cdot}5$ per cent.

These results prove conclusively that the above substance was a *di-phenylurethane of methyl ipurolate*. Ipurolic acid, therefore, is a dihydroxymonocarboxylic acid.

Methyl Monomethylipurolate, $C_{13}H_{25}(OH)(OCH_3)CO_2CH_3$.—A quantity (2·5 grammes) of methyl ipurolate was heated in a sealed tube with an excess of methyl iodide and dry silver oxide at 100–110° C. for four hours. The product was then filtered, the filter with its contents being thoroughly washed with ether. After the removal of the ether, a residue was obtained, which, when recrystallized from light petroleum, separated in small needles melting at 64–65° C., and this melting point was not changed by further crystallization. The *substance* was then analyzed.

0·0848 gave 0·2066 CO_2 and 0·0834 H_2O. $C = 66{\cdot}4$ $H = 10{\cdot}9$.
$C_{16}H_{32}O_4$ requires $C = 65{\cdot}7$; $H = 11{\cdot}1$ per cent.

It is evident that by the above treatment only one of the hydroxyl groups in methyl ipurolate had become methylated.

Hydrolysis of the Alcohol Extract of the Resin with Barium Hydroxide.

A quantity (200 grammes) of the purified resin was dissolved in alcohol (1000 c.c.), and a freshly prepared, cold, saturated solution of barium hydroxide gradually added until the liquid showed an alkaline reaction. The liquid was then kept at a temperature of about 35° C., small portions of solution of barium hydroxide being added from time to time in order to maintain alkalinity. This treatment was continued until, on testing a small portion of the liquid with water, no precipitate was produced, a condition which was never attained in less than twelve hours. The liquid was then diluted with a little water, filtered, and the alcohol removed, after which it was deprived of the excess of barium by means of carbon dioxide and filtering. The barium, which still remained in the filtrate in combination with the acids formed from the resin, was exactly precipitated by sulphuric acid, when, after removing the barium sulphate, a clear, lemon-yellow liquid was obtained. This liquid was subjected to distillation with steam in order to remove any volatile acids present. The distillate, which contained no oily drops, was extracted with ether. The ethereal liquid was shaken with a solution of sodium carbonate, washed with water, dried with calcium chloride, and the ether removed, when a very small amount of an oily residue was obtained, which possessed a somewhat disagreeable odor. The sodium carbonate liquid and washings were then acidified and extracted with ether, the ethereal liquid being dried with calcium chloride and the ether removed, when 10 grammes of a colorless acid were obtained, thus representing 5 per cent. of the weight of resin originally employed. This acid was distilled under the ordinary pressure, when it passed over almost completely between 174 and 176° C. as a colorless liquid, having an odor resembling that of valeric acid. On analysis it gave the following results:

0·1274 gave 0·2760 CO_2 and 0·1132 H_2O. C = 59·1; H = 9·9
0·1436 gave 0·3090 CO_2 and 0·1240 H_2O. C = 58·7; H = 9·6
0·1428 gave 0·3082 CO_2 and 0·1256 H_2O. C = 58·9; H = 9·8
$C_5H_{10}O_2$ requires C = 58·8; H = 9·8 per cent.

The silver salt of the acid was also prepared and analyzed. 0·2240 gave, on ignition, 0·1156 Ag. Ag = 51·6.

$C_5H_9O_2$ Ag requires Ag = 51·7 per cent.

The density of the acid was 0·9471 at 16·5° C. It was optically active, and a determination of its specific rotatory power gave the following result:

α_D in a 25 mm. tube at 16·5° C. = + 4°15′, whence $[\alpha]_D$ + 17·95°.

It is evident, therefore, that the above-described liquid consisted of the quite pure, optically active valeric acid, *d*-methylethylacetic acid, $CH(CH_3)(C_2H_5) . CO_2H$, which is recorded[1] as having

$$[a]_D + 17{\cdot}85^\circ$$

The aqueous distillate, after the removal of the methylethylacetic acid by extraction with ether, still contained some acid, which was converted into a barium salt. This afforded the reactions of both formic and butyric acids, although the amount of the former acid was relatively small. After drying at 110° C. it was analyzed.

0·3936 of the dried salt gave 0·2904 $BaSO_4$. Ba = 43·4.

Since barium butyrate requires Ba = 44·1 per cent., it is probable that the above-mentioned barium salt also contained valerate.

After the removal of the volatile acids by distillation with steam, there remained in the distillation flask a clear liquid. This was extracted with ether, but as nothing was removed by this treatment it was concentrated under diminished pressure to the consistency of a syrup. It then still remained clear, possessed an orange-yellow color and a strongly acid reaction, but did not reduce Fehling's solution until after heating with a mineral acid. With the object of effecting a purification of the product, which may be termed the hydrolyzed resin, it was mixed with prepared sawdust, and the thoroughly dried mixture extracted successively in a Soxhlet apparatus with the same solvents as had been employed for the extraction of the original mixture of resins. The results were as follows:

Petroleum (B. P. 40–60° C.) removed nothing.

Ether extracted a light yellow syrup (13 grammes), which did not become solid.

Chloroform extracted a dark yellow syrup (4 grammes), which did not become solid.

Ethyl acetate extracted a dark yellow syrup (9·3 grammes), which, on drying, formed a hygroscopic, amorphous mass.

Alcohol removed the remainder of the material (130 grammes), which solidified to a clear, brittle mass, and could be reduced to a nearly colorless powder.

All the above products were then subjected to treatment with dilute sulphuric acid, in the following manner:—

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[1] *Ber. d. deutsch. chem. Ges.*, 1896, **29**, 52.

Ether Extract of the Hydrolyzed Resin.—The entire amount of this extract (13 grammes) was brought into a flask provided with a reflux condenser, together with 130 c.c. of 5 per cent. aqueous sulphuric acid, and the mixture boiled for three hours. The liquid, on cooling, remained quite clear, and had a pale yellow color. It was distilled with steam, and the distillate extracted with ether, but this removed practically nothing. A very small amount of acid was, however, contained in the aqueous distillate, and this, after conversion into a barium salt, afforded reactions indicating the presence of formic and butyric acids.

The aqueous acid liquid remaining in the distillation flask after the removal of the volatile acids with steam, as above described, was extracted with ether, and the ethereal liquid shaken with a solution of sodium carbonate. After the removal of the ether, a very small amount of an oily liquid was obtained. The sodium carbonate liquid, when acidified and extracted with ether, yielded a small amount of an oily acid, but not sufficient for its further examination.

The aqueous acid liquid, which had been extracted with ether, reduced Fehling's solution on heating. It was treated with baryta for the removal of the sulphuric acid, and the filtrate concentrated, when it formed a thick syrup which was found to contain the barium salt of a readily soluble organic acid. The attempts to obtain this acid in a solid state were unsuccessful.

Chloroform Extract of the Hydrolyzed Resin.—The amount of this extract was only 4 grammes. On treatment with dilute sulphuric acid it yielded products very similar to those afforded by the ether extract of the hydrolyzed resin. Thus in distilling the acid liquid with steam, the distillate was found to contain a very small quantity of a neutral oil, together with formic and butyric acids, while the liquid remaining in the distillation flask reduced Fehling's solution on heating, and, after the removal of the sulphuric acid by baryta and concentrating, yielded a very small amount of a syrup containing the barium salt of a readily soluble organic acid.

Ethyl Acetate Extract of the Hydrolyzed Resin.—This extract, like the preceding ones, was relatively small in amount. The entire quantity (9·3 grammes) was heated for about four hours with 100 c.c. of 5 per cent. aqueous sulphuric acid. On cooling, the liquid in the flask was observed to contain a small amount of a white, flocculent substance, together with a small cake of solid matter. It was therefore extracted with ether, which removed all the solid material. The ethereal liquid, after being shaken with a solution of sodium carbonate, was dried with calcium chloride, and the ether removed, when a very small, oily residue was obtained, which soon solidified in the form of crystalline needles. This substance was practically insoluble in water, and was therefore recrystallized from ether, after which it melted at 233–235° C., but the amount was much too small for further investigation.

The sodium carbonate liquid was acidified and extracted with ether, when a very small amount of a substance was obtained, which, after recrystallization from 50 per cent. alcohol and finally from hot water, separated in handsome needles melting at 100–101° C. On analysis it gave the following result :

0·0346 gave 0·0820 CO_2 and 0·0338 H_2O. $C = 64{\cdot}6$; $H = 10{\cdot}8$.

$C_{14}H_{28}O_4$ requires $C = 64{\cdot}6$; $H = 10{\cdot}8$ per cent.

This substance was evidently identical with ipurolic acid, which has previously been described.

The acid liquid, from which the above-mentioned substances had been extracted by ether, was distilled with steam. The distillate contained a small amount of acid, which, after conversion into a barium salt, was found to consist of a mixture of formic and butyric acids. The liquid remaining in the distillation flask was treated with baryta for the removal of the sulphuric acid, filtered and concentrated. A syrup was thus obtained which reduced Fehling's solution on heating, and, like the corresponding products from the above-described ether and chloroform extracts, contained the barium salt of a readily soluble organic acid.

Alcohol Extract of the Hydrolyzed Resin.

This product represented by far the largest portion of the hydrolyzed resin, and amounted to 130 grammes. As first obtained it was in the form of a syrup, but, after drying, could be reduced to a fine powder, and by treatment with animal charcoal was obtained quite white. The powdered material is not altered on exposure to the air, and dissolves readily in cold water, forming a clear solution. After drying in a vacuum over sulphuric acid, it melted at 105–110° C. With cold concentrated sulphuric acid it gives a deep red color. It is optically active, and its specific rotatory power was determined with the following result :—

An aqueous solution containing 1·7680 grammes of substance in 25 c.c. gave a_D — 4° 47′ in a 1 dcm. tube, whence $[a]_D$ — 67.63°.

Treatment with Dilute Sulphuric Acid.—A quantity (25 grammes) of the above-described material was dissolved in 250 c.c. of 5 per cent. aqueous sulphuric acid, and the solution heated for about four hours in a reflux apparatus. It was then distilled with steam, and the distillate extracted with ether, when a very small quantity of a neutral oil was obtained, which was similar in character to that afforded by the treatment of the alcohol extract of the original resin with dilute sulphuric acid. After extraction with ether, the distillate still contained a small quantity of acid which was converted into a barium salt, and this gave reactions indicating the presence of formic and butyric acids. The liquid remaining in the distillation flask, after the removal of the volatile substances by steam, and being allowed to cool, contained a considerable quantity (5·5 grammes) of a solid crystalline product, part of which was in the form of a brownish cake. It was therefore extracted with ether, the ethereal solution dried, and the solvent removed. The product thus obtained was dissolved in alcohol, the solution mixed with purified sawdust, and, after thoroughly drying the mixture, it was extracted successively in a Soxhlet apparatus with (*a*) light petroleum and (*b*) ether.

(*a*) *Petroleum Extract.*—This liquid deposited a small amount of a crystalline substance in the form of handsome rosettes, which were associated with a little oily matter. After the complete removal of the solvent, the substance was crystallized from 50 per cent. alcohol, and finally from a large volume of hot water. It was thus obtained in handsome, colorless needles, melting at 69–70° C., and on analysis gave the following result :

0·0676 gave 0·1646 CO_2 and 0·0670 H_2O. C = 66·4; H = 11·0.
$C_{12}H_{24}O_3$ requires C = 66·6; H = 11·1 per cent.

The *silver salt* of the acid was also prepared and analyzed.

0·2042 of salt gave on ignition 0·0678 Ag. Ag = 33·2.
$C_{12}H_{23}O_3Ag$ requires Ag = 33·4 per cent.

The above-described substance is thus seen to agree in composition with a *hydroxylauric acid.*

A hydroxylauric acid has previously been obtained by Hoehnel[1]

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[1] *Archiv der Pharm.*, 1896, **234**, p. 670.

from the so-called purgic acid, a product of the alkaline hydrolysis of "convolvulin" by treatment with dilute sulphuric acid. As Hoehnel, however, did not record the melting point of his acid, and the amount of acid obtained by us having been too small to permit of the preparation of the derivatives described by him, it is impossible to decide whether the two substances are identical.

Guérin[1] has synthesized α-hydroxylauric acid, the melting point of which is stated to be 73–74° C. As Guérin had prepared an anilide of this acid (m. p. 83° C.), a little of the corresponding derivative was made from the acid obtained by us for the purpose of comparison, the method employed having been precisely the same as that adopted by Guérin. A product was obtained in the form of small, lustrous plates, which melted at 155–157° C. It is, therefore, evident that the hydroxylauric acid obtained from *Ipomœa purpurea* is not the *alpha* compound.

An attempt was made to obtain an acetyl derivative of the above-described acid, but the product was an oil, which did not solidify.

(*b*) *Ether Extract.*—This constituted the remainder of the solid product obtained from the alcohol extract of the hydrolyzed resin. After purification it was found to consist entirely of ipurolic acid, $C_{14}H_{28}O_4$, which had previously been obtained by the treatment of the alcohol extract of the original resin with dilute sulphuric acid. On analysis it gave the following result:

$$0{\cdot}2228 \text{ gave } 0{\cdot}5280\ CO_2 \text{ and } 0{\cdot}2146\ H_2O.\ C = 64{\cdot}6;\ H = 10{\cdot}7.$$
$$C_{14}H_{28}O_4 \text{ requires } C = 64{\cdot}6;\ H = 10{\cdot}8 \text{ per cent.}$$

The acid liquid, from which the above-mentioned crystalline acids had been separated, was treated with baryta for the removal of the sulphuric acid, and, after filtration, diluted to the measure of 1 litre. This liquid readily reduced Fehling's solution on heating, and yielded an osazone which, after crystallization from pyridine, melted at 212–213° C., and was therefore *d*-phenylglucosazone. A quantitative determination, by means of Fehling's solution, of the amount of sugar, formed by the action of dilute sulphuric acid on the alcohol extract of the hydrolyzed resin, indicated that 25 grammes of the latter had yielded 4·3 grammes of glucose. If the amount of crystalline acid (5·5 grammes), consisting essentially of ipurolic

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[1] *Bull. Soc. chim.*, 1903 [3], 29, 1124–1128, and *Journ. Chem. Soc.*, 1904, 86, Part I, p. 138.

acid, which was obtained by the above-described treatment was present in the extract in the form of a glucoside, the latter would have yielded on hydrolysis an amount of glucose corresponding to 3·8 grammes. It is evident, therefore, that practically the entire amount of glucose found resulted from the hydrolysis of the glucosides of ipurolic and hydroxylauric acids. On the other hand, as the 5·5 grammes of crystalline acids obtained would correspond to about 9 grammes of the respective glucosides, and as the weight of alcohol extract of the hydrolyzed resin which was treated with sulphuric acid was 25 grammes, it follows that this extract contained a considerable proportion of a substance which was not a glucoside.

The liquid which had been freed from sulphuric acid by means of baryta, as described above, contained, besides glucose, a considerable quantity of a barium salt, but this did not separate, even when the liquid was concentrated to the consistency of a thick syrup and allowed to stand for a long time. The acid contained in this salt was evidently highly oxygenated, and doubtless represented that constituent of the alcohol extract of the hydrolyzed resin which was not glucosidic in character. Numerous attempts were made to isolate this soluble organic acid, but without success. A determination of the amount of barium in the liquid showed, however, that the soluble non-glucosidic acid yielded by 25 grammes of the alcoholic extract of the hydrolyzed resin corresponded to 4·15 grammes Ba.

SUMMARY AND PHYSIOLOGICAL TESTS.

As the details of the preceding investigation are necessarily somewhat extended, it appears desirable that the more important results should be briefly summarized.

The material employed, consisting chiefly of the aerial stems of *Ipomœa purpurea*, Roth, was kindly supplied to us by Mr. J. Medley Wood, Director of the Natal Botanic Gardens, Durban, South Africa. When extracted with alcohol, and the resulting extract distilled with steam, an amount of essential oil was obtained corresponding to 0·018 per cent. of the weight of the drug. This essential oil was a pale yellow liquid, having a strong, characteristic odor and the following constants: $d\ 20^\circ / 20^\circ = 0{\cdot}9085$; $a_D - 4^\circ 52'$ in a 1 dcm. tube. After the removal of the volatile substances by distillation with steam, there remained in the distillation flask a dark-colored aqueous liquid and a quantity of a soft resin. The aqueous liquid contained a considerable quantity of potassium chloride and nitrate, together with tannic and coloring matters, and yielded glucose on heating with a dilute mineral acid.

The most important product yielded by *Ipomœa purpurea* is the above-mentioned resin, the amount of which corresponded to 4·8 per cent. of the weight of the drug, and of this resin 15·5 per cent. was soluble in ether. The crude resin, which, when dry, can be reduced to a dark brown powder, is, however, an exceedingly complex mixture, as has been shown by the results of its successive extraction with the following solvents: (I) light petroleum, (II) ether, (III) chloroform, (IV) ethyl acetate, and (V) alcohol. The examination of these various extracts has, moreover, rendered it evident that each of them is likewise of complex composition.

The crude resin is optically active. After treatment with animal charcoal to deprive it of coloring matter, it was found to have a specific rotatory power, in alcoholic solution, of $[\alpha]_D - 50{\cdot}95^\circ$.

The products obtained from the various extracts of the resin were as follows:

I. *Petroleum Extract.*—This represented 8 per cent. of the total resin. After treatment with an alcoholic solution of potassium hydroxide, it yielded pentatriacontane, $C_{35}H_{72}$ (m. p. 74-75° C.); a phytosterol, $C_{27}H_{46}O, H_2O$ (m. p. 132–133° C.; $[\alpha]_D - 32{\cdot}1^\circ$); formic, butyric, and higher volatile acids; stearic, and apparently some palmitic acid, with a very small amount of an unsaturated oily acid.

II. *Ether Extract.*—This represented 7·3 per cent. of the total resin. When fused with potassium hydroxide it yielded formic and butyric acids, a mixture of higher volatile acids, and a very small amount of a crystalline acid, melting at 103–104° C., which was apparently azelaic acid, $C_9H_{16}O_4$, together with a trace of substance giving the catechol reaction. The extract, when heated with 5 per cent. alcoholic sulphuric acid, yielded, besides a quantity of resin, a small amount of a neutral oil, having a pleasant odor, together with formic, butyric and higher volatile acids, a readily soluble non-volatile acid, and glucose.

III. *Chloroform Extract.*—This represented 9·8 per cent. of the total resin. When fused with potassium hydroxide, it yielded products analogous to those obtained under the same conditions from the ether extract, but no crystalline acid could be isolated. When heated with 5 per cent. alcoholic sulphuric acid, it likewise afforded products which were very similar to those obtained from the ether extract of the resin.

IV. *Ethyl Acetate Extract.*—This represented 23·8 per cent. of the total resin. From this extract there was isolated a very small amount of a new crystalline alcohol, *ipuranol*, having the formula $C_{23}H_{38}O_2(OH)_2$, and melting at 285–290° C. Its *acetyl derivative* formed pearly leaflets, melting sharply at 160° C. The extract, when fused with potassium hydroxide, as also when heated with 5 per cent. alcoholic sulphuric acid, yielded products analogous in character to those obtained from the above-described ether and chloroform extracts of the resin by the same treatment.

V. *Alcohol Extract.*—This represented about one-half of the total crude resin. When purified by means of animal charcoal, it was obtained in the form of a perfectly white powder, which, after drying at 110° C., melted somewhat indefinitely between 150 and 160° C. Its specific rotatory power was $[\alpha]_D - 51{\cdot}64°$.

When heated with 5 per cent. alcoholic sulphuric acid, this extract like the preceding ones, yielded a small amount of a neutral oil, formic, butyric and higher volatile acids, and a non-volatile acid which was readily soluble in water, together with glucose. In addition to these products, however, it afforded a quantity of a new dihydroxymonocarboxylic acid, $C_{13}H_{25}(OH)_2{\cdot}CO_2H$, designated *ipurolic acid*, which crystallizes in fine, colorless, silky needles, melting at 100–101° C. Several derivatives of this acid have been prepared, such as its *sodium salt*, $C_{13}H_{25}(OH)_2{\cdot}CO_2Na,H_2O$; *silver salt*, $C_{13}H_{25}(OH)_2CO_2Ag$ (m. p. 160° C.); *methyl ester*, $C_{13}H_{25}(OH)_2{\cdot}CO_2CH_3$ (m. p. 68–69° C.); the *monomethyl derivative of the methyl ester*, $C_{13}H_{25}(OH)(OCH_3)CO_2CH_3$ (m. p. 64–65° C.); and the *diphenylurethane of the methyl ester*, $C_{13}H_{25}(O\,CO{\cdot}NH{\cdot}C_6H_5)_2{\cdot}CO_2CH_3$, melting at 96–97° C.

The above-described alcohol extract of the resin, when treated in alcohol solution with barium hydroxide, yielded, besides formic and butyric acids, a quantity of optically active valeric acid (*d*-methylethylacetic acid), b. p. 174–176° C.; $[\alpha]_D + 17{\cdot}95°$, together with a mixture of acids which was readily soluble in water. This mixture of acids was extracted successively with ether, chloroform and ethyl acetate, when small amounts were removed by each of these solvents, the larger proportion being soluble only in alcohol. These various extracts were finally subjected to treatment with 5 per cent. aqueous sulphuric acid. The portions extracted by ether and chloroform yielded, for the most part, identical products, namely, formic and butyric acids, together with a readily soluble, non-volatile acid, and apparently a little glucose. The portion extracted by ethyl acetate yielded, in addition to the products just mentioned, a very small amount of ipurolic acid. The portion which was soluble only in alcohol was considerable in amount. After further purification with animal charcoal, it was obtained in the form of a nearly white powder. It melted at 105–110° C., and was optically active, having in aqueous solution $[\alpha]_D - 67{\cdot}58°$. When treated with 5 per cent. aqueous sulphuric acid, it yielded, besides formic and butyric acids, a *hydroxylauric acid* (m. p. 69–70° C.) and ipurolic acid, together with a readily soluble organic acid and glucose.

The physiological action of the above-described extracts of the original resin was kindly determined for us by Dr. H. H. Dale, Director of the Wellcome Physiological Research Laboratories, and our thanks are due to him for the assistance which he has thus rendered us.

One gramme of each of the extracts was administered at intervals of several days to a dog, with the following results. The petroleum extract produced no definite effect. The ether, ethyl acetate and alcohol extracts had a very marked purgative action two hours after ingestion, which lasted for about twenty-four hours, after which the animal became quite normal. There was no noticeable difference in the action of these three extracts. The chloroform extract, on the other hand, had a rather less pronounced aperient effect, and caused slight vomiting.

The alcohol extract of the resin which had been hydrolyzed by means of baryta, consisting of a product which was readily soluble in water, had no perceptible physiological action when administered to a dog in doses of one gramme. This result is in accordance with the observations previously recorded respecting the action of an analogous, but less completely purified product from jalap resin, which has been designated "convolvulic acid" (compare Husemann, "Die Pflanzenstoffe," second edition, 1882, p. 1141).

It will be seen from this investigation that *Ipomœa purpurea*, Roth, like many other species of the same genus, contains resins which possess purgative properties, and is thus capable of being utilized medicinally.