

The Sooty Details of Ink

The Chinese and Egyptians developed writing ink as early as 2600 BC. Ink is a mixture of coloring matter dispersed or dissolved in a liquid "vehicle" or carrier. The earliest inks were made with soot—carbon black produced by combustion—suspended in water, and stabilized with a natural gum or animal glue. Commonly referred to as India ink or China ink, this ancient writing material is still in use, particularly in China and Japan, where it is used for writing with brushes.

Such inks were used in northern India as early as the second century AD. In the south of India, a technique was developed in which writing or a design was scratched into a specially treated palm leaf, then rubbed with black ink. The leaf was then washed clean, leaving ink only in the incised lines. Ink for this process was made with soot from burned coconuts or almonds, mixed with a vehicle of oil.

Two millennia ago, Jewish scribes developed special inks for particular applications. Inks for writing sacred texts were generally oil-based and included extra ingredients meant to make them indelible, as were inks for the writing of legal documents. One particular application, however, required an erasable ink. When a married woman was accused of infidelity, the prescribed procedure was for the rabbi to write down the accusations against her, then erase the freshly inked words with "bitter water." The woman was forced to drink the water and if she became ill as a result, this was taken as a sign that she was guilty. Ink for this purpose was probably made by mixing soot from burnt olive oil together with fresh oil. The erasing solvent, rather than the ink, was likely to have sickened the accused woman. In fact, according to Chinese custom, ink was sometimes swallowed as a cure for stomach ailments.

A European recipe of the 12th century describes the manufacture of writing ink from hawthorn bark, made by drying and then cooking the bark together with water and wine. The resulting brew was boiled down, then dried for long-term storage. A small batch of ink could be prepared for writing by mixing some of the dried material together with wine and iron sulphate over a fire. Other common recipes used

acids derived from gall-nuts instead of bark. Such inks contained dissolved dyes instead of suspended pigment particles like carbon black. A recipe using gall-nuts was published in 1571:

To make common yncke of wyne take a quart,
Two ounces of gomme, let that be a parte,
Five ounces of galles, of copres take three,
Long standing dooth make it better to be;
If wyne ye do want, rayne water is best,
And as much stufte as above in the least:
If yncke be to thicke, put vinegre in,
For water dooth make the colour more dimme.

Writing inks in use today are similar, and are generally composed of a solution of dyes in water or an organic solvent. Writing inks with dissolved dyes rather than suspended pigments can flow more easily through a felt-tip or ball-point pen without clogging, or the clumping of pigment particles.

Printing inks were developed by the Chinese in the 11th century, when the first hand-made movable-type printer was invented in China. Four centuries later Gutenberg introduced the concept of the movable-type in Europe. Printing inks are more viscous than writing inks, and must stay wet on the press and yet dry rapidly on the printed page. Inks can be designed to dry or set by a number of mechanisms. If the vehicle is water or a solvent, it can dry by evaporation, leaving the pigment behind on the page. If the printed surface is absorbent, like newsprint, the vehicle may be drawn into the micropores of the paper and leave the pigment affixed to the surface.

Oxidation is another process by which inks dry. Printing inks similar to those in use today were first developed in Europe in the 15th century. These were made by mixing soot with a vehicle of varnish made by cooking linseed oil together with resin. Such an ink dries through oxidation, the linseed oil having already been partially oxidized by the heat applied in cooking it. Carbon black is still the most common pigment used in inks for printing newspapers. The vehicle may contain either petroleum derivatives or vegetable oils, the lat-

ter being more expensive but preferable in many ways, as vegetable oils are derived from a renewable resource, whereas petroleum-derived vehicles emit environmentally hazardous gases upon drying.

Current technology allows properties of inks to be tailored to particular uses. Inks are characterized by their viscosity, yield stress, and thixotropy (dependence of viscosity on shear rate and shear history). Rheological properties are controlled by the addition of waxes, resins, and other additives. Wetting properties can be tailored for special applications. "Tackiness," or the adhesion strength of ink, is a critical property for the proper function of rollers and presses. Ink for a ball point pen must have a high yield stress and be shear thinning so that ink does not leak around the roller ball when it is at rest but flows freely when the ball rolls during writing. When writing stops, the ink flow must stop immediately so the ink must quickly recover its original higher viscosity.

The fine particles in colored writing inks such as those used in felt-tip pens are generally made from organic compounds in solution rather than suspension. These are usually fine suspensions of either organic or inorganic compounds in an oil-based vehicle, ground into a paste in a grinding mill. The particle size and dispersion affect not only the color and opacity of the resulting ink but also its rheological properties, and can be difficult to match from one grinding mill to another. For this reason, in the 1920s, the ink and paint department of the Disney studios purchased three stone mills for grinding pigments for the colored inks that were used in the making of every Disney animated feature until 1986. When the mills were scrapped, an animation-art conservation company bought and refurbished them, and the company now produces ink and paint according to the original Disney formula for use in conservation of original animation art.

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FOR FURTHER READING: M. Zerdoun Bat-Yehouda, "Les Encres Noires au Moyen Age," CNRS (Paris) 1983; and the animation-art conservation company on the World Wide Web at <http://www.vintageip.com>.

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