Design and development of an Echelle spectrograph for Multi-elemental simultaneous trace analysis in nuclear-grade samples

An echelle grating spectrograph (see Fig. 5) has been designed and developed indigenously for simultaneous impurity analysis of trace elements in nuclear grade materials using the inductively coupled plasma as a source of excitation i.e. atomic emission spectroscopy (AES). The method involves excitation of the sample to very high temperatures (> 4000 K) and recording of the light emitted, which is characteristic of the sample constituents.

The instrument has been designed (Fig. 6) to consist of two concave spherical mirrors, an echelle grating having frequency of 79 lines/mm, and a CCD detector (of size 13.3 mm X 13.3 mm) for recording the spectral lines in two-dimensional format. Fused silica Littrow prism is used to sort the different spectral orders to avoid their overlapping in the focal plane of the instrument. The focal lengths for the collimating mirror and focusing mirror have been calculated to be 250 mm and 175 mm respectively. The reciprocal linear dispersion of the instrument is 3.49 Å/mm for a grating of 79 g/mm and at a wavelength of 3000 Å for a diffraction order of 81. The spectral range of the instrument is 2000 – 4000 Å with a wavelength resolution of 0.15 Å at 3000 Å. Fig. 7 shows the emission spectra recorded by introducing a 500 µg/ml tungsten aqueous solution, into the ICP flame. A calibration plot as recorded for some elements been shown in Fig. 8.

Fig. 5: Photograph of echelle spectrograph coupled to an ICP torch assembly, withan RF generator (27.2 MHz, 1.5 kW)

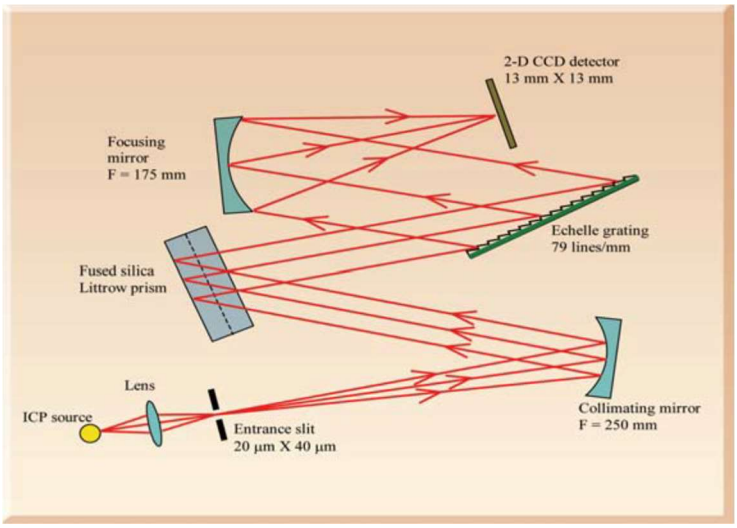

Fig. 6: Optical layout of echelle grating spectrograph

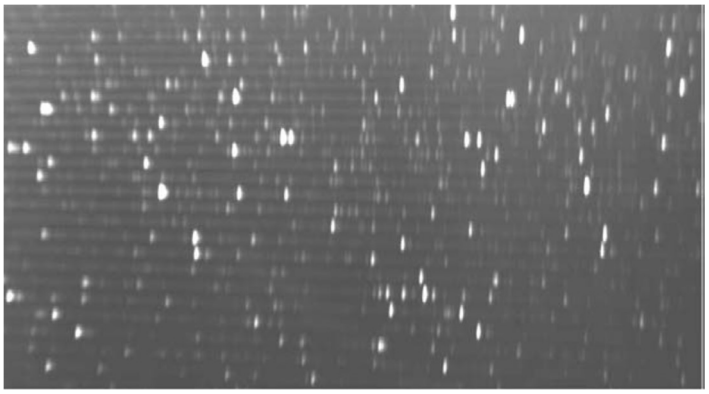

Fig. 7: CCD image of tungsten spectra over the region 2100 – 3000 Å, recorded by introducing a 500 mg/ml tungsten aqueous solution into the ICP flame. The bright spots correspond to the characteristic emission lines of tungsten.