

The Pectic Substances of Plants.

A KNOWLEDGE of the properties of the pectic compounds present in fruits and other plant tissues is of considerable practical interest: thus they play an important part in the setting of jams, in the fermentation processes of wine, beer, and cider, and in the preparation of textile fibres. They undergo changes during the ripening and senescence of fruit, or with the onset of disease, and hence are closely connected with problems of storage. Branfoot,¹ in a recent review of these compounds, classifies them into five groups: *pectose* is an insoluble compound of cellulose and pectin, present in the cell walls of tissues; it is of variable composition, since a variable number of the methoxy groups of pectin may be replaced by cellulose residues. *Pectin* is a neutral methoxy ester of pectic acid, and contains 11.76 per cent methyl alcohol; *pectinic acids* are intermediate between pectin and pectic acid, simple carboxyl groups replacing those esterified with methyl alcohol. *Pectic acid* is a complex of four molecules of galacturonic acid and one each of arabinose and galactose; methylpentose is possibly present in some pectic acids. Pectic acid forms salts of definite composition, of which that with calcium is insoluble and is useful in the estimation of the pectin content of plants. The simplest compound of the group is *metapectic acid*, which appears to be *d*-galactose-galacturonic acid.

Pectin and pectinic acids can be removed from the plant tissues by washing with water: pectose cannot always be extracted unchanged, and it is therefore usual to hydrolyse it first to pectin with dilute mineral acid. After treatment with water and acid

¹ Department of Scientific and Industrial Research: Food Investigation. Special Report No. 33: A Critical and Historical Study of the Pectic Substances of Plants. By M. H. Branfoot (M. H. Carré). London: H.M. Stationery Office, 1929. 3s. 6d. net.

there is still pectic material present in the middle lamella: this can be extracted by boiling with very dilute sodium hydroxide or by solution in dilute ammonium oxalate. For the preparation of pectose it is sometimes possible to dissolve out the cellulose with Schweitzer's reagent and thus obtain it unchanged, but in many plants this reagent also dissolves the pectose: pectin is precipitated from its solutions by alcohol, especially if acidified, whilst pectic acid can be prepared by the hydrolysis of pectin with sodium hydroxide, followed by addition of excess of acetic acid to dissolve out impurities, and calcium chloride to precipitate the insoluble calcium pectate. The pectic compounds can be estimated as pectin by precipitation with alcohol, but the method is not strictly quantitative, or better as calcium pectate after hydrolysis to pectic acid.

The distribution of the pectic substances in the cell walls and middle lamella of plant tissues can be followed by staining sections with ruthenium red before and after the application of known pectic solvents. They undergo definite changes during development and senescence, which can be well followed in fruits: the general course is a breakdown into nonpectic soluble bodies. The changes have now been so far worked out that it is possible by chemical and microscopical examination to gauge the stage of maturity of a given sample of fruit with considerable accuracy. These hydrolytic changes are due to the action of enzymes of which at least three have been described, a pectosase, a pectinase, and a pectase, producing respectively pectin and pectinic acids, pectic acid, and reducing sugars, etc. Similar changes occur in fungal and bacterial diseases and are presumably due to enzymes secreted by the organisms.

Locomotive Firebox Stays and Plates.

FROM relatively early days, the problem of the wastage of firebox stayheads has troubled successive locomotive engineers, who from time to time have devoted considerable attention to investigating its cause, with, however, little real success. In 1924 the British Non-Ferrous Metals Research Association, with the co-operation of all the British railway groups, commenced an exhaustive examination of the problem, a report on which has now been published by the Institute of Metals. The main conclusions of the authors of the paper, Messrs. O. F. Hudson, T. M. Herbert, F. E. Ball, and F. H. Bucknall, may be summarised as follows:

The wastage of stayheads is primarily due to oxidation of the copper which, though not serious under dry conditions, at once becomes so when leakage of water occurs. Apart from the effect of the water, an oxide scale is formed which, being hard and tenacious, causes little trouble. As a result of plastic deformation of the firebox plate and stay, however, due to the thermal stresses set up in service, leakage sets in, causing the detachment of the scale and exposing fresh surfaces to attack. Much speculation has existed in the past with regard to the actual temperatures attained at the stayhead and plate surfaces, but by inserting metallic plugs of known melting point in selected stays, the authors have shown that the temperature attained at the top of the firebox was of the order of 200°-250° C. with, perhaps, 300°-350° C. under the arch. In no instance was a temperature exceeding 350° C. observed.

The work, therefore, has been extended to discover an otherwise suitable alloy which at a temperature of

300° C. is not appreciably softened and will still possess an elastic limit of about 5 tons per sq. in. Of the materials so far examined, one of the most hopeful is a copper alloy with about 0.05 per cent of silver, which in the cold-worked condition had, after being annealed at 300° C. for 100 hours, a Brinell hardness of 73, an elastic limit of 7.2 tons per sq. in., and a tensile strength of 18.3 tons. That such material possesses all the ductility required is shown by the fact that the elongation on 2 in. is 36 per cent.

Considerable attention has been paid to the chemical nature of the oxidation of copper at high temperatures, and it is shown that the presence of small quantities of hydrochloric acid and sulphur dioxide, both more or less normal constituents of the firebox atmosphere, have a profound influence in accelerating the attack. Further, the conditions which determine the adhesion of the oxide to the metal have been carefully investigated. The presence of both soot and smoke is essential to the formation of a hard, adherent oxide of the nature of that produced on actual stayheads. A dark grey scale is then formed at 260° C., which readily withstands subsequent exposure to at least 400° C. without perceptible reduction of hardness or adherence. Such a scale would certainly not be removed by the abrasion encountered in a firebox.

Finally, experiments have been carried out on the effect of salts in the water. These have demonstrated that the detachment of scale from stayheads in service is independent of the composition of the leakage fluid, the presence of corrosive salts playing little part in the actual detachment of the scale.

F. C. T.