CII.—*The Constitution of Carthamin. Part I.*

By (Miss) CHIKA KURODA.

CARTHAMIN, the red colouring matter of safflower, was formerly an important dye, and although the demand for it has declined considerably since the advent of artificial colouring matters, the safflower is still cultivated on a large scale, especially in India and China. Notwithstanding its high cost, carthamin is much appreciated in Japan for certain purposes : it is believed to have remarkable medicinal properties.

Malin (*Annalen*, 1840, **36**, 117), Preiser (*J. pr. Chem.*, 1844, **32**, 142), Schlieper (*Annalen*, 1846, **58**, 357), Radcliffe (*J. Soc. Dyers and Col.*, 1897, **13**, 158), and Kametaka (*J. Chem. Soc. Tokyo*, 1906, **27**, 1202) investigated carthamin, but Kametaka and Perkin (J., 1910, **97**, 1415) were the first to isolate it in a pure crystalline condition. Both Preiser and Radcliffe, the latter using methyl alcohol as solvent, claimed to have isolated carthamin in a crystalline form; their descriptions, however, are somewhat contradictory. Kametaka and Perkin found methyl alcohol unsatisfactory as a solvent and obtained crystalline carthamin by using pyridine : they gave it the provisional formula $C_{25}H_{24}O_{12}$ and obtained *p*-hydroxybenzoic acid (this was first isolated by Malin), *p*-coumaric acid, *p*-hydroxybenzaldehyde, and picric acid from it by various means, but were unable to prepare crystalline derivatives by methylation, benzoylation, or acetylation; carthamin, however, gave crystalline additive compounds with aniline and with β-naphthylamine.

The author began an investigation of carthamin in 1924, but owing to the outbreak of civil war in China the supply of the raw material failed. During the last two years, supplies have again been available, and the author is also deeply indebted to Dr. Kametaka, who provided her with material collected in China by Dr. Momoji Yamazaki.

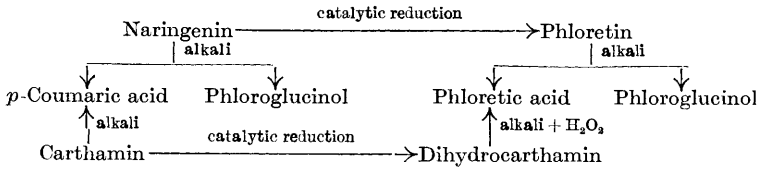
The initial substance used in the present work was a paste (sold as carthamin paste) prepared from the raw material by the traditional method of Japanese manufacturers. The paste was submitted to filtration, and the residue quickly dried on porous tile. The product, when crystallised, with great loss, from pure pyridine by a modification of Kametaka and Perkin's method (*loc. cit.*), gave carthamin, although not in a pure condition. When, however, the dried product was digested with cold dilute hydrochloric acid and again dried, it was converted into a crystalline substance which could be recrystallised from dilute methyl alcohol in good yield,

giving fine, yellow, hydrated needles, m. p. about 228° (decomp.; colour change at about 168°) (Schlieper, *loc. cit.*, obtained from a methyl-alcoholic extract of commercial carthamin a yellow substance, though not in a crystalline form, m. p. about 168°). When the yellow needles were recrystallised from pyridine, a substance separated in red needles with a green iridescence, like those of carthamin obtained by Kametaka and Perkin. Many facts indicate that the red and the yellow substance are isomeric. The latter, named iso*carthamin*, gave analytical results corresponding to the formula $C_{21}H_{22}O_{11},2H_2O$ when freshly prepared and quickly dried, to $C_{21}H_{22}O_{11}$ after being dried at 60° under reduced pressure, and to $C_{21}H_{20}O_{10}$ ($C_{21}H_{22}O_{11} - H_2O$) after being dried at 100° under reduced pressure. The last formula also agrees with the analytical data recorded by Kamataka and Perkin (*loc. cit.*, p. 1418).

Carthamin and *iso*carthamin are glucosides. They can be hydrolysed by dilute sulphuric or hydrochloric acid or by emulsin, yielding glucose (1 mol.), but only when the hydrolysis is effected with dilute phosphoric acid can the other components of the glucosides, namely, *carthamidin* and iso*carthamidin*, be ultimately obtained in the crystalline condition. These two substances are separable by means of moist chloroform, in which *iso*carthamidin is insoluble and carthamidin is slightly soluble. The latter separates from the solution in pale yellow, hydrated needles, $C_{15}H_{12}O_6,H_2O$, m. p. 218°. *iso*Carthamidin separates from dilute methyl alcohol in yellow, hydrated, rhombic crystals, m. p. 240°, which lose water at 100° under reduced pressure.

Carthamidin and *iso*carthamidin have phenolic properties: they can be acetylated, but are inert towards methyl iodide, methyl sulphate, and diazomethane. When they are reduced in methyl-alcoholic solution with magnesium and hydrochloric acid, they give a magenta coloration, resembling in this respect a flavonol such as quercetin. Their absorption spectra, however, differ from those of the flavonols, and also, on decomposition by alkali, they behave somewhat differently from quercetin in that they easily yield *p*-hydroxybenzaldehyde and *p*-coumaric acid, whereas quercetin under the same conditions gives, not the corresponding aldehyde, but protocatechuic acid. It is interesting that naringin (the glucoside of naringenin), until recently considered to be a hydroxychalkone derivative, develops a red coloration on treatment in methyl-alcoholic solution with magnesium and hydrochloric acid (Tsujimura, *Bull. Inst. Phys. Chem. Res. Tokyo*, Vol. VI, 12, 1111). On the other hand, phloretin, which is closely related to naringenin, gives on treatment with alkali the products mentioned below (Will, *Ber.*, 1885, **18**, 1322; Michael, *Ber.*, 1894, **27**, 2687;

Sonn, *Ber.*, 1913, **46**, 4050; Franck, *Centr.*, 1914, II, 253). Dihydrocarthamin (IX), obtained from carthamin by catalytic reduction, gives phloretic acid when treated with hydrogen peroxide in alkali-carbonate solution. These relationships are shown in the following scheme :

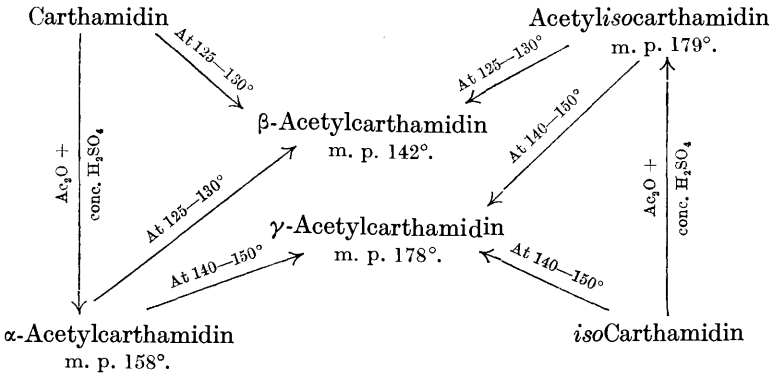


The author has so far been unable to prepare a polyhydroxybenzene from carthamin and its derivatives : only monohydric phenols such as *p*-hydroxybenzaldehyde, tribromophenol, and *p*-hydroxybenzoic, *p*-coumaric, phloretic, and picric acids—and these in poor yield—have been obtained. The following reactions of carthamidin and *iso*carthamidin, however, indicate, not only the presence of a polyhydroxybenzene nucleus, but also, when compared with similar reactions of di- and tri-hydric phenols of known conconstitutions (see table on p. 761), the relative positions of the hydroxyl groups. (1) Ferric chloride in methyl-alcoholic solution produces a transient bluish-green coloration, changing to purple-brown, and finally a brown precipitate (compare quinol). (2) An aqueous solution of barium hydroxide gives a bright indigo-blue colour (a precipitate from concentrated solutions) and then a reddish-brown precipitate : this is a very delicate test. (3) Lead acetate in methyl-alcoholic solution produces a yellow precipitate which becomes brown and then bluish-green or dark green. (4) When carthamidin is rubbed on a watch-glass with a rod moistened with 2*N*-sodium hydroxide, it becomes blue and then reddish-brown (*iso*carthamidin does not give this test).

When the tests (1), (2), and (3) were applied to the di- and trihydric phenols of known constitutions, the relative positions of the hydroxyl groups were distinguishable in the following manner : (1) if two hydroxyls are in the ortho-position with respect to each other, precipitation occurs in all three tests; (2) if there are two hydroxyls in the para-position with respect to each other, the substance gives a delicate colour change. Quinol and 2 : 4-dihydroxy-1 : 3-dimethoxybenzene resemble carthamidin in their colour reactions in test (4).

In view of these results, it is concluded that reactions (1), (2), and (3) show that hydroxyl groups in carthamidin must be arranged as those in hydroxyquinol, *viz.*, one pair in the ortho relation, and another pair in the para relation, to each other. These two sub-

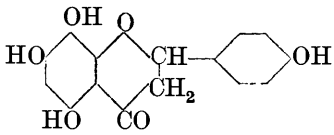
stances are also alike in their instability towards boiling water and on exposure to air. Numerous attempts were made to produce a polyhydroxybenzene from carthamin, *iso*carthamin, and carthamidin by very cautiously decomposing them with hot aqueous barium hydroxide in an atmosphere of hydrogen; however, only *p*-coumaric acid, *p*-hydroxybenzaldehyde, and an acid which appeared to be gluconic acid were isolated. The hydroxylated nucleus of carthamidin is therefore much more unstable than hydroxyquinol. Now, 1 : 2 : 3 : 5-tetrahydroxybenzene is so unstable that it is decomposed by boiling water, and its colour reaction with alkali given in the literature resembles reaction (4) of carthamidin. If, then, this is the hydroxylated nucleus of carthamidin, the reactions described above and also the results of acetylating carthamidin and *iso*carthamidin under various conditions (see below) become explicable.



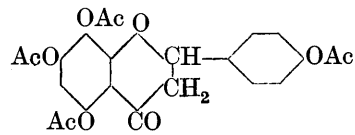
(For the reactions where no reagent is indicated, a mixture of sodium acetate and acetic anhydride was used.)

Shortly after reaching the above conclusion regarding the constitution of carthamidin the author discovered that Chapman, Perkin, and Robinson (J., 1927, 3015) had shown that carajurin gave no appreciable quantity of polyhydric phenol on decomposition with alkali—a fact which in their opinion supported rather than discredited the constitution of a tetrahydroxybenzene derivative assigned to the substance. Hence it is concluded that carthamidin and *iso*carthamidin are hydroxychalkone derivatives. It is in general difficult to distinguish hydroxychalkones from hydroxyflavanones owing to their easy interconvertibility. According to Asahina, Shinoda, and Inubuse (*J. Pharm. Soc. Japan*, 1928, **48**, 208, 868) the colour reaction (2) above is negative for hydroxychalkones but positive for hydroxyflavanones, and on this ground

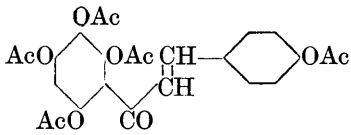
naringin and other similar substances were shown to be hydroxyflavanones. Hence it follows that carthamidin also belongs to this class of substance. The colour reaction (2) is also given by *iso*carthamidin, *α-acetylcarthamidin*, and *acetylisocarthamidin*, but not by β- and *γ-acetylcarthamidin*. β-Acetylcarthamidin is a pentaacetyl derivative and α-acetylcarthamidin and acetyl*iso*carthamidin are tetra-acetyl derivatives. The analytical results are in complete accord with the following formulations of carthamidin and its acetyl derivatives.



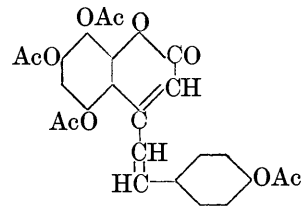
(I.) Carthamidin.



(II.) α-Acetylcarthamidin.



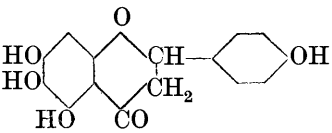
(III.) β-Acetylcarthamidin.



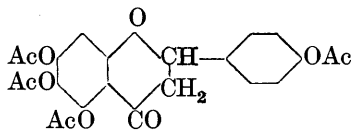
(IV.) γ-Acetylcarthamidin.

When rubbed with alkali [colour reaction (4) above], *iso*carthamidin behaves like pyrogallol in that both turn brown without previously becoming indigo-blue; 1 : 2 : 3 : 5-tetrahydroxybenzene behaves like carthamidin; and pyrocatechol becomes indigo-blue, the colour being fairly persistent.

The structures of *iso*carthamidin and acetyl*iso*carthamidin are probably (V) and (VI) respectively.



(V.) *iso*Carthamidin.

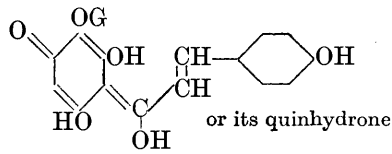


(VI.) Acetyl*iso*carthamidin.

The constitutional change from a flavanone (I, II, V, VI) into a chalkone (III) or into a coumarin derivative (IV) which accompanies the acetylation finds support in the analogies furnished by naringenin (Asahina, Shinoda, and Inubuse, *loc. cit.*) for the former change and by phloretin and maclurin (*Ber.*, 1895, **28**, 1393) for the latter change. Moreover, the absorption spectrum of β-acetylcarthamidin (III) resembles that of chalkone (phenyl styryl ketone)

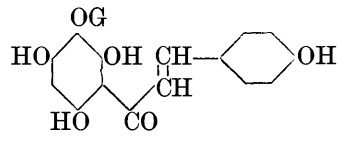
itself very closely, whereas the spectra of carthamidin and *iso*-carthamidin resemble the spectrum of naringin.

The glucosides carthamin and *iso*carthamin are considered to have the formulæ (VII) and (VIII) respectively (they may also be *cis*- and *trans*- isomerides), because by means of reactions (2) and (3) it can be shown that neither contains two hydroxyls in the ortho-relation and hence it is probable that the glucose residue is in the position indicated. Moreover, the glucosides yield *p*-hydroxybenzaldehyde very easily, whereas the components carthamidin and *iso*carthamidin do not under the same conditions. The difficulty of obtaining carthamidin from dihydrocarthamin may be explained by representing the latter by the formula (IX).

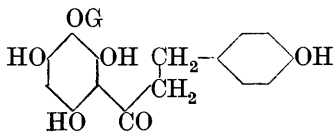


or its quinhydrone

(VII.) Carthamin.



(VIII.) *iso*Carthamin.



(IX.) Dihydrocarthamin.

(G = the glucose residue.)

The investigation is being continued.

Experimental.

Preparation of Carthamin.—The filtered dried product (20—25 g.) obtained from commercial carthamin paste (1 kg.) was in quantities of 5 g. extracted several times with pyridine (200 c.c. in all) on a water-bath; the insoluble material was 25—30% of the whole. The extracts were concentrated under reduced pressure to small bulk, water was added, and the fine red needles that slowly formed were collected and washed with acetone (yield, 2—3 g.). The sample for analysis was submitted to the above purification at least three times and was then warmed with acetone and ether and dried at 100° under reduced pressure. The analytical results, the melting point, and other properties agreed with those recorded by Kametaka and Perkin (*loc. cit.*) and the substance was identical with a specimen of carthamin kindly supplied by Dr. Kametaka (Found : C, 58·8, 57·8; H, 4·9, 4·8; ash, trace. Calc. for $C_{21}H_{20}O_{10}$: C, 58·2; H, 4·6%).

Each crystallisation from pyridine caused the loss of almost half of the carthamin; some of this was recovered by acidifying the fresh mother-liquor with sulphuric acid at 0°.

Preparation of iso*Carthamin.*—Crude carthamin (5 g.) was digested with water (100 c.c.) and 12% hydrochloric acid (15 c.c.) and after several hours the solid was collected, washed with water and dried on tile (yield, about 4·5 g. There was no loss when purified carthamin was used in the digestion). When a little water was added to a hot methyl-alcoholic solution of the product, iso*carthamin* gradually separated in yellow needles (yield, about 50%); these were collected and dried quickly by washing with methyl alcohol and then with ether; m. p. 228° (reddening at about 168°) (Found: C, 52·1, 52·0; H, 5·1, 5·2. $C_{21}H_{22}O_{11},2H_2O$ requires C, 51·9; H, 5·3%. Found in material dried at 60° under reduced pressure: C, 55·7; H, 4·9. $C_{21}H_{22}O_{11}$ requires C, 56·0; H, 4·9%). When *iso*carthamin was heated at 100° under reduced pressure, it changed into a brown substance resembling that obtained from carthamin under the same conditions (Found: C, 57·9; H, 4·8. Calc. for $C_{21}H_{20}O_{10}$: C, 58·2; H, 4·6%).

*iso*Carthamin could not be obtained crystalline from ethyl-alcoholic solution, nor from methyl alcohol if the solution was concentrated by distillation, even under reduced pressure: in order to recover *iso*carthamin from such spoiled solutions, repetition of the treatment with hydrochloric acid is necessary. The yellow crystals of *iso*carthamin are stable in a sealed tube, but change to a red powder on exposure to air. *iso*Carthamin is soluble in water, but the yellow solution, on standing or when boiled, becomes pink in the same way as an aqueous solution of carthamin.

Decomposition of Carthamin or iso*Carthamin with Hot Dilute Hydrochloric Acid.*—When either substance was heated with 7% hydrochloric acid for 20 minutes, it changed into a black amorphous powder. The aqueous solution (1) yielded nothing crystalline to ether, (2) reduced Fehling's solution, (3) gave no immediate precipitate when treated with phenylhydrazine, the absence of mannose thus being indicated, (4) gave no results when tested for gluconic acid and pentoses by means of naphtharesorcinol and phloroglucinol respectively.

Glucosazone from Carthamin or iso*Carthamin.*—A mixture of 12% hydrochloric acid (5 c.c.), *iso*carthamin (or carthamin) (0·55 g.), and water (5 c.c.) was heated on a water-bath for 1 hour, and the black product was washed with water. The filtrate and washings were neutralised with sodium carbonate, concentrated on a water-bath, and warmed with sodium acetate (0·57 g.) and phenylhydrazine hydrochloride (0·38 g.). Glucosazone, which separated

very slowly, after being washed and dried (yield, 0·055 g.), melted at 206°, alone or mixed with an authentic specimen (Found : C, 60·2; H, 6·1. Calc. : C, 60·3; H, 6·2%).

Determination of glucose. In a similar experiment (*iso*carthamin, 0·2043 g.; water, 4 c.c.; 12% hydrochloric acid, 6 c.c.) the neutralised filtrate and washings were diluted to 100 c.c. with 10% aqueous ammonia and the glucose in the solution was estimated by Pavy's volumetric method (Found : $C_6H_{12}O_6$, 37·0, 36·9. $C_{21}H_{22}O_{11},2H_2O$ requires $C_6H_{12}O_6$, 37·0%). The same result was obtained with carthamin.

Optical rotation of the sugar solution. *iso*Carthamin (0·6 g.), water (6 c.c.), and 12% hydrochloric acid (9 c.c.) were heated together as before, the aqueous solution was made up to 20 c.c. (it was assumed to be a 1·1% glucose solution), and the rotation was observed : $[\alpha]_D^{21°}$ + 53° (calc., + 52·6°). The author wishes to thank Mrs. Okada and Miss Yamaguchi for their help in this experiment.

Catalytic Reduction of Carthamin.—Carthamin (0·2 g.), suspended in ethyl alcohol (25 c.c.), was treated with hydrogen in the presence of palladium-black. The volume of the gas diminished during the first 10 minutes, then increased fairly rapidly to the original value, and thereafter remained almost constant. The carthamin gradually dissolved, giving a yellow solution. After 4—5 hours, the solvent was evaporated at the ordinary temperature and the residue, freed from the palladium, was kept in contact with a little water in an open vessel : fine yellow needles (probably hydrated) separated; they were insoluble in benzene and chloroform, fairly readily soluble in acetone, and very soluble in methyl alcohol (yield, about 70%). The crystals became red on drying in a desiccator, but yellow again on exposure to the air. The combustion of the substance was sluggish, requiring 2 hours for completion even on the micro-scale (Found in material dried at 90° under reduced pressure : C, 55·0; H, 5·5. $C_{21}H_{24}O_{11}$ requires C, 55·6; H, 5·3%), but the behaviour of the product on decomposition with alkali and hydrogen peroxide (see p. 763) convinced the author that it was actually *dihydrocarthamin*.

Decomposition of Carthamin or iso*Carthamin with Phosphoric Acid.*—The powdered material (5 g.) was heated with a 9% aqueous solution of phosphoric acid (100 c.c.) on a water-bath for 40 minutes in a closed vessel, carbon dioxide being passed during the whole time. The liquid was filtered hot, cooled, extracted repeatedly with ether, and used again to decompose more of the residual solid : after four repetitions, only a small quantity of a black solid remained. The combined ethereal extracts were evaporated, leaving a residue which, after addition of a very little aqueous

acetone, slowly solidified to a yellow crystalline cake (yield, about 30%). Subsequently it was found that the dry raw material obtained directly from the original carthamin paste may be used for the preparation of the same substance in good yield (about 15% of the raw material).

Isolation of carthamidin (I). The crystalline cake (above) was warmed with successive quantities of moist chloroform for a few minutes, until nothing crystallised from the rapidly filtered extract on cooling. *Carthamidin* was thus obtained in pale yellow needles containing one molecule of water (yield, 30% of the crude product), and sometimes also in long needles on repetition of the purification; m. p. 218° (Found: C, 58·8, 58·9; H, 4·8, 4·4. $C_{15}H_{12}O_6,H_2O$ requires C, 58·8; H, 4·6%. Found in material heated at 100° under reduced pressure: C, 62·7; H, 4·4; *M*, ebullioscopic in acetone, 298, 286, 270.* $C_{15}H_{12}O_6$ requires C, 62·5; H, 4·2%; *M*, 288).

Carthamidin is very soluble in acetone, methyl alcohol, acetic acid, and ethyl acetate, but sparingly soluble in light petroleum, benzene, dry chloroform, and cold water. It crystallises from hot aqueous solution in the hydrated form, but is decomposed by prolonged boiling: even at the ordinary temperature it seems to decompose slowly in aqueous solution.

When carthamin or *iso*carthamin was heated with 1% sulphuric or hydrochloric acid, no trace of carthamidin or *iso*carthamidin was produced.

iso*Carthamidin* (V). The residue left after the extraction of the carthamidin with moist chloroform was dissolved in the minimum quantity of acetone: on addition of chloroform (3—4 vols.), iso*carthamidin* remained in solution but a dark resinous substance was precipitated. The latter was repeatedly dissolved in acetone and reprecipitated with chloroform. When the combined filtrates were allowed to evaporate to dryness, somewhat rounded crystals were produced; these were washed with ether and recrystallised twice from dilute methyl alcohol, *iso*carthamidin being obtained in yellow hydrated prisms, m. p. 240° (Found in material dried at 100° under reduced pressure: C, 62·5; H, 4·3. $C_{15}H_{12}O_6$ requires C, 62·5; H, 4·2%).

When dihydrocarthamin was treated with dilute phosphoric acid under the same conditions as carthamin, no crystalline product was obtained.

Carthamidin and *iso*carthamidin resemble each other very closely in many of their properties. The former seems to be converted into the latter under certain conditions; for instance, when it is

* The author is indebted to Mr. Shiba for carrying out these determinations of molecular weight.

heated with water in air or in a sealed tube at 100° or higher or with animal charcoal at 100° in aqueous solution.

Reactions of Phenols (see p. 754).—A = ferric chloride in methyl-alcoholic solution; B = lead acetate in methyl-alcoholic solution; C = barium hydroxide in aqueous solution.

	A.	B.	C.
Resorcinol	No ppte.	No ppte.	No change
Phloroglucinol	,,	,,	,,
Pyrocatechol	Blue ⟶ green ppte.	Ppte.	Light blue ⟶ white ppte.
Pyrogallol	Green ⟶ brown ppte.	,,	Violet-brown ppte.
Quinol	Blue ⟶ brown ppte.	No ppte.	Yellowish-brown ppte.
Hydroxyquinol	Reddish-brown	Ppte.	Reddish-brown ppte.
2 : 4-Dihydroxybenzoic acid	Violet	No ppte.	No change
3 : 4-Dihydroxybenzoic acid	Green	White ppte.	Light blue ⟶ white ppte.
2 : 5-Dihydroxybenzoic acid	Blue	No ppte.	No change
3 : 4 : 5-Trihydroxybenzoic acid	Blue ppte.	White ppte.	Blue ppte.
3 : 4 : 5-Trihydroxyacetophenone	Violet	Yellow ppte.	Violet ppte.

α-*Acetylcarthamidin* (II).—When carthamidin (0·1 g.), suspended in acetic anhydride (1 c.c.), was cooled and treated with a trace of concentrated sulphuric acid, reaction started immediately with evolution of heat. After several hours, water was added and the precipitate, which separated slowly, was collected, washed with water, and dried (yield, almost theoretical). This *acetyl* compound crystallised from methyl alcohol in colourless prisms, m. p. 158° [Found: C, 60·5, 60·3; H, 4·5, 4·4; $CH_3{\cdot}CO$, determined by Freudenberg's method (*Annalen*, 1923, **433**, 230), 36·4, 36·6; *M*, ebullioscopic in benzene, 425, 445, 470. $C_{15}H_8O_6(CH_3{\cdot}CO)_4$ requires C, 60·5; H, 4·4; $CH_3{\cdot}CO$, 37·7%; *M*, 456]. It was very easily soluble in chloroform, benzene and acetone, fairly readily soluble in ether and methyl alcohol, and difficultly soluble in water. A methyl-alcoholic solution gave (1) no colour with ferric chloride, (2) a magenta colour (slowly) on reduction with magnesium and hydrochloric acid. When heated with hydrochloric acid in methyl-alcoholic solution, the acetyl derivative gave carthamidin, which was identified by its m. p. after being washed with ether to remove a red impurity. Acetylcarthamidin was optically inactive in benzene solution.

*Acetyl*iso*carthamidin* (VI).—This was prepared in almost theoretical yield in the same way as α-acetylcarthamidin. It is easily soluble in benzene, chloroform, and acetone, sparingly soluble in

methyl alcohol, and almost insoluble in ether. When ether or methyl alcohol is added to its chloroform solution, *acetylisocarthamidin* separates in fine, colourless, silky needles, m. p. 179° [Found: C, 60·5, 60·4; H, 4·5, 4·4; $CH_3 \cdot CO$, 37·4; *M*, ebullioscopic in benzene, 430, 442. $C_{15}H_8O_6(CH_3 \cdot CO)_4$ requires C, 60·5; H, 4·4; $CH_3 \cdot CO$, 37·7%; *M*, 456].

The absorption spectrum of acetyl*iso*carthamidin and its behaviour towards ferric chloride and towards magnesium and hydrochloric acid are the same as those of α-acetylcarthamidin.

The differences in melting point, crystalline form, and solubility in methyl alcohol and in ether of these two acetyl compounds are important as means of identifying carthamidin and *iso*carthamidin, which are otherwise difficult to distinguish from each other.

β-*Acetylcarthamidin* (III).—A mixture of carthamidin (0·1 g.), anhydrous sodium acetate (0·5 g.), and acetic anhydride (1·5 c.c.) was heated at 125—130° for 5 hours; the product was then cooled and mixed with water. After the excess of acetic anhydride had been decomposed, the precipitate was collected, washed with water, and dried (yield, nearly 0·14 g.). It crystallised from methyl alcohol in large rhombs, m. p. 142° [Found: C, 60·3, 60·3; H, 4·5, 4·5; $CH_3 \cdot CO$, 42·7, 42·1. $C_{15}H_7O_6(CH_3 \cdot CO)_5$ requires C, 60·2; H, 4·4; $CH_3 \cdot CO$, 43·2%].

β-*Acetylcarthamidin* in methyl-alcoholic solution gives a colour reaction neither with ferric chloride nor with magnesium and hydrochloric acid. It is very easily soluble in chloroform and acetone and sparingly soluble in cold methyl alcohol and ether. It may also be obtained in almost theoretical yield from *iso*carthamidin, α-acetylcarthamidin and acetyl*iso*carthamidin by the same method.

γ-*Acetylcarthamidin* (IV).—A mixture of carthamidin (0·1 g.), anhydrous sodium acetate (0·5 g.), and acetic anhydride (1·5 c.c.) was heated in an oil-bath at 140—150° for 5 hours: the procedure was then as described above, but a further quantity of the product was obtained from the aqueous filtrate by extraction with ether. γ-*Acetylcarthamidin* separated from methyl alcohol in minute colourless crystals, m. p. 178°. The yield was poor (about 25%), because β-acetylcarthamidin and a decomposition product were also formed: these rendered the purification rather tedious (Found: C, 62·5, 62·6; H, 4·3, 4·3. $C_{25}H_{20}O_{10}$ requires C, 62·5; H, 4·2%). The compound may also be obtained from *iso*carthamidin, α-acetylcarthamidin, and acetyl*iso*carthamidin by the above method, though in poor yield.

γ-Acetylcarthamidin resembles acetyl*iso*carthamidin in appearance and their melting points are almost the same. The two sub-

stances, however, differ in solubility in many solvents, particularly methyl alcohol and ether, in each of which the former is the more soluble and dissolves fairly readily. Its methyl-alcoholic solution gives a colour reaction neither with ferric chloride nor with magnesium and hydrochloric acid.

Action of Hydrogen Peroxide on Carthamin (compare Kametaka and Perkin, *loc. cit.*).—A solution of carthamin (1 g.) in 1% aqueous sodium carbonate (60 c.c.) and 3% aqueous hydrogen peroxide (40 c.c.) was kept at the ordinary temperature until it became yellow; it was then acidified with dilute sulphuric acid and extracted with ether. The residue after evaporation of the ether was dried, extracted with hot benzene to remove a trace of *p*-hydroxybenzaldehyde, dissolved in hot water, and decolorised with animal charcoal; on cooling, *p*-coumaric acid crystallised (yield, about 10%), m. p. 210° (Found : C, 65·9; H, 4·8. Calc. : C, 65·9; H, 4·9%).

Action of Hydrogen Peroxide on Quercetin.—The above operation was applied to quercetin, protocatechuic acid, m. p. 199°, being obtained in theoretical yield (Found : C, 54·3; H, 3·9. Calc. : C, 54·6; H, 3·9%).

Action of Hydrogen Peroxide on Dihydrocarthamin and on Phloretin.—Dihydrocarthamin (0·2 g.) was treated in the same way as carthamin (one-fifth quantities). The product obtained after evaporation of the ether was pressed on a tile; the crystalline residue (about 0·03 g.), m. p. about 125°, separated from hot concentrated aqueous solution (animal charcoal) in prisms, m. p. 129° (Found : C, 65·1; H, 6·1. Calc. for $C_9H_{10}O_3$: C, 65·1; H, 6·0%).

In a similar way phloretin gave phloretic acid (Found : C, 65·1; H, 5·9%) which, alone or mixed with the specimen obtained from dihydrocarthamin, melted at 129°.

Action of Bromine Water on Carthamin.—When digested with bromine water (100 c.c.), carthamin (0·5 g.) yielded a yellow precipitate (about 0·6 g.), decomp. about 146° (Found : C, 26·7; H, 2·5; Br, 53·0%). This substance slowly changed into a brown resin and a small quantity of tribromophenol sublimed. When the substance was heated with 5% aqueous alkali and the acidified product distilled with steam, tribromophenol was obtained.

Action of Alkali on Carthamin and its Decomposition Products.—The black amorphous powder produced by the decomposition of carthamin with dilute hydrochloric acid (see p. 758) (4·5 g.) was heated with potassium hydroxide (5 g.) and water (2 c.c.) at 160° for 30 minutes. The bluish-green product, when dissolved in water, became violet and then brown. The solution was acidified with dilute sulphuric acid, the precipitate (0·15 g.) removed, and the

filtrate extracted with ether. From the extract, a substance (0·2 g.) was obtained which gave *p*-hydroxybenzoic acid, m. p. and mixed m. p. 210°, on purification (Found: C, 60·8; H, 4·2. Calc.: C, 60·9; H, 4·4%).

Carthamin was heated with 5% aqueous caustic alkali and the solution was then acidified and extracted with ether: *p*-hydroxybenzaldehyde and *p*-coumaric acid were isolated from the extract. When concentrated caustic alkali (about 20%) was used, only *p*-hydroxybenzaldehyde was obtained (compare Kametaka and Perkin, *loc. cit.*). When carthamin was fused with potassium hydroxide and a little water at 140°, a bluish-green mass was obtained from which *p*-hydroxybenzoic acid, m. p. 210°, was isolated in a yield of nearly 10%. Various concentrations of caustic alkali produced only *p*-hydroxybenzaldehyde from carthamidin or *iso*carthamidin (even from 0·02 g.).

Action of Hot Baryta Water on Carthamin.—Carthamin (3 g.) and hot saturated aqueous baryta (60 c.c.) were heated together on a water-bath for 5 hours in an atmosphere of hydrogen. Carbon dioxide was passed through the cooled liquid, the precipitate removed, and the filtrate extracted with ether: from the extract, *p*-hydroxybenzaldehyde (0·33 g.) was isolated. Dilute sulphuric acid was added to the aqueous liquid, the barium sulphate removed, and the filtrate extracted with ether: from this extract, *p*-coumaric acid (0·24 g.) was isolated. The aqueous liquid was now treated with basic lead acetate and, after filtration, with hydrogen sulphide. After further filtration it was concentrated by distillation under reduced pressure, a colourless, acidic, syrupy residue (about 0·5 g.) being obtained. This substance did not reduce Fehling's solution and gave no colour reaction with ferric chloride. When it was heated, it swelled and charred, emitting an odour resembling that of burning tartaric acid or sugar. The substance, which appeared to be gluconic acid, was neutralised with potassium carbonate and the concentrated aqueous solution was treated with alcohol; the white crystals produced were washed with ether and dried in a desiccator (Found: K, 16·0. Calc. for $C_6H_{11}O_7K$: K, 16·7%).

The same process applied to *iso*carthamin gave the same products, but its application to carthamidin was not successful owing to the insolubility of the barium salt in water.

Absorption Spectra of Carthamidin, iso*Carthamidin, α-Acetylcarthamidin, Acetyl*iso*carthamidin, γ-Acetylcarthamidin, Chalkone, and Naringin.*—The spectra were photographed through the kindness of Mr. Sakurai. In each case the substance was dissolved in ethyl alcohol and concentrations of $N/5000$—$N/10000$ were employed, the iron arc being used as the light source. Carthamidin

and *iso*carthamidin resemble each other closely and have bands with centres at about λ 2900 Å. Both substances cut off the violet end of the visible spectrum to nearly equal extents in $N/5000$-solutions. The absorption spectrum of naringin has a general resemblance to that of carthamidin in $N/10000$-solution. α-Acetylcarthamidin and acetyl*iso*carthamidin give similar absorptions, both having shallow bands with centres at about λ 2600 Å and transmitting the light rather more freely in the ultra-violet region. The absorption spectra of these two substances differ from that of β-acetylcarthamidin, which, however, resembles that of chalkone to some extent, since it has a band with centre at about λ 3000 Å. All the absorption spectra seem to have some sharp narrow bands in the near ultra-violet region, but these are difficult to fix with certainty owing to the strong iron lines in their neighbourhood.

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