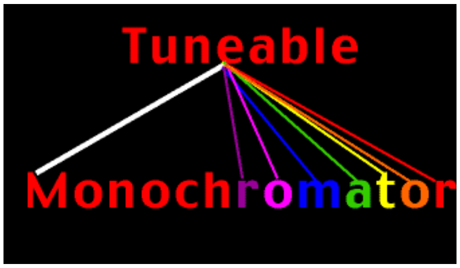
Tunable Monochromator

Introduction

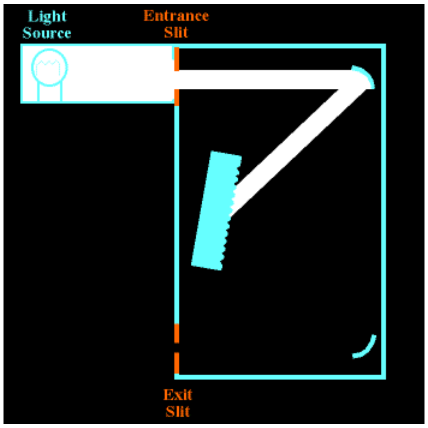


The job of a monochromator is to produce a single spectral line from a broadband (multi-wavelength) source. In spectrometers, this can be used to collect light from an atomic emission source, like the atomic emission detector, and allow only a specific line to exit. It can also be used to isolate a single line from a light source such as a hollow cathode lamp. The simple monochromator shown here is called a Czerny-Turner monochromator; however, other types are common.

Source

The instrument described here assumes that the input light is from a white light (a broadband source); although, many different inputs from which individual lines can be isolated are possible: a flame along with a hollow cathode lamp—as in AAS, a plasma—as in an atomic absorption spectrometer, an ultraviolet source—as in a UV/Vis spectrometer, or in a fluorescence spectrometer, emission from a fluorescing sample.

Entrance and Exit slits

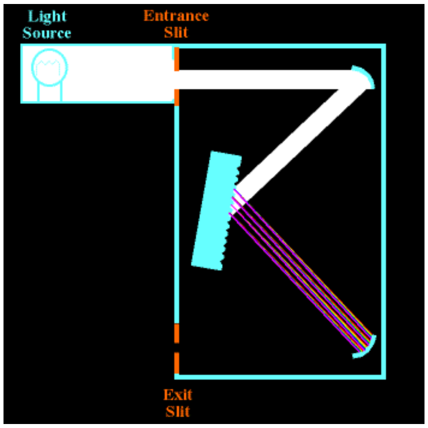


The purpose of the two slits in this monochromator is to control the size and "position" of the beam of light passing through the slit. On the way in, the entrance slit makes sure that only a small area of the input beam passes into the monochromator and that the light waves are relatively parallel coming from the source. Since the light will be carefully allowed to shine (flow?) among the mirrors and a grating inside the monochromator, parallel beams insure alignment of the light beams with the internal optics and cut down on stray light that might end up where it's not wanted. The edges of the slit are very carefully machined so that the distance between the two edges through which the light passes are equidistant all along the slit opening. The slit size is variable, though usually not continuously. Instead slit settings are usually preset to 4 or 5 settings which can be chosen by the analyst for each experiment.

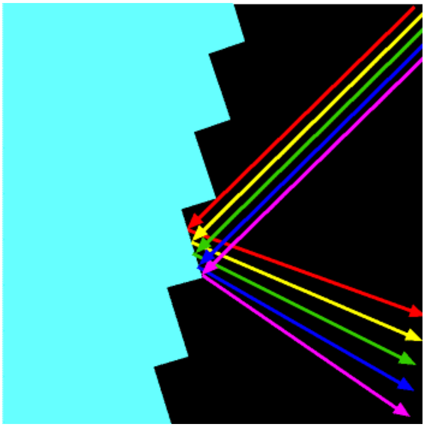
Mirrors

Once light enters from the entrance slit, as the adjacent figure shows, it is redirected by the first mirror toward the grating (this was a prism in the early monochromators). After light is dispersed by the grating (see below) it is captured by a second mirror and redirected towards the exit slit The surface of these mirrors must be reflective in the wavelength region of the light involved. This can be polished aluminum, silver or gold. This metal is sometimes covered with a protective coating that prevents the metal from tarnishing, obviously also transparent to the light involved.

The Grating

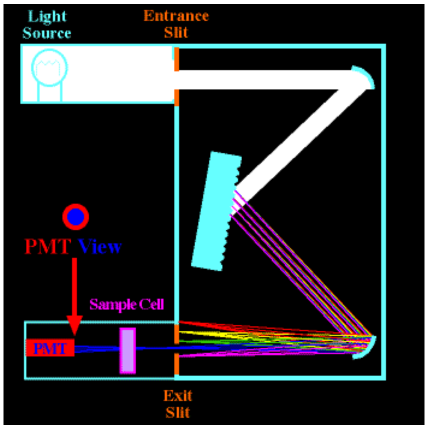


The dispersion element in this monochromator is a grating. Its job is to take parallel light incoming from the entrance slit, light that contains multiple different wavelengths, and to disperse the



wavelengths in space such that they are no longer parallel but instead leave the grating at slightly different angles, angles dependent upon the wavelength. While this statement is strictly true it is, in reality it is a poor description of a more complicated process. Furthermore the adjacent figures only generally approximates this process, and in fact, suggest that the process merely involves simple reflection when in fact this is not the case.

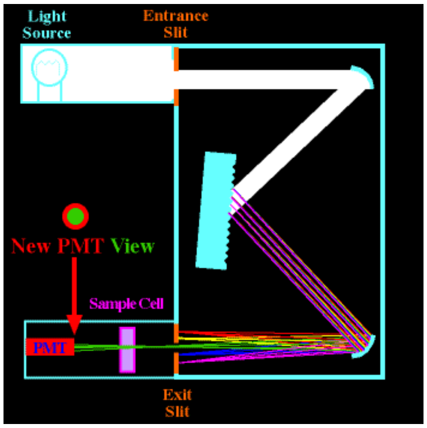
Since light passes off the grating at angles dependent upon its wavelength, it will also reflect off the mirror “down stream” at different angles. The further away from the dispersion element—and here’s the important part—the further apart will be the colors of light (read wavelengths) in the dispersing beam.



So that means that at the second mirror the individual wavelengths are some distance apart and after reflecting off that mirror, the beams diverge even further. When they arrive at the exit slit they are so substantially separated in space that they fall like a rainbow across the plane of the exit slit.

Selecting Wavelengths

All that is required to isolate a wavelength of choice—and get it out of the monochromator—is to adjust the position of “the rainbow” so that a desired wavelength passes through the slit and



the undesired wavelengths hit the edges of the slit and the inside wall of the monochromator around the slit and are blocked. This is the reason why many monochromators are painted black inside so that light that strikes the walls of the monochromator is absorbed instead of reflecting around inside and possibly escaping through the exit slit. This fine adjustment, of which wavelengths fall where in the exit plane, is accomplished by slightly—very slightly—adjusting the position of the grating. In modern instruments, this is controlled by a servomotor controlled by a computer. The monochromator can be calibrated by using a lamp with a well defined spectral line and adjusting the grating position until that line comes out of the exit slit. The grating’s position is then set to “display” that known wavelength. In some instruments this is done automatically.

These notes were written by Dr. Thomas G. Chasteen; Department of Chemistry, Sam Houston State University, Huntsville, Texas 77341. Copyright 2000.