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THE CHEMISTRY OF PAPER MAKING

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The manufacture of paper is largely a mechanical process. The foundation material is cellulose which is derived from various sources and is provided by nature in a state of greater or less purity. Cotton fiber is almost pure cellulose though slightly modified on the outside and having a protecting film of wax and oily matter. The fibres consist of a single cell, for the most part between one and two inches in length and about 1-2000 inch in diameter. Linen fiber is not so pure cellulose as cotton but is stronger and has greater lustre.

In cotton and linen thread the fibers are twisted together in the direction of their length, and cloth is woven from threads which run in two directions. But in paper, the fibers should lie in all directions forming a felt, the length of fiber not being so important a matter as in thread and cloth. Hence when paper is manufactured from rags these must be torn and divided in such a way as to isolate the individual fibers. The mechanical treatment is however not usually sufficient. Rags are often dirty and must be cleaned. This is done to a certain extent by beating, but afterwards the rags are boiled for several hours with soda or lime. This treatment, moreover, removes size and attacks colouring matter which is thus more easily bleached. The amount of caustic soda is from five to ten per cent. of the weight of the rags, the pressure under which the boiling takes place is two or three atmospheres. Too great pressure would fix the dirt in the rags instead of removing it. For delicate fibers some manufacturers prefer lime, as being less injurious to the fibers, but a larger proportion of lime than is actually necessary to reduce the stock must be used and the excess must be washed out. Furthermore, lime is liable to contain small gritty particles which are apt to become fixed in the fibers.

Since the length of fiber is not so important in paper as in cloth, cellulose, which is not suitable for the latter may be employed in the former, and though cotton and linen rags furnish the best paper other raw material is largely used. Before the year 1837 there was in Britain an excise duty on paper of 3d. a pound and the demand for paper could be easily supplied by the use of rags. In that year the duty was reduced to 1½d. and the demand increased. When in 1861 the duty was abolished altogether, the demand for paper became still greater and other raw materials came into requisition, for example straw, esparto

or Spanish grass, and, most important in this country, wood pulp.

A very coarse paper may be made by simply grinding wood to a pulp, but the cellulose is mixed with intercellular tissue such as lignin and resinous matters which turn brown on exposure to light. "Mechanical pulp" is not suitable for the finer qualities of paper for which "chemical pulp" may be used. Chemical pulp is usually made by the action of soda or calcium bisulphite upon wood which has first been cut into boards, and, after being freed from knots, is broken or cut into small chips.

It may readily be imagined that many other chemicals have been used for the purpose. In most cases the action has consisted in hydrolysis or an addition of water, more or less aided by secondary reactions. In 1866 a process involving the use of water alone at a temperature of 150°C (302° Fahr.) was made use of. A brown pulp is obtained containing 70% of the original wood but there is an accumulation of matters of an aldehydic nature and there is a reversal of the reaction the wood being dehydrated by the high temperature. The addition of hydrochloric acid was tried for some time in Switzerland, and coarse packing paper was made, but the process was open to the same objection as with water alone. In 1852, the action of nitric acid was tried, also in 1862. Here the hydrolysis was aided by the oxidising action of the acid and a yield of pulp of 40% was obtained. But it is difficult to get large vessels to withstand the action of the acids and nitric acid is liable to yield explosion compounds.

Caustic soda was first used in 1853 and for some years continued to be the most suitable reagent discovered. There have been many patents and many slight variations in detail but the process practically consists in boiling the wood at a temperature 150° to 180°C (302° to 356° Fahr.) the pressure being about 90 pounds. The solution contains 10% to 20% caustic soda and the boiling is continued from eight to twelve hours. In some cases there is an alternation of treatment with soda and with chlorine, the soda in the later treatments being dilute. In the treatment with soda, the oxidation goes farther than with water or hydrochloric acid; for, instead of aldehydes, acids are produced and these uniting with soda form salts. The action is complicated as is shown by the number of bi-products.

In 1866 Tilghmann made use, though not very successfully, of sulphurous acid as a digester of wood, but obtained better results with acid sulphites. In 1882, Pictet also made use of sulphurous acid and apparently with some success. The sulphurous acid is largely recovered by being allowed to blow off from the digester into cold water where it is absorbed. As the sulphurous acid is little changed in the digester, its better action than that of hydrochloric acid is probably to be attributed to unstable compounds being formed under pressure and decomposed when the pressure is removed. About 40% of the wood is changed into a soluble modification and the brownish pulp which is left gives on bleaching a pure cellulose.

The rise of acid sulphites has an advantage over sulphurous acid alone. Calcium bisulphite is the most common reagent because usually the cheapest, but the presence of