REFLECTANCE MEASURING INSTRUMENT WITH INTEGRATING SPHERE

BACKGROUND OF THE INVENTION

This invention relates to an instrument for making reflective measurements on a sample at different wavelengths and, more particularly, to an instrument in which the sample is illuminated by an integrating sphere and the light reflected from the sample is separated into its spectral components by a monochromator.

The purpose of using an integrating sphere to illuminate a sample in a reflectance measuring instrument is to provide uniform diffuse illumination of the sample. The integrating sphere receives light from a light source through an entrance port and the diffusely reflecting interior walls of the integrating sphere reflect the light in multiple reflections so that uniform diffuse illumination is provided over the interior surface of the integrating sphere. As a result, a sample positioned at a sample port in the sphere will be illuminated with this uniform diffuse illumination. A sample beam exit port is positioned to receive diffusely reflected light from the sample and the light passing through the sample beam exit port can then be separated into its spectral components to provide reflectance measurements of the sample at each wavelength. When an integrating sphere is used to provide the illumination to a sample, the color of the sample itself will cause a diminution and discoloration of the uniform illumination over the interior of the sphere and there is a need to correct the reflectance measurements for this diminution and discoloration. This correction can be provided by providing a second exit port in the sphere, called a reference beam exit port, positioned to receive light reflected from the wall of the sphere. The light reflected from the wall of the sphere through the reference beam exit port provides a measurement for comparison with the reflectance measurements made from the sample.

SUMMARY OF THE INVENTION

In accordance with the present invention, a fiber optic cable is provided to receive light reflected by the sample through the sample beam exit port and transmit it to the entrance slit of a monochromator. A second fiber optic cable is provided to receive light reflected by the wall of the sphere through the reference beam exit port and to transmit this reference light to the entrance slit of the monochromator. The transmitting ends of the fiber optic cables at the entrance slit of the the monochromator are mounted in a pivoting plate. In one position of the pivoting plate, the end of the fiber optic cable transmitting the light from the sample beam exit port is aligned with the entrance slit of the monochromator and in the other position of the pivoting plate, the end of the fiber optic cable transmitting light from the reference beam exit port is aligned with the entrance slit of the monochromator. The transmitting ends of the fiber optic cables are rectangularly shaped to conform with the shape of the entrance slit of the monochromator. A detent mechanism is provided to precisely position the pivoting plate so that the transmitting ends of the fiber optic cables align precisely with the entrance slit at each of the two positions of the pivoting plate. The pivoting plate thus provides the function of a mechanical optical switch for switching the input to the monochromator from the light reflected from the sample and the reference light reflected from the wall of the sphere. The fibers in the cables are randomly mixed so that differences in the reflectivity of the surface will be averaged over the transmitting ends. In addition, the light will be depolarized by the transmission through the fiber optic cable so that polarization of the reflectivity of the sample surface will be eliminated as a factor.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram illustrating the system of the present invention;

FIG. **2** illustrates the optical beam switching mechanism of the present invention in more detail; and

FIG. **3** is an enlarged view taken along the lines **3—3** of FIG. **1** to illustrate the relationship between the shape and position of the transmitting ends of the fiber optic cables and the entrance slit of the monochromator of the system of the present invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

As shown in FIG. **1**, a light source **11**, which may be a tungsten halogen lamp, providing a color temperature of about 3000° K., directs a beam of light through an infrared absorbing filter **13** and through a blue D-65 filter **15** to make the light beam have a color temperature of 6500° K. The filtered light beam is directed through an entrance port **19** of an integrating sphere **21** and falls upon the interior wall of the sphere. The interior wall of the sphere has a high reflectance matte surface and the light beam entering the entrance port **19** is reflected through a series of reflections by the interior wall of the sphere **21** so that a uniform intensity of diffuse radiation is provided over the interior wall surface of the integrating sphere. A sample port **23** is defined in the sphere to receive a sample to be analyzed (or a standard sample) and the integrating sphere will irradiate the sample placed over the sample port **23** with uniform diffuse radiation. A sample beam exit port **25** is defined in the sphere on the wall opposite from the sample port on an axis extending at an angle of 8° from normal to the plane of the sample port so that light diffusely reflected at an angle of 8° will radiate through the exit port **25**. The light radiated through the exit port **25** reflected from the sample positioned at the sample port is focused by an achromat lens **27** onto the entrance end **29** of a fiber optic cable **31**.

A second exit port **33**, called the reference beam exit port, is positioned near the top of the sphere to receive light diffusely reflected from the opposite interior wall of the sphere at the bottom thereof. The light reflected from the bottom wall of the sphere and radiated through the exit port **33** is reflected by a mirror **35** and focused by an achromat lens **37** onto the entrance end of a fiber optic cable **41**.

An additional port **40** called a specular port is located 8° from normal to the sample port **23** directly on the opposite side from the exit port **25** so that light radiated to the sample from the specular port and specularly reflected by a sample at the sample port would be radiated through the sample beam exit port **25**. The specular port may either be closed by a wall finish having the same finish as the interior of the sphere or by a black cavity entrance. If the specular port is closed by a black cavity, this will mean that the light being focused on the entrance end of the sample fiber optic cable **31** by the achromat **27** will contain no specular component. If the specular port **40** is closed by the matte wall finish of the