obtained 6.3 g. (15%) of β-methylallylmethylamine, b. p. 86–86.5° and $n^{20}D$ 1.4200 which was condensed with benzene after a titration indicated it was substantially pure.

Anal. Calcd. for $C_5H_{11}N$: neut. equiv., 85.15. Found: neut. equiv., 85.46.

There was obtained as the principal product 27.2 g. of di-(β-methylallyl)-methylamine, b. p. 145–145.5°, $n^{20}D$ 1.4372, which is 78% of the theoretical yield.

Anal. Calcd. for $C_9H_{17}N$: neut. equiv., 139.2; C, 77.63; H, 12.31. Found: neut. equiv., 141.1; C, 78.12; H, 11.95.

β-Methylallyldimethylamine, b. p. 82.4–82.6° (750 mm.), $n^{20}D$ 1.4092, was obtained in a 41% yield from dimethylamine and methallyl chloride.

Anal. Calcd. for $C_6H_{13}N$: neut. equiv., 99.2; C, 72.66; H, 13.21. Found: neut. equiv., 99.7; C, 73.06; H, 12.99.

The attempt to prepare unsaturated amines from the equilibrium mixture of crotyl chloride and 3-chloro-1-butene gave a complex mixture which has not been separated.

Oxidation Reactions.—The structures of the fluorobenzene and toluene condensation products were determined by oxidation with permanganate.[23] Terephthalic acid from the toluene derivative was identified as its dimethyl ester, m. p. 137–138°. No phthalic acid was isolated although the amine hydrochloride before purification melted over a range indicating the presence of more than one base. The crude *p*-fluorobenzoic acid also melted over a wide range but only the one acid was isolated.

Summary

1. A new method of preparing β-substituted phenethylamines by condensing unsaturated amines with aromatic compounds in the presence of aluminum chloride is described.

2. A number of allylamine derivatives have been prepared.

3. Some preliminary pharmacological data on the phenethylamines are reported.

(23) We are indebted to Mr. Kermit Streeter now of Sharp and Dohme for the oxidation experiments.

EVANSTON, ILLINOIS RECEIVED FEBRUARY 10, 1943

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, UNIVERSITY OF CALIFORNIA]

Anthochlor Pigments. IV. The Pigments of *Coreopsis grandiflora*, Nutt. I.

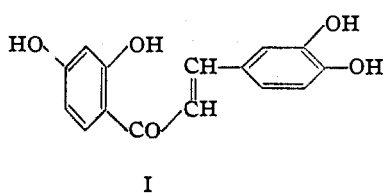
BY T. A. GEISSMAN AND CHARLES D. HEATON

In the continuation of studies on the flower pigments of those members of the tribe *Heliantheae*, family *Compositae*, which contain pigments of the anthochlor type, the examination of the flowers of *Coreopsis grandiflora*, Nutt. has been undertaken. Previous work has shown that the tetrahydroxychalcone butein (I) is present in *Dahlia variabilis* (yellow),[1] *Coreopsis Douglasii*[2] and *Coreopsis gigantea*,[3] and that a butein glycoside, coreopsin, is present in *Cosmos Sulphureus*[4] and *Coreopsis gigantea*.[3]

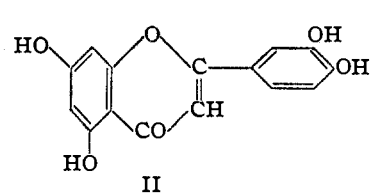
Coreopsis grandiflora, Nutt. is a common garden perennial whose showy orange-yellow rays and yellow disk-florets show the presence of pigments of the anthochlor type by their color change to deep red when treated with dilute alkali. Since the formation of orange to red salts with alkali is a characteristic property of many polyhydroxy chalcones, particularly those containing the 3,4-dihydroxyphenyl residue as ring B (*cf.* XIII), it has heretofore appeared reasonable to expect that the anthochlor pigments would all prove to be substances of this type. An interesting and from the standpoint of the biosynthetical aspects of pigment formation, important departure from this expectation is encountered in the case of *Coreopsis grandiflora*. From the ray flowers of this species have been isolated four compounds. One of these is the known flavone, luteolin (II), which has been reported to occur in *Cosmos Sulphureus*.[4] The other three compounds are new. One of them is a flavanone (III) which is probably 8-methoxybutin; this may occur in the flower as the chalcone, 3′-methoxybutein, and may have been isomerized to the flavanone in the isolation process, but no evidence on this point is available at present. The remaining two compounds are related as glucoside and aglucone. The aglucone gives the typical anthochlor color change with alkali but it is not a polyhydroxychalcone. It appears from present evidence to be unique in that it is probably a polyhydroxybenzalcoumaranone, and as such is probably the first representative of this structural type to be isolated from a natural source.[5] These substances will be re-

(1) Price, *J. Chem. Soc.*, 1018 (1939).
(2) Geissman, THIS JOURNAL, **63**, 656 (1941).
(3) Geissman, *ibid.*, **63**, 2689 (1941).
(4) Geissman, *ibid.*, **64**, 1704 (1942).

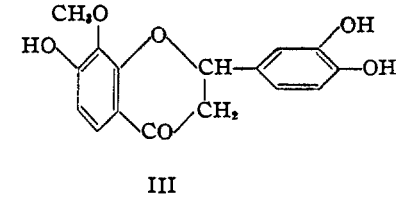
(5) The structures of pedicinin and isopedicin, which were originally considered to be methyl ethers of a tetrahydroxybenzalcoumaranone [Sharma and Siddiqui, *J. Indian Chem. Soc.*, **16**, 1 (1939)] are still not established, and Bose and Dutt [*J. Indian Chem. Soc.*, **17**, 499 (1940)] have assigned to them a structure containing a cinnamoylbenzoquinone nucleus.



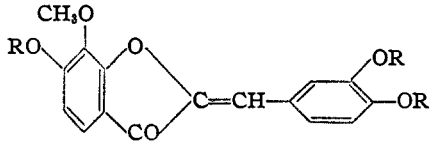
I



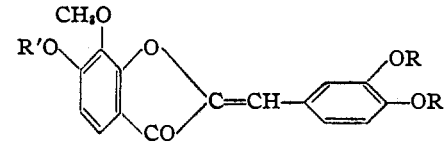
II



III



IV R = H
VII R = —COCH$_3$
VIII R = —CH$_3$



V R′ = $C_6H_{11}O_5$; R = H
VI R′ = $C_6H_7O(OCOCH_3)_4$; R = $COCH_3$

ferred to as leptosidin and leptosin, and to them have been assigned, respectively, the structures IV and V.

The evidence to be presented in support of the assignment of the above structures to III, IV and V rests upon (a) the primary assumption of the C_6–C_3–C_6 carbon skeleton which butein and other substances so far found associated with it possess in common with many other compounds found in plant tissues, (b) the secondary assumption, based upon biogenetical grounds, that a considerable degree of correspondence was to be expected between the structures of the pigments found in *Coreopsis grandiflora* and that of butein, (c) a complete agreement of the analytically determined compositions of III, IV, V and their methyl and acetyl derivatives with those calculated for these formulas, (d) the appearance of certain color reactions consistent with the proposed structures, and (e) a fair agreement between the properties of certain methyl ethers of III and IV and those of substances previously described as possessing the structures of these derivatives. The present paper deals with the details of the experimental findings which have led to the proposed structures for III, IV and V.

Leptosin (V) is a bright orange, crystalline compound. It forms an acetyl derivative (VI) the composition of which is that of the hexaacetate of a glucoside of IV. Hydrolysis of V with dilute acid yields IV and a reducing sugar, probably glucose. The most striking property of V, and one that is an important clue to its structure, is the deep purple color of its alkaline solution. This is good evidence that it is not a chalcone derivative since no compounds of this type have been reported to form purple or blue salts. Certain properly substituted polyhydroxybenzalcoumaranones do, however, form blue to violet salts with alkalies, and those which have been described as possessing this property contain the 3′,4′-dihydroxy grouping but do not contain a hydroxyl group in the coumaranone nucleus.[6,7] It is probable, therefore, that the glucoside has the 3′,4′-dihydroxy grouping and that the methoxy and glucosidoxy groups are in the coumaranone nucleus.

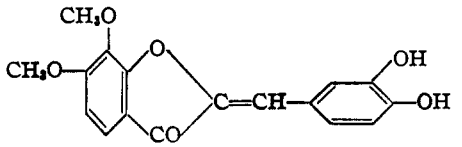
Leptosidin (IV) was isolated from an ether-soluble portion of the petal extract. It contains a methoxyl group and three hydroxyl groups as shown by its conversion into a triacetate (VII) and a tetramethyl ether (VIII). The latter compound was prepared in two ways: by the use of diazomethane and by the use of the deacetylation-methylation method of Freudenberg.[8] No conditions of methylation or acetylation used gave rise to derivatives in which all of the oxygen atoms were substituted. Two, of which one is in the carbonyl group, remained unaffected. This behavior is to be expected of the benzalcoumarone derivative IV, but is not that of a chalcone or flavanone. Leptosidin is soluble in dilute alkali, giving a deep red solution, an indication that the color change observed when the fresh flower petals are treated with alkali must be due in large part to the presence of this compound.

The presence of the 3′,4′-dihydroxy grouping in leptosidin (and thus in leptosin) has been proved by the isolation of veratric acid (3,4-dimethoxybenzoic acid) from the oxidation of fully methylated leptosidin with potassium permanganate. It should be noted that the use of alkaline hydrogen peroxide for the oxidation resulted in a colorless, acidic substance which appeared to be a

(6) v. Auwers and Pohl, *Ann.*, **405**, 266 (1914).
(7) Felix and Friedländer, *Monatsh.*, **31**, 68 (1910).
(8) Freudenberg, *Ann.*, **433**, 237 (1923).

mixture of veratric acid and a dimethoxy-salicylic acid. The substance melted over a range, gave a ferric chloride color and had a methoxyl content which was that calculated for a mixture of about equal amounts of these two acids. It was obtained in too small an amount to permit its resolution into its components.

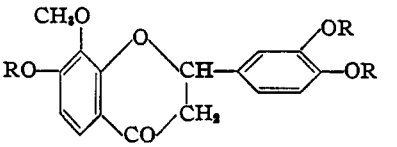
The evidence so far discussed does not furnish any basis for assigning the positions of the remaining methoxyl and one of the hydroxyl groups in leptosidin. That they are not in the positions 4,6- is shown by the fact that the melting point of VIII is different from that reported for 3′,4′,4,6-tetramethoxylbenzalcoumaranone (175°).[9] From the methylation of leptosidin with a limited amount of diazomethane there was isolated an orange-yellow compound which dissolved in alkali to form a purple solution similar in color to that given by leptosin (V). Analysis showed it to be a dimethoxy-dihydroxy compound and it is probable that it has the structure IX.



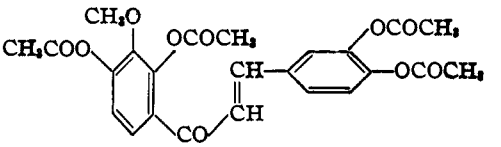
IX

This compound has been described[10] and is reported to have a melting point of 217°. The compound isolated from the methylation of leptosidin melted at 214°, uncor. In view of this difference (no mention was made[7] of whether the value 217° was a corrected melting point) the identity of these substances is still open to some question, but can be assumed for the present. From the biogenetical relationship between leptosidin and butein, and between leptosidin and its accompanying flavanone, there is reason to believe that leptosidin is hydroxylated in positions 3′,4′,6. Whether the remaining hydroxyl (or methoxyl) group is at 5- or 7- is a question to which the melting point of IX furnishes an incomplete answer. Further evidence on this point is found in a consideration of the structure of the flavanone (III).

The flavanone was isolated from an ether extract from which leptosidin had been separated, an indication that it occurs on the flower in a non-glycosidic condition. It was obtained as a pale yellow, crystalline substance. It dissolves readily in ice-cold aqueous alkali to a nearly colorless solution which on standing or warming acquires a deep red color which is strikingly similar to that of alkaline solutions of butein. Treatment of an alcoholic solution of III, or its triacetate, with magnesium and hydrochloric acid produces a deep blue-violet color similar in tone and intensity to that produced by the reduction in this way of butin or butin triacetate. This is good evidence that III is a flavanone, and this conclusion is substantiated by the fact that III forms a tri- (X) or a tetraacetate (XI), depending upon the conditions used for the acetylation.



X R = $COCH_3$
XII R = $—CH_3$



XI

The methylation of III with diazomethane yielded a fully methylated flavanone (XII), an indication that there is no hydroxyl group in the 5-position, since it has been shown[11] that 5-hydroxyl groups in flavanones resist methylation by this reagent under ordinary conditions. The tetramethoxyflavanone of structure XII has been described[12] and is reported to melt at 144°. The compound isolated by methylation of the flavanone III melted at 140°, uncor.

The similarity in the colors given by III in alkali and in the reduction test to those given by butein and butin, coupled with the biogenetical relationship of III, to IV and butein, make it highly probable that the flavanone has the catechol (3′,4′-dihydroxyphenyl) nucleus and that it has a 7-hydroxyl group. The melting point of the fully methylated compound offers a basis for placing the methoxyl group at position 8, but it could be at 6 since 3′,4′,6,7-tetramethoxyflavanone has not been described. That it is not at position 5 is further shown by the fact that the melting point of tetramethyleriodictyol (160°)[13] is not the same as that of XII.

(9) Dumont and Tambor, *Ber.*, **43**, 1971 (1910).

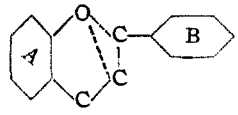
(10) A. G. Perkin and Wilson, *J. Chem. Soc.*, **83**, 138 (1903); see also ref. 7.

(11) Asahina and Inubuse, *Ber.*, **61**, 1514 (1928).

(12) Kostanecki and Rudse, *ibid.*, **38**, 937 (1905).

(13) Kostanecki, Lampe and Tambor, *ibid.*, **37**, 1403 (1904).

The similarity in the fundamental patterns of hydroxylation and carbon skeletons of butein (I) and, so far as they are known at present, of III, IV and V, is striking. Again, as in *Cosmos sulphureus*, in the flowers of which have been found luteolin (II) and glycosides of quercetin and butein (I), the common structural feature of all the pigments isolated is the catechol nucleus. Again, the differences between the individual substances lie in the state of oxidation of the $C_{6(A)}$–C_3 (*cf.* XIII) portion of the molecule.



XIII

In the present case, however, the state of oxidation of ring A in II, III, IV and V is the same. the positions of hydroxylation being different. The oxidation level of IV (and V) is that of a flavone (*e. g.*, II) and is higher by a difference of two hydrogen atoms than that of a chalcone or flavanone.

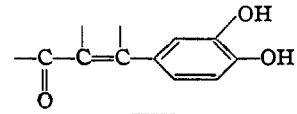
These facts are the more significant when viewed from the standpoint of the hereditary relationships existing between the pigments of *Coreopsis grandiflora* and between these substances and those which occur in the other *Heliantheae* so far studied. All of these plants belong to genera which form a closely related group having a number of unique morphological characteristics in common.[14] At the same time all of them possess a distinctive type of pigmentation in which the fundamental similarity, it now appears, lies not so much in a complete correspondence in structural type as in the property of the yellow pigments of forming red salts. Hence, it seems not improbable that this property also is an hereditary character.

The hereditary and biosynthetic relationships which exist between pigments of the C_6–C_3–C_6 ("flavonoid") type in different states of oxidation in a given species still rest upon inference, but it is becoming increasingly clear that numerous developmental factors are involved in the synthetic processes by means of which a pigment is produced from its (carbohydrate) starting materials and that many of these factors appear to exercise highly specific functions in modifying the structure of the molecule to its final form.

(14) *Butea frondosa* (Leguminosae) contains butein; it is the only example, so far as is known, outside of the Compositae.

Robinson[15] has discussed some of the questions concerning the biosynthesis of substances of the C_6–C_3–C_6 type and has suggested that one step in their formation consists of the condensation of $C_{6(B)}$–C_3 with $C_{6(A)}$. He has further suggested, after a theory of pigment biosynthesis proposed by Lawrence and Scott-Moncrieff,[16] that in a series of related pigments in a given species (of different color forms, for example) the $C_{6(A)}$ unit is common to all and limited in amount, and that more than one $C_{6(B)}$–C_3 unit may compete for this. That this hypothesis does not apply to the genera under present consideration is clear from the fact that of all the pigments so far isolated from any species it is only $C_{6(B)}$ which is common to all. It is to be noted however that one element of similarity exists between the various $C_{6(A)}$ units: namely, the 7-hydroxyl group (flavone numbering).

Too little information is at present at hand concerning the genetical aspects of the chemical relationships so far discovered in the *Heliantheae* to permit them to be treated in detail. It is suggested that the hereditary factors possessed by the various species under consideration include a number which have been retained through the evolutionary processes by which these species have evolved from a common ancestor, and that among this group of factors are some which are specific in their ability to direct the formation of the nucleus XIV.



XIV

Superimposed upon these factors are others which vary from species to species and direct (a) the state of oxidation of the α- and β-carbon atoms of XIV and (b) the state and pattern of oxidation of the $C_{6(A)}$ unit with which XIV is condensed.

Experimental[17]

Coreopsis grandiflora was grown from commercially available seed.[18] In the work described here the fresh rays were used and were separated from the disk-florets immediately after picking the flowers.

Isolation of Pigments.—A quantity of 1551 g. of the fresh rays was covered with 95% alcohol and, after soaking

(15) Robinson, *Nature*, **137**, 172 (1936).

(16) Lawrence and Scott-Moncrieff, *J. Genetics*, **30**, 155 (1935).

(17) Melting points are uncorrected.

(18) The authors wish to express their thanks to Dr. G. A. L. Mehlquist, who allowed the use of a part of the experimental Horticulture tract and supervised the growing of the plants.

overnight, run through a meat-grinder. The resulting mixture of alcohol and petal-meal was allowed to stand forty-eight hours at 0°, after which time the meal was pressed dry and the extract filtered.

(A) **Leptosidin** (IV).—The alcohol extract was evaporated under reduced pressure and the sirup remaining was taken up in 600 ml. of water. The solution was extracted continuously with ether until fresh portions of ether were colorless. Extraction of the ether solution with several portions of dilute potassium carbonate solution yielded a deep red solution which, after washing with ether, was acidified and again extracted with ether. This ether solution was washed with several portions of dilute sodium acetate solution (discarded) and then with a cold, concentrated solution of potassium carbonate. A copious orange-red, crystalline precipitate formed. It weighed (dry) 7.1 g., was soluble in water to give an orange solution and in dilute alkali to give a deep red solution. Upon treatment of this salt with dilute acid there was obtained 5.6 g. of crude leptosidin. A sample (850 mg.) was recrystallized six times from aqueous methanol (yielding 620 mg.), after which it melted at 252–254° (dec). The last three recrystallizations did not materially improve the melting point but improved the appearance of the compound so that it was finally obtained as tiny orange-yellow needles. Leptosidin dissolves in cold dilute alkali to give a deep red solution, and is colored a bright red by concentrated sulfuric acid.

Anal. Calcd. for $C_{16}H_{12}O_6$: C, 64.00; H, 4.03; —OCH_3, 10.32. Found: C, 64.01, 64.03, 64.00, 63.98; H, 4.17, 4.21, 4.16, 4.05; —OCH_3, 10.10, 10.25.

(B) **Leptosin** (V).—The aqueous solution left after the continuous ether-extraction of leptosidin was saturated with ammonium sulfate and extracted with several portions of butyl alcohol. The butyl alcohol extract was diluted with petroleum ether (b. p. 30–60°) and extracted with several portions of dilute potassium carbonate solution. Acidification of the potassium carbonate extract yielded a deep red-brown solution which was shaken with a little butyl alcohol and allowed to stand. A deep orange-red precipitate formed. This was collected and recrystallized by dissolving it in cold, dilute alkali and acidifying the solution immediately. After partial purification it weighed 1.65 g. and melted over a range, starting at about 210° (with decomposition). Recrystallization from aqueous methanol furnished pure material, melting at 229–31° dec. (heating rate 10°/min.). The pure substance consists of bright red-orange needles which evidently contain water of hydration, since upon drying a sample at 100° and 25 mm. the color changes to a dull yellow. Determinations of the amount of water regained by the yellow form when it is exposed to the air gave values which indicated that the red-orange needles are a dihydrate but that these are somewhat hygroscopic. The compound dissolves in cold, dilute alkali to give a deep blue-violet solution and in concentrated sulfuric acid to give an intensely red solution.

Anal. Calcd. for $C_{22}H_{22}O_{11}$: C, 57.14; H, 4.80; —OCH_3, 6.72. Found: C, 56.66; H, 5.18; —OCH_3, 6.54.

A sample of 92.6 mg. of the dried (yellow) compound gained 7.3 mg. after one hour's exposure to the air. This corresponds to a water content of 7.3% in the red-orange hydrate. Calcd. for a dihydrate ($C_{22}H_{22}O_{11}\cdot 2H_2O$): 7.23% H_2O.

(C) **The Flavanone** (III).—The aqueous potassium carbonate solution from which the salt of leptosidin (see A) had separated was acidified and extracted thoroughly with ether. The ether solution was washed with sodium acetate solution, dried and evaporated to a small volume. A few ml. of petroleum ether was added and a dark oil separated. After the mixture had stood for two weeks much of the oil had solidified to a yellow solid. This material was collected, washed with ether and recrystallized several times from ethyl acetate–ligroin (b. p. 95–110°). The pure material (1.7 g.) was a light yellow in color, m. p. 195–197°.

The compound dissolves in cold (0°) dilute sodium hydroxide to give a pale red solution; allowing this solution to come to room temperature causes the color to deepen to an intense blood-red. The compound gives a red color with concentrated sulfuric acid. When its alcoholic solution is treated with a fragment of magnesium and a few drops of concentrated hydrochloric acid a deep red-violet to blue-violet color is produced.

Anal. Calcd. for $C_{16}H_{14}O_6$: C, 63.58; H, 4.67; —OCH_3, 10.27. Found: C, 63.82; H, 4.93; —OCH_3, 10.42.

(D) **Luteolin** (II) **(as the tetraacetate)**.—The ether–petroleum ether solution from which the flavanone had separated (C) was evaporated to dryness. The residual tarry material was acetylated by heating with 20 ml. of acetic anhydride and 2 g. of anhydrous sodium acetate. The excess acetic anhydride was decomposed by the addition of water, ether was added and the ether layer separated. A crystalline material was obtained by allowing the ether to evaporate slowly. This material melted over a range, but after several recrystallizations from alcohol there was obtained 0.21 g. of white silky needles, m. p. 218–221°. A mixture of this material with a sample of authentic luteolin tetraacetate, m. p. 220–222°, melted at 218–221°. It showed color reactions (magnesium and hydrochloric acid: red-orange; hot sodium hydroxide: yellow) identical with those of the authentic substance.

Anal. Calcd. for $C_{23}H_{18}O_{10}$: C, 60.79; H, 3.99. Found: C, 60.57, 60.56; H, 4.05, 4.07.

The petal-meal left after extraction with cold alcohol was extracted with boiling alcohol. From this extract were isolated, by the procedures described above, 1.28 g. of leptosidin (IV) and 0.62 g. of leptosin (V).

Leptosidin Triacetate (VII).—A solution of 1.10 g. of leptosidin and 2 g. of anhydrous sodium acetate in 10 ml. of acetic anhydride was heated to boiling, cooled and allowed to stand overnight at room temperature. The excess acetic anhydride was decomposed with water and the yellow precipitate which formed was collected and recrystallized from aqueous alcohol. The product (1.03 g. after five recrystallizations) formed pale yellow needles, m. p. 164.5–165.5°. It gave the same colors in concentrated sulfuric acid and in hot alkali as leptosidin.

Anal. Calcd. for $C_{22}H_{18}O_9$: C, 61.97; H, 4.24; —OCH_3, 7.28. Found: C, 61.76, 62.10; H, 4.36, 4.45; —OCH_3, 7.41, 7.44.

The same acetate was formed when 0.20 g. of leptosidin was refluxed for four hours with 0.40 g. of sodium acetate and 4 ml. of acetic anhydride.

Leptosidin Trimethyl Ether (VIII). (A) Deacetylation-methylation.—To a solution of 0.73 g. of leptosidin triacetate in 50 ml. of warm methanol was added 5 ml. of dimethyl sulfate and then 2 ml. of 50% aqueous potassium hydroxide. This was repeated with three more such portions of dimethyl sulfate and potassium hydroxide. Four portions, each of 2 ml. of dimethyl sulfate and 5 ml. of 50% potassium hydroxide solution, and finally 10 ml. of potassium hydroxide solution, were then added. The solution was diluted with water and extracted with ether. Evaporation of the ether left a crystalline residue which after six recrystallizations from aqueous alcohol formed lemon-yellow needles (0.43 g.), m. p. 156–157°. The compound gave a red color with concentrated sulfuric acid.

Anal. Calcd. for $C_{19}H_{18}O_8$: C, 66.66; H, 5.30; —OCH_3, 36.26. Found: C, 66.57; H, 5.59; —OCH_3, 36.38, 36.18.

Acidification of the alkaline solution from which VIII had been extracted yielded a small amount of yellow solid. After two recrystallizations from aqueous alcohol it melted at 203–205°. Too little (25 mg.) was obtained for extensive study. It is evidently a partially methylated substance, probably a leptosidin dimethyl ether having a free 6-, 3′- or 4′-hydroxyl group.

Anal. Calcd. for $C_{18}H_{16}O_6$: —OCH_3, 28.3. Found: —OCH_3, 27.6.

(B) Diazomethane (excess).—To a solution of 2.7 g. of leptosidin in methanol was added an ether solution containing a fourfold excess of diazomethane. After the solution had stood for two days at 0° the excess diazomethane was destroyed with acetic acid and the ether was evaporated. Dilution of the remaining solution with water gave a yellow solid which was washed with sodium carbonate solution. After two recrystallizations from alcohol the product weighed 1.4 g. and melted at 154–156°. It was identical with the substance obtained by methylation with dimethyl sulfate.

The sodium carbonate solution with which the fully methylated substance had been washed was acidified and extracted with ether. From the ether extract was isolated 0.095 g. of a yellow compound, m. p. 193–194°, which dissolved in alkali to give an orange solution. This material has not been examined further.

Partial Methylation of Leptosidin. Leptosidin Monomethyl Ether (IX).—A solution of 0.30 g. of leptosidin in methanol was treated with the amount of diazomethane (in ether) required for the methylation of three hydroxyl groups. After twenty minutes the remaining diazomethane was destroyed with acetic acid and the ether removed under reduced pressure. Addition of water caused the separation of an oil, which crystallized after several days. The product melted over a range (130–180°), and after seven recrystallizations from glacial acetic acid finally afforded 35 mg. of yellow-orange needles, m. p. 213–214°.

The compound dissolves in cold, dilute sodium hydroxide solution to give a deep purple solution, and gives a bright red color with concentrated sulfuric acid.

Anal. Calcd. for $C_{17}H_{14}O_6$: C, 64.96; H, 4.49; —OCH_3, 19.72. Found: C, 65.42; H, 4.70; —OCH_3, 19.83.

Leptosin Hexaacetate (VI).—A mixture of 0.20 g. of leptosin (V), 0.40 g. of anhydrous sodium acetate and 4 ml. of acetic anhydride was heated to boiling. The leptosin dissolved to give a pale yellow solution. After cooling, water and a little ether were added. The acetate separated as pale yellow needles. Recrystallized from aqueous dioxane and then from ethyl acetate–petroleum ether, the acetate (0.15 g.) formed tiny yellow needles, m. p. 233–234°. Upon treatment with warm, alcoholic alkali it gradually dissolved to form a deep purple solution.

Anal. Calcd. for $C_{34}H_{34}O_{17}$: C, 57.14; H, 4.80; —OCH_3, 4.34. Found: C, 57.49, 57.11; H, 4.92, 4.93; —OCH_3, 4.12, 4.38.

Hydrolysis of Leptosin. Identification of the Sugar as Glucose.—A suspension of 0.50 g. of leptosin in 20 ml. of water containing 2 ml. of concentrated hydrochloric acid was heated on the steam-bath overnight. The bright orange solid originally present was replaced by a dirty yellow material. This was removed by filtration, dissolved in alcohol and ether, and the alcohol removed by thorough washing with water. The ether solution was washed with sodium acetate solution, dried and evaporated. Acetylation of the orange semi-solid residue yielded 0.31 g. (76%) of leptosidin triacetate (m. p. 165°).

The original aqueous filtrate was continuously extracted with ether (a small amount of leptosidin acetate was obtained by working up the ether solution) and the hydrochloric acid removed by shaking the solution with silver carbonate and filtering through a layer of Norite. The colorless filtrate was concentrated under reduced pressure to a volume of 5 ml. and to it was added 0.4 g. of phenylhydrazine hydrochloride and 0.6 g. of sodium acetate. The filtered solution was heated on the steam-bath and soon deposited bright yellow needles. The osazone was recrystallized from 60% alcohol and was obtained as bright yellow needles which decomposed at 207–208° when heated at a rate of about 10° per minute.[19] An authentic sample of glucosazone and a mixture of the two behaved in exactly the same way.

Acetylation of the Flavanone. (A) Mild Acetylation to a Triacetate (X).—A mixture of 0.10 g. of the flavanone (III), 0.20 g. of anhydrous sodium acetate and 2 ml. of acetic anhydride was warmed for a few minutes and when solution was complete it was cooled and the excess acetic anhydride decomposed with ice. The product was collected and recrystallized from aqueous alcohol and then from ethyl acetate–ligroin (b. p. 90–110°). The acetate formed nearly colorless plates, m. p. 122–123.5°. The same product was formed when the acetylation was carried out in the cold in the presence of pyridine.

A solution of a few mg. of the acetate was dissolved in alcohol and a fragment of magnesium and a few drops of concentrated hydrochloric acid were added. The bright blue-violet color which was produced is qualitatively almost identical with that obtained with butin triacetate under the same conditions.

Anal. Calcd. for $C_{22}H_{20}O_9$: C, 61.67; H, 4.71; —OCH_3, 7.24. Found: C, 61.65, 61.42; H, 4.88, 4.63; —OCH_3, 7.42, 7.47.

(B) Vigorous Acetylation to a Tetraacetate (XI).—A solution of 0.20 g. of the flavanone (III), 0.40 g. of anhydrous sodium acetate and 4 ml. of acetic anhydride was refluxed for four hours. The solid obtained after decompos-

(19) Levene and LaForge, *J. Biol. Chem.*, **20**, 429 (1915).

ing the excess acetic anhydride was recrystallized from ethyl acetate–ligroin and formed colorless needles, m. p. 106–107.5°.

Anal. Calcd. for $C_{24}H_{22}O_{10}$: C, 61.27; H, 4.72; —OCH_3, 6.58. Found: C, 61.21; H, 5.00; —OCH_3, 6.45,

Methylation of the Flavanone. The Methyl Ether, XII.—Methylation of 0.30 g. of the flavanone (III), dissolved in methanol, with a fourfold excess of diazomethane in ether solution, afforded 0.195 g. of a compound as faintly yellow crystals, m. p. 139–140° after three recrystallizations from dilute alcohol.

Anal. Calcd. for $C_{19}H_{20}O_6$: C, 66.26; H, 5.86; —OCH_3, 36.00. Found: C, 66.27; H, 5.95; —OCH_3, 35.81.

Oxidation of Leptosidin Trimethyl Ether. (A) With Hydrogen Peroxide.—A solution of 0.50 g. of leptosidin trimethyl ether (VIII) in 50 ml. of acetone, 0.5 ml. of 50% aqueous potassium hydroxide and 7 ml. of 30% hydrogen peroxide was refluxed for two hours. After the addition of 2 ml. of saturated sodium bisulfite solution the acetone was removed under reduced pressure, 20 ml. of 1% hydrochloric acid was added and the solution was extracted with ether. The ether solution was extracted with three small portions of sodium bicarbonate solution and upon acidification of the bicarbonate extract a white precipitate formed (0.150 g.). This melted from 140° to 155° and repeated recrystallization did not raise or sharpen the melting point appreciably. The substance gave a purple color with ferric chloride. Its methoxyl content was intermediate between that of veratric acid and a dimethoxysalicylic acid.

Anal. Calcd. for $C_9H_{10}O_4$ (veratric acid): —OCH_3, 34.07. Calcd. for $C_9H_{10}O_5$: —OCH_3, 31.31. Found: —OCH_3, 32.62.

(B) With Potassium Permanganate.—Powdered potassium permanganate was added slowly to a hot solution of 0.60 g. of leptosidin trimethyl ether in 60 ml. of acetone until the purple color remained for five minutes. The solution was cooled and the solid collected by filtration. The solid was extracted with several small portions of hot water. Acidification of the aqueous solution so obtained yielded a white solid. A small additional amount was obtained by working up the acetone solution. After three recrystallizations from hot water the product (85 mg.) no longer gave a ferric chloride color and melted at 178–179.5°. An authentic sample of veratric acid melted at 179–180° and a mixture of this and the oxidation product melted at 178.5–179.5°.

Anal. Calcd. for $C_9H_{10}O_4$: C, 59.33; H, 5.53. Found: C, 59.12; H, 5.69.

Summary

1. From the ray flowers of *Coreopsis grandiflora* have been isolated luteolin (as the acetate) and three new substances: a glucoside, leptosin, its aglucon, leptosidin, and a flavanone.

2. Tentative structures have been assigned to leptosin, leptosidin and the flavanone, on the basis of (a) their compositions and those of their methyl ethers and acetates, (b) their distinctive color reactions and (c) biogenetic evidence from previous studies of flower pigments of related members of the *Compositae*.

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[CONTRIBUTION FROM THE CONVERSE LABORATORY, HARVARD UNIVERSITY]

Normal Addition of Hydrogen Bromide to 3-Butenoic, 4-Pentenoic and 5-Hexenoic Acids in Hexane[1]

BY ARTHUR MICHAEL AND HOWARD S. MASON[2,3]

Evidence exists that non-polar solvents can induce abnormal addition of hydrogen bromide to terminally unsaturated aliphatic acids, but the independence of the character of this phenomenon has been controversial since the development of an understanding of the role of peroxides and oxygen in such reversals. The object of this investigation was to resolve this controversy[4,5] by determining whether or not the direction of addition of hydrogen bromide to such acids can be influenced by hexane under rigidly anti-oxidant conditions.

It has now been found that under these conditions 3-butenoic, 4-pentenoic, and 5-hexenoic acids in hexane solution add hydrogen bromide preponderantly normally (Table I).

(1) This paper was originally presented before the Organic Division at the Buffalo meeting of the American Chemical Society, September, 1942.

(2) Although this research was carried out under the direction of the late Professor Arthur Michael, the statements contained in this report, and the responsibility for them, are those of the junior author.

(3) Now at the National Institute of Health, Bethesda, Maryland.

(4) Gaubert, Linstead and Rydon, *J. Chem. Soc.*, 1974 (1937). "The persistent anomaly is the formation of the terminal bromoacids in hexane or petroleum solution in the presence of hydrogen and anti-oxidant, which we have now observed in the case of five acids of the general formula $CH_2{=}CH[CH_2]_nCO_2H$ (where n = 1, 2, 3, 4, and 6) but which is not shown by undecenoic acid (n = 8), or by allylacetic acid in the experiments of Kharasch and McNab."

(5) Kharasch and McNab, *Chem. and Ind.*, **54**, 989 (1935). "The addition of hydrogen bromide to allyl acetic acid with . . . solvents [hexane] has now been repeated in this Laboratory . . . It is evident that these data are in complete agreement with our previous statements that peroxides and not the solvents control the direction of addition."