Distributors, for timely publishing this work. Finally, I must thank my wife, Dr. (Mrs) Manjula Khare and my children, Gunjan and Amit, for their patience and cooperation during the entire course of this work.

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TUTORIAL-2

2.1 A typical manufacturer's manual describes the monochromator as follows:

Type of mount: Littrow

Aperture ratio : F/8.0

Focal length: 400 mm

Reciprocal linear dispersion: 0.02μm/mm at the exit slit Type of grating: Reflection grating, 50 mm x 50 mm ruled area, 1200 grooves/mm, blazed for 0.63 μm.

(a) Sketch the optical diagram of the system.

(b) What is the significance of the term "aperture ratio"? Calculate the size of the limiting aperture. How is this size related to the grating size?

(c) Calculate the theoretical half intensity spectral bandpass of this instrument with slits of 50 μm width.

(d) Calculate the resolving power of the grating in the first order.

(e) What is the blaze angle of the grating ?

(f) Predict the spectral range in which the efficiency of the grating is better than 50% in the first order.

SOLUTION

(a) Optical diagram of the system is shown in Fig.2.30 a, and the enlarged cross-sectional view of reflection from a single groove is shown in Fig.2.30 b.

(b) The light gathering power or ability of a monochromator is described quantitatively by the "aperture ratio" or the f-number of the optical system. This is given by

$f/- = F/D$

where F is the focal length of the collimating device (lens or mirror) and D is the diameter of the circular aperture of the same area as the limiting aperture of the monochromator. The latter is generally decided by the dispersing element (in the present case, by the grating). An increase in D would result in a collection of a larger fraction of radiation.

In the present problem,. since the f-number is 8.0 and F = 400 mm, therefore, the size of the limiting aperture = 400 mm/8 = 50 mm reference or blank. Thus the three terms combined together inside the square brackets simply give the power transmitted by the reference or the blank. This can be expressed by $P_{o\lambda}$ of equation (3.1). Substituting for the terms in square brackets in (3.2), we get

$$S = P_{o\lambda}\, e^{-abc}\, D(\lambda) \qquad (3.3)$$

As $P_{o\lambda}$ is the power incident on the sample, according to Beer's law, the transmitted power P_λ will be equal to $P_{o\lambda}\, e^{-abc}$. Finally, the function $D(\lambda)$ represents a factor that gives the response of the detector as a function of wavelength, λ.

It is obvious from equation (3.2) that for obtaining a larger signal, the performance of each module must be optimized. In other words, the modules must be selected according to the spectral range of interest (e.g. UV/VIS/IR) and must be arranged in such a manner so as to avoid losses due to reflection, scattering and absorption and also avoid stray radiation. Thus the source should have some area of uniform intensity. Only this area should be imaged on the entrance slit of the monochromator. The entrance aperture can then be imaged and reimaged employing front-surface off-axis mirrors and/or corrected lenses. It should be noted that the beam cross-section be as small as possible at the site of the sample, so that, if the occasion arises, microsamples can also be analysed with no change in optical design.

As a rule of thumb, the monochromator precedes the sample in UV-VIS instruments, whereas it follows the sample in IR spectrometers. This is done to minimize the stray radiation coming inside the photometric system.

3.3 COMPONENTS

3.3.1 Radiation sources

The success of absorption measurements depends considerably on the proper choice of the radiation source. The latter are classified as continuous or discrete. The continuous sources are those whose spectrum extends over a considerably large spectral region. Continuous spectra are, generally, emitted by black body radiators, incandescent solids, incandescent liquids and certain high pressure discharge tubes. The spectrum of a discrete source is characterised by discrete or sharp lines. Such a spectrum is emitted by an atom or molecule in a gaseous or vapour state which acquires excess energy in some manner to be excited to higher levels; subsequent de-excitation giving rise to the radiation. Electric arcs, sparks and low-pressure ionic discharges are examples of discrete sources. The discrete sources are, generally not employed in absorption measurements and hence we shall not be discussing them here. In the following paragraphs, we discuss the continuous sources only.

end of the plates is reached. Considering only the first two emerging beams, (b) and (d), we find that beam (d) traverses distance inside the dielectric material twice more than that traversed by beam (b). If the incident radiation is at right angles to the filter, and if the thickness of the spacer is t, then these two beams will be in phase and will reinforce each other at wavelengths which are integral multiple of 2t (a condition for constructive interference).

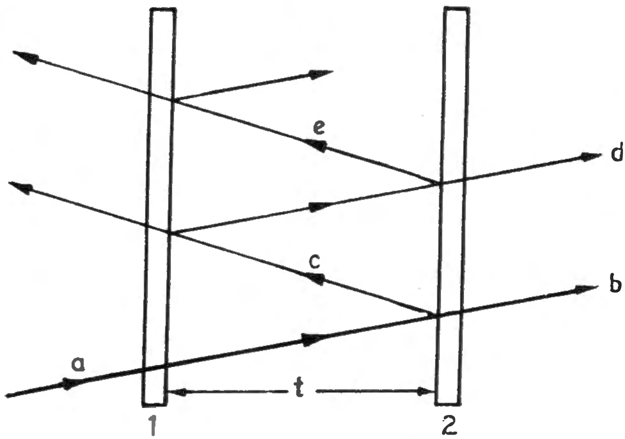

Fig. 3.5 : Schematic diagram of a Fabry-Perot interference filter. For clarity, the distance between the two plates is shown excessively large. Normally, t is of the order of few μm.

Mathematically

$$\frac{m\lambda}{n} = 2t \text{ (for normal incidence)} \tag{3.7}$$

where m is an integer and is known as the order of interference, λ is the wavelength of the incident radiation (in vacuum) and n is the refractive index of the spacer. At other wavelengths, which do not satisfy the above conditions, destructive interference will occur and hence the intensity of the radiation at those wavelengths will be reduced. A filter of thickness corresponding to m = 1(i.e, $t = \lambda/2n$), is called a first order filter, a filter of thickness corresponding to m = 2 (i.e. $t = \lambda/n$) is called a second order filter and so on.

In Febry Perot type of filters the transmittance is limited by the absorption of the metallic reflecting films that are deposited on the plates. The modern trend, therefore, is to replace the metallic reflecting films by all-dielectric multilayer stacks. By this method, narrow bandpass filters of extremely high