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Stains for the Determination of Paper Components and Paper Defects

J. H. Woodward

Buckman Laboratories, Inc., 1256 N. McLean Blvd., Memphis, TN 38108

Stains for fiber analysis have been utilized since the 1930's with the first color monograph being published in 1940 [1]. Throughout the years, stains and indicators have been routinely used to determine paper components and paper defects.

Interpretation of staining reactions requires a basic knowledge of the papermaking process. Wood fiber can be from either softwood (conifers) or hardwood (deciduous). Softwood fibers are generally characterized by long, thin-walled cells whereas hardwoods have relatively shorter, narrow cells and very short, wider cells. All wood fiber must be pulped prior to the papermaking process. The pulping process can be mechanical where the wood is basically ground. In this process, the lignin component of the fiber is not removed. Semi-chemical and chemical pulping, such as sulfite and sulfate (Kraft), remove various levels of lignin. The brightness of the resulting pulps ranges from low (e.g. brown paper bag) to relatively high (e.g. newsprint). Pulp can then be bleached by a variety of chemical means to achieve a higher brightness. Paper or paperboard is made at acid, neutral, or alkaline pH. Wet-end additives can include retention aids, starch, sizing, dyes, optical brighteners, and microbicides. Depending on the pH of the process, the fillers consist of calcium carbonate ($CaCO_3$), titanium dioxide (TiO_2), or clay. Coating components include binders, dispersants, preservatives, defoamers, clay, $CaCO_3$, and TiO_2.

For basic fiber analysis, the paper or paperboard must first be disintegrated. A sample is torn into pieces and boiled in distilled water. The pieces are then rolled into pellets, placed into a test tube of water, and shaken vigorously. Additional water is added and the tube is shaken again. This is repeated until the sample is completely defibered. The resulting suspension is further diluted for staining procedures. If the paper is not disintegrated by this method, a sample is boiled in a 1% NaOH solution, washed several times with distilled water, allowed to stand in a 0.05N HCl for several minutes, and again washed several times with water. The paper is then rolled into small pellets, placed into test tubes with water, and shaken as previously described. Disintegration methods for specially treated papers are described in TAPPI Official Test Method T 401 om-93 [2].

The most commonly used stain for fiber analysis is the Graff "C" stain which reacts with lignin to produce a yellow color. Unbleached chemical and semi-chemical pulps will stain yellow with the depth of color dependent upon the type and degree of cooking. When the pulp is bleached, the fiber will stain a red color. As seen in FIG.1, thermo-mechanical pulp stains a bright yellow due to the high lignin content. Another useful stain for fiber analysis is the Herzberg stain because it differentiates chemical pulp from mechanical pulp. Both bleached and unbleached chemical pulps stain blue. Fibers from a paper towel stained blue, yellow, and light red (FIG. 2) indicating the presence of chemical and mechanical pulp.

Starch, commonly found in and on paper, reacts with iodide-potassium iodide to form a characteristic blue-purple color. The procedure can be as simple as placing a drop of the indicator

on the paper sample. A ninhydrin solution can be used to detect protein in a coating as well as microorganisms in a paper defect.

Basic microbiological stains prove useful in the identification of paper defects. For example, an unknown yellow defect appeared to be a fiber lump when viewed by a stereomicroscope. Lactofuchsin was applied and portions of the defect turned pink (FIG.3). Under oil immersion, the stain revealed filamentous bacteria wrapped around fibers (FIG. 4), indicating that the defect was due to the presence of actinomycetes growing in one of the furnishes.

Both traditional and non-traditional stains can be useful in the identification of paper components and defects.

References

[1] J.H. Graff, *Color Atlas for Fiber Identification*, Institute of Paper Chemistry, Appleton, WI, 1940.
[2] *2000-2001 TAPPI Test Methods*, TAPPI, Atlanta, 2000.

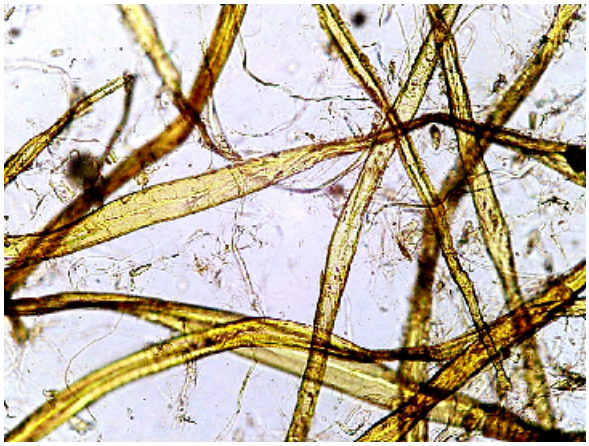

FIG. 1. Graff "C" stain of thermo-mechanical pulp with high lignin content. 40X

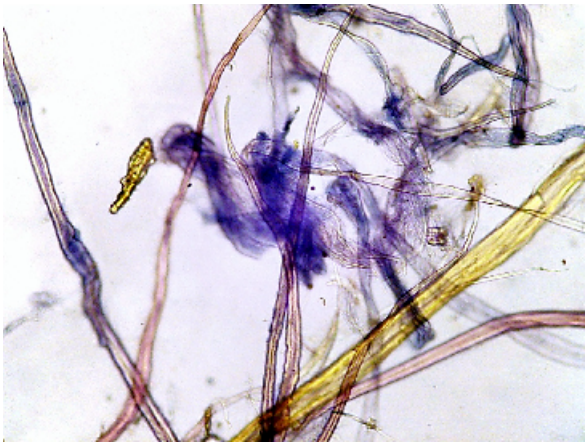

FIG. 2. Herzberg stain of paper towel fibers indicating chemical and mechanical pulp. 40 X

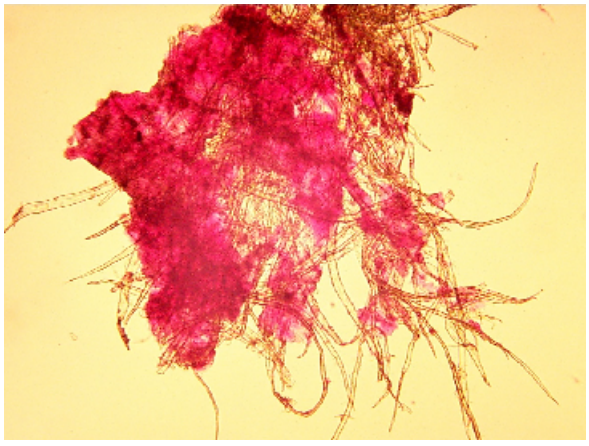

FIG. 3. Lactofuchsin stain of a paper defect. 10X

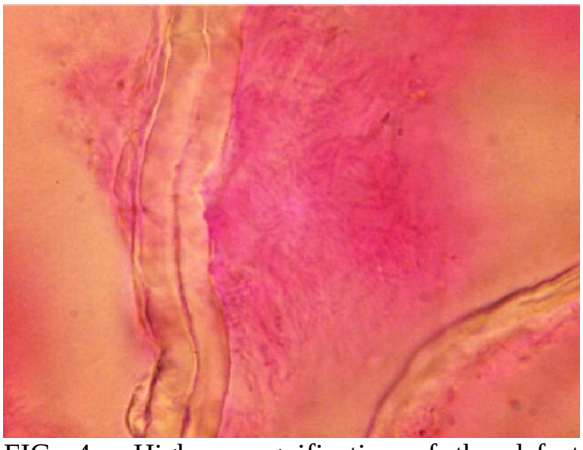

FIG. 4. Higher magnification of the defect revealing filamentous bacteria. 1000X

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