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Determination of effective residual ink concentration (ERIC) by infrared reflectance measurement

1. Scope

This method provides a means for determining the Effective Residual Ink Concentration (ERIC) in recycled pulp and paper. The presence of ink influences the brightness and color of recycled paper. Trace amounts of residual ink can leave recycled paper darker and grayer than paper made from virgin pulp, however, deliberate bleaching or incidental bleaching by deinking chemicals can recover some brightness loss if most of the ink has been removed. Counteracting the tinting power of residual ink can be easier if one can monitor the effective concentration of the ink. Brightness is not only affected by the presence of ink but also by other absorbers of visible wavelengths of light such as lignin and dye. For this reason brightness has been found to be an ineffective way to monitor the deinking process. The ERIC method employs reflectance measurements in the infrared region of the spectrum where the absorption coefficient for the ink is several orders of magnitude greater than the absorption coefficient for the fiber and other components resulting in a sensitive means for determining the concentration of ink (1). The ERIC measurement is dependent on the distribution of ink particle sizes and is most effective for submicron particles (2).

2. Summary

The function defined by Kubelka and Munk as *absorption coefficient* may be determined from reflectance measurements taken on ink alone and on recycled paper which contains ink. If the ink in a sheet of paper is of a type that has an absorption coefficient of 10,000 m²/kg (3), and if the residual ink in the sheet has increased the sheet's absorption coefficient by 1 m²/kg, then the "effective concentration" of the residual ink can be estimated at 1/10,000 or 100 ppm (parts per million). The term *effective concentration* is used because the ERIC value is relative rather than absolute. The absorption coefficient, as determined by this method, depends strongly upon the kind of ink, the particle size of the ink and the dispersion or agglomeration of the ink.

NOTE 1: Highly dispersed (or deagglomerated) ink provides more surface area for light absorption than an equal concentration of agglomerated ink. Visual assessments of recycled paper brightness are also affected more by a large number of deagglomerated ink specks than by a few agglomerated specks. For this reason, the ERIC method provides better correlation with visual assessments than other methods, e.g. image analysis of visible specs as described in TAPPI T 563 "Equivalent Black Area (EBA) and Count of Visible Dirt in Pulp, Paper and Paperboard by Image Analysis."

3. Significance

The ERIC method converts near infrared reflectance (NIR) measurements to light absorption which is related to ink concentration. The infrared area of the spectrum is chosen for these measurements because in this area of the spectrum, ink (not dye, lignin or other colorants) is the predominant absorber of infrared light (1). Once the absorption coefficient of the residual ink is known, an effective residual ink concentration value may be determined. This value can be used as a control parameter, to assist in the deinking/decolorization process, or as an end product specification. The estimation of residual ink by optical measurements in the infrared area is more accurate and much less time consuming for submicron ink particles than determination by image analysis methods (4). Also image analyzers typically respond to ink particle sizes of 5 microns and above whereas the ERIC method is sensitive to the smallest particles below 10 microns. This follows from the exponentially increasing number of particles occurring at diminishing sizes.

4. Definitions

4.1 *Diffuse reflectance factor.* The ratio of the radiance of the specimen to that of a perfectly reflecting diffuser, each being irradiated hemispherically and viewed identically.

4.2 *Absorption coefficient.* The fraction of light incident upon an infinitesimally thin layer of material that is absorbed (converted to heat or other form of energy) divided by the (infinitesimal) grammage of the layer. The absorption coefficient (k) is expressed in reciprocal grammage units. A multiplier (1,000) is used to convert m^2/g to the standard units, m^2/kg .

4.3 *Scattering coefficient.* The fraction of light incident upon an infinitesimally thin layer of material that is scattered backwards by that layer, divided by the (infinitesimal) grammage of the layer. Scattering coefficient (s) is expressed in reciprocal grammage units. A multiplier (1,000) is used to convert m^2/g to the standard units, m^2/kg .

4.4 *Effective residual ink concentration.* Ratio of the absorption coefficient of pulp or paper, which contains ink, to the absorption coefficient of the ink itself as determined at 950 nm wavelength. ERIC units are expressed as parts per million (ppm).

5. Apparatus

5.1 *Reflectometer.* An instrument designed for the measurement of diffuse reflectance which employs the geometric and photometric characteristics specified in T 525, and the following spectral characteristics:

5.1.1 *Spectral characteristics.* The effective wavelength of the reflectometer, must be 950 ± 5.0 nm, the bandpass at 50% peak height must not exceed 150 nm, and the bandpass at 10% peak height must not exceed 250 nm. This spectral response is arrived at with a combination of lamps, integrating sphere, glass optics, filters or other spectrally selective device and photoelectric cells.

5.2 The following *ancillary items* must be available:

5.2.1 *Reference standard.* A white standard material with R_{950} value provided by an ISO Level III Authorized Laboratory (5).

5.2.2 *Instrument standard.* Opal glass, ceramic or spectralon standard which can be measured after calibration to the reference standard and maintained for future reference.

NOTE 2: Some instruments are equipped with an integral instrument standard.

5.2.3 *Black cavity.* A cavity coated with black felt, black paint or other coating material, having a known cavity reflectance of less than 1% at 950 nm.

6. Test specimens

6.1 Measurement of the ERIC value of a sample is highly dependent upon the sample being analyzed. In order for the ERIC analysis to be at its most effective level, the sample must be: