3 Light sources and optical components

In general terms, the function of the light source is to produce radiation of the appropriate wavelength and of sufficient intensity to allow a measurement after interaction with the sample material. An ideal source should have spatial and temporal stability, and uniform power output per wavelength interval across the spectral region of interest. The sources that are commonly used in UV–VIS spectrometers emit radiation continuously and are intrinsically stable, although, of course, freedom from noise and drift also demands a stable power supply. No source produces a uniform power output at all wavelengths and no one source adequately covers the UV and visible region of the spectrum. An instrument covering the whole spectral range must have two sources that are usually interchanged in the optical path by the movement of a mirror but sometimes by moving the lamps themselves. As will be seen later, the two sources will have different physical sizes and the changeover can cause problems of optical alignment and light gathering. The optics of the instrument may be designed, for example, to produce an image of the UV source which just fills the entrance slit of the monochromator thus using the monochromator to its greatest effect, but it may not be possible to do this with the light from the visible source as well.

Sources have a limited lifetime and will need to be replaced periodically. A deterioration in the signal-to-noise characteristics will usually be noticed before catastrophic failure occurs. For UV–VIS spectrometers the sources used can be conveniently classified as (a) gas discharges and (b) thermal radiators. Classification according to spectral region is somewhat arbitrary as most sources emit some radiation over a greater range of wavelengths than is encompassed by the terms UV, visible or IR.

The optical system of the instrument normally consists of a sequence of reflective surfaces together with the occasional lens.
Lenses suffer from a number of aberrations which are difficult and costly to correct for, so mirrors are the preferred means of directing the light along the optical path. Recently instruments using fibre optic light guides have appeared on the market [1].

3.1 Sources for the UV region

3.1.1 Deuterium arc

In absorption spectrometers the most commonly used source is the deuterium arc. This has a three- to five-fold increase in output over the hydrogen arc that was used formerly. Before an arc can be struck between the electrodes, the cathode has to be heated to a temperature of a few hundred degrees by means of a low voltage filament. A starting voltage of several hundred volts then initiates the arc which produces enough heat to maintain the discharge and the heating current can be switched off. During normal running, the voltage is 80–100 V and the current flow is a few hundred milliamps giving a power consumption of between 30 and 60 W. The arc is confined to a small volume by a metal enclosure around the electrodes and the radiation escapes through a small circular (1 mm diameter) or rectangular (1 mm x 5 mm) aperture. A typical lifetime is 500 h and the lamp should be switched off when not in use to conserve its life: a wise practice in view of the high cost of replacement. The spectral output is a continuum from 180 to 400 nm with a few scattered lines in the visible which are useful for wavelength checking purposes (e.g. lines at 486.0 and 656.1 nm), and thus the lamp envelope must be capable of transmitting this range of wavelengths: usually the lamp is made from a suitable grade of silica. A typical lamp is shown in Fig. 3.1a and the spectral output as a function of wavelength is shown in Fig. 3.3.

3.1.2 Mercury and xenon arcs

For some absorbance applications and for other types of analytical spectroscopy, such as luminescence or photoacoustic, a deuterium arc source is not sufficiently intense and a higher power mercury or xenon arc is used. Lamps can be obtained with powers up to 2000 W. Both mercury and xenon lamps are essentially similar in construction consisting of two tungsten electrodes spaced 1–8 mm apart and sealed inside a quartz envelope. The gas filling is at such a pressure that under normal operating conditions a pressure of 750–1200 psi