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Atomic Spectroscopy: Technique of Paramount Credence

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Analytical technique is can be defined as a means to verify the chemical or physical property of a matter. In actual practice, there are extensive assortment of techniques ranging from simple ones like sample weighing to sophisticated methods using highly dedicated instrumentation. The most primordial technique is the classical method like gravimetry (based on weight measurement), titrimetry (based on addition of a solution to sample solution). Spectrochemical methods are based on the measurement of spectrum of the samples using different instruments. Electroanalytical methods utilize the potential or current of a electrochemical cell for determination of sample concentration. Chromatography is a separation based technique used to isolate the analyte from the other species to enable interference free determination.[1]

Spectrochemical methods depends on spectroscopy which is the study and measurement of the spectrum produced upon interaction of sample with electromagnetic (EM) radiation as function of frequency or wavelength of radiation. There are diverse forms of spectroscopy namely acoustic resonance (Cost effective spectroscopy technique in acoustic region, mainly ultrasonic & sonic regions), X-ray photoelectron (relies on diffraction patterns created while X-rays pass through crystalline materials), circular dichroism (helps in differentiating left & right circularly polarised light by sample), Ultraviolet-Visible (UV/Vis) Spectroscopy (probing the electronic structure for identification of compounds), NMR Spectroscopy (measure magnetic fields around nuclei using radio waves), Infrared Spectroscopy (IR region of EM radiation is used), Raman spectroscopy (for identification of molecules based on Raman scattering, i.e., inelastic scattering of monochromatic light). Spectrometry is application to attain quantification using basis of spectroscopy.

Atomic spectroscopy deals with the interaction of matter with EM radiation. This can result in either absorption of light source energy by sample or emission of radiation wherein sample emits light at wavelength diverse from the original wavelength of light. Very first work related to spectroscopy was by the English chemist,

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W.H. Wollaston who observed dark lines (known as Fraunhofer lines) in the solar spectrum.[2] In 1832 by D. Brewster established that these lines were due to the absorption of Sun's radiation by atomic vapours.[3] Further it was work of R.Bunsen and G.Kirchoff which showed that upon heating a chemical element to incandescence, its characteristic colour was produced (eg. sodium (Na) yellow; potassium (K) violet) while obtaining the black lines.[4] It was A. Walsh who established the utility of atomic absorption spectroscopy for determination of small concentrations of metals.[5] Atomic spectroscopy consists of 2 forms of techniques, atomic absorption spectroscopy & atomic emission spectroscopy.[6] The absorption of radiation leads to excitation of the molecules to higher energy level while in emission spectroscopy, the electrons while dexcitation emit electromagnetic radiation with a wavelength different from original light source. In absorption spectroscopy the population of the ground state atoms becomes important in determining the sensitivity while in emission spectroscopy the population of the excited state atoms plays a major role. The spectrum in absorption spectroscopy is coloured while emission spectroscopy has dark lines. Solid samples can be analyzed using only emission spectroscopy. In AAS, monochromatic light source is used to offer energy for excitation of electrons while in AES, flame is used. Atomization in AAS occurs in a separate chamber while in AES this occurs in a sequence of many steps upon overview of sample to the flame. Atomic emission spectroscopy (AES) is technique of chemical analysis that uses intensity of light emitted from flame, plasma, arc, or spark at a specific wavelength to determine quantity of element in sample. Wavelength of atomic spectral line in emission spectrum gives identity of element while intensity of emitted light is proportional to number of atoms of element. Sample may be excited by innumerable procedures like flame, inductively coupled plasma atomic emission source or Spark and arc. The main recompenses of ICP-AES include excellent detection limit, wide linear dynamic range, multi-element potential, low chemical interference & stable & reproducible signal. But method is expensive with severe spectral interferences and can be used only for liquid samples. Spark or arc atomic emission spectroscopy is generally used for solid samples but the main requirement is that sample has to be conductive in nature. For non-conductive materials, sample is ground with graphite powder and analyzed. This method can be used for both qualitative & quantitative analysis. In both absorption & emission spectroscopy techniques, the basic principle of Lambert Beers' law is followed.

Atomic spectroscopy finds extensive applications in various fields like forensic,[7] cosmetic (determine metals in toothpaste, sunscreen, shampoos, cosmetic pigments),[8] geochemistry[9] etc. The technique becomes a great support for many other analytical procedures involved in the treatment of waste water or effluent samples. When a method for separation of a species of interest is being developed, atomic spectroscopy is used to determine the concentration of metal ions in aqueous solutions before and after separation process. This indicates the separation efficiency of the different separation procedures developed. For instance, the efficiency of different procedures developed for separation of thorium using sorption with glass powders, impregnated sorbents and bulk liquid membrane could be evaluated using atomic spectroscopy[10-12]

Conclusions

Atomic spectroscopy is mainly used for the measurement of trace level concentrations of metals in varied matrices ranging from organic to inorganic. The ongoing research in instrumentation has made the technique very sensitive. It is established that this technique is very valuable due to its versatility, moderate cost, and proven method.

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