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Calibration of reflectance standards for hemispherical geometry

1. Scope

1.1 This standard practice describes the calibration of standards for hemispherical reflectance in relation to the theoretically perfect reflecting diffuser with an assigned value of unity.

1.2 The calibration of an instrument standard is made by means of a standard coated flat plate.

1.3 The absolute reflectance of the flat plate is determined with a spectrophotometer equipped with an integrating sphere to which has been added an auxiliary sphere.

1.4 The flat plate is coated at the same time, and in the same manner as, the interior of the auxiliary sphere, so that it is essentially a flat segment of the sphere's interior surface. The flux reflected from the interior of the auxiliary sphere through its port is compared with that reflected from the flat plate. The absolute or total diffuse reflectance of the flat plate is calculated by comparing the two reflected fluxes and the ratio of the port area to the wall area of the sphere.

2. Significance

The flat plate is assumed to have a perfectly diffusing surface, but it may possess structural characteristics that will influence a reflectance determination by the way in which the surfaces are illuminated and viewed. The spectrophotometer used for determining an absolute reflectance ideally should have the same optical geometry as the instrument for which the standard is calibrated. The absolute reflectance obtained using this auxiliary sphere method is for diffuse-diffuse (d/d) geometry. Most instruments employed for the measurement of reflectance in the paper industry have either $45/0$ geometry or $d/0$ geometry. These differences in geometry between the auxiliary sphere system and the test instruments means that significant differences can result when different materials are employed as transfer standards. Translucency effects must also be considered. If the transfer materials used have similar characteristics with regard to scattering, absorption, and goniophotometric curves, then the differences relating to geometry will be fixed.

3. Apparatus

3.1 *Spectrophotometer*, capable of measuring hemispherical reflectance by means of an integrating sphere and having a photometric precision of 0.001.

3.2 *Auxiliary sphere*, of metal and made in two halves that can be taken apart easily for coating¹. One half has an entrance port to admit light to the sphere. The edge of this port must be finely beveled. The other half has a removable flat plate so located that its center coincides with the center of the irradiating beam. The diameter of the entrance-port of the auxiliary sphere is larger than the diameter of the irradiating-beam and slightly smaller than the diameter of the outer-port in the instrument sphere (see Fig.1). The diameter of the auxiliary-sphere is such that its internal area is of the order of 100 times the area of its port. The interior surface of the sphere should be roughened, as by sand blasting, to facilitate adhesion of the coating.

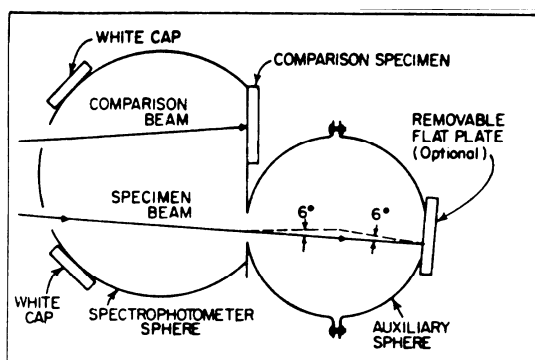


Fig. 1. Application of auxiliary sphere to spectrophotometer

3.3 *Jig for coating sphere*, with pressed powder, constructed of the following parts: (a) a semicircular plastic blade with a tapered edge, (b) an accurately centered bearing on which to rotate the blade to form a hemisphere; and (c) a guard ring of plastic to be mounted on the larger hemisphere flange to prevent chipping of the edge of the formed coating (see Fig. 2). The radii of the flange and semicircular blade are made 3 mm smaller than the larger sphere radius so as to produce a coating 3 mm thick.

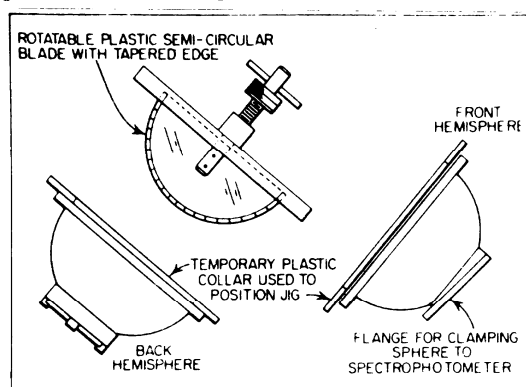


Fig. 2. Hemispheres and jig for scooping out pressed powder.

3.4 *Flat plates*. When the sphere is designed without a removable flat plate, two separate flat plates, about 100 by 100 by 5 mm, are provided for coating at the same time as the sphere. These are provided with a cylindrical recess having a diameter of 1.2 times that of the port of the instrument sphere. The depth of this recess is 1 mm for paint and 3 mm for pressed powder.

3.5 *Coating materials*. Suitable materials for coating spheres and plates are: (a) reagent grade barium sulfate powder, (b) reagent grade magnesium oxide powder and (c) spectralon or an equivalently lambertian and opaque material with equal or greater reflection characteristics.

3.6 *Instrument standard*, a durable standard such as pressed barium sulfate, porcelain enamel, or white opaque glass.

3.7 *Preparation of spheres and plates*. Coat the sphere uniformly and thick enough so that any variation of

¹ Alternatively, the sphere may be constructed without this removable plate, with a separate flat plate about 100 × 100 × 5 mm, provided to be coated along with the sphere.