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# Atomic Emission Spectroscopy

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**ABSTRACT** *The atomic emission spectroscopy is method based on the study of light emitted by atoms to determine the proportional quantity of a particular element in a given sample. Three techniques of atomic emission spectroscopy flame emission arc & spark emission and plasma atomic emission spectroscopy, their working,*

*Principle and applications has been discussed in detail.*

**KEYWORDS : -spectroscopy, flame, spark & arc, plasma, qualitative & quantitative analysis**

## INTRODUCTION

Atomic spectroscopy is the determination of elemental composition by its electromagnetic spectrum. Electrons exist in energy levels within an atom. These levels have well defined energies and electrons moving between them must absorb or emit energy equal to the difference between them. The wavelength of the emitted radiant energy is directly related to the electronic transition which has occurred. Since every element has a unique electronic structure, the wavelength of light emitted is a unique property of each individual element. As the orbital configuration of a large atom may be complex, there are many electronic transitions which can occur, each transition resulting in the emission of a characteristic wavelength of light. The energy emitted in the decay process is measured and used for analytical purpose.

## ATOMIC EMISSION SPECTROSCOPY

In atomic emission spectroscopy, a sample is subjected to a high energy, thermal environment in order to produce excited state atoms, capable of emitting light. The energy source can be an electrical arc, a flame, or more recently, plasma. The emission spectrum of an element exposed to such an energy source consists of a collection of the allowable emission wavelengths, commonly called emission lines, because of the discrete nature of the emitted wavelengths [1]. This emission spectrum can be used as a unique characteristic for qualitative identification of the element. Emission techniques can also be used to determine how much of an element is present in a sample. For a "quantitative" analysis, the intensity of light emitted at the wavelength of the element to be determined is measured. The emission intensity at this wavelength will be greater as the number of atoms of the analyte element increases.

## TYPES OF ATOMIC EMISSION SPECTROSCOPY

Atomic emission spectroscopy has a long history. Qualitative applications based on the color of flames were us ed in the smelting of ores as early as 1550 and were more fully developed around 1830 with the observation of atomic spectra generated by flame emission and spark emission. Quantitative applications based on the atomic emission from electric sparks were developed by Lockyer in the early 1870 and quantitative applications based on flame emission were pioneered by Lundegardh in 1930. Atomic emission based on emission from plasma was introduced in 1964[2].

### Flame Atomic Emission Spectroscopy

#### Principle

The basic principle of flame emission spectrometry is that the sample solution is converted into a fine aerosol and put into the flame. Here heat from the flame is used to break the molecules into the atoms and then excite these atoms. These atoms come to ground state by emitting radiations that can be detected by spectrometer.

#### Working

In flame emission spectrometry, the material to be analyzed should be dissolved in a solution. The analyst must be aware of substances that interfere with the emission measurement. Reagents used to dissolve samples must not contain substances that lead to interference problems. Then the sample is introduced into the flame. The device that introduces the sample into the flame plays a major role in determining the accuracy of the analysis. The most popular sampling method is nebulization of a liquid sample to provide a steady flow of aerosol into a flame. An introduction system for liquid samples consists of three components: (a) a nebulizer that breaks up the liquid into small' droplets, (b) an aerosol modifier that removes large droplets from the stream, allowing only droplets smaller than a certain size to pass, and (c) the flame or atomizer that converts the analyte into free atoms. In nebulization technique, the sample solution is introduced through an orifice into a high velocity gas jet, usually the oxidant. The sample stream may intersect the gas stream in either a parallel or perpendicular manner. Liquid is drawn through the sample capillary by the pressure differential generated by the high-velocity gas stream passing over the sample orifice. The liquid stream begins to oscillate, producing filaments. Finally, these filaments collapse to form a cloud of droplets in the aerosol modifier. In the aerosol modifier the larger droplets are removed from the sample stream by mixer paddles or broken up into smaller droplets by impact beads or wall surfaces. The final aerosol, now a fine mist, is combined with the oxidizer/fuel mixture and carried into the burner. After the aerosol droplets containing analyte enter the flame, the solvent is evaporated, leaving small particles of dry, solid analyte. Next, solid analyte is converted to vapors. Finally, molecules are dissociated to give neutral free atoms. Processes that interfere with the production of free analyte atoms include: (a) excitation and emission of radiation by analyte(g) molecules, (b) reaction of analyte(g) atoms with flame components at high temperatures to produce molecules and ions that also absorb and emit radiation, and (c) formation of analyte ions, which, in addition to reducing the efficiency of free-atom production, complicate the analysis by adding lines to the spectrum. Subsequently, atoms and molecules are raised to excited states via thermal collisions with the constituents of the partially burned flame gases. Upon their return to a lower or ground electronic state, the excited atoms and molecules emit radiation characteristic of the sample components. Light is then dispersed by a prism or grating and detected in spectrometer. The emitted radiation passes through a mono-chromator that isolates the specific wavelength for the desired analysis. A photo detector measures the radiant power of the selected radiation, which is then amplified and sent to a readout device, meter, recorder, or microcomputer system. A satisfactory flame source must provide the temperature and fuel/oxidant ratio required for a given analysis. The maximum operating temperature of the flame is determined by the identities of the fuel and oxidant, whereas the exact flame temperature is fixed by the fuel/oxidant ratio. In addition, the spectrum of the flame itself should not interfere with the emission or absorption lines of the analytes. Components of the flame gases limit the usable range to wavelengths longer than 210 nm.

#### Applications

It is used in agricultural and environmental analysis, industrial analyses of ferrous metals and alloys as well as glasses and ceramic materials, and clinical analyses of body fluids. It can be automated to handle a large number of samples. It is used for the determination of trace metals, especially in liquid samples. The method is simple, inexpensive, and sensitive method for detecting common metals, including the alkali and alkaline earths, as well as several transition metals such as Fe, Mn, Cu, and Zn. FES has been extended to include a number of nonmetals: H, B, C, N, P, As, O, S, Se, Te, halogens, and noble gases [3,4]

### Inductively Coupled Plasma Atomic Emission Spectroscopy

#### Principle

Inductively coupled plasma atomic emission spectroscopy employs the use of inductively coupled plasma for producing excited ions and atoms that radiate electromagnetically charged particles at wavelengths characteristic to a definite element after which a spectrometer separates this light in the characteristic wavelengths.

#### Working

In this method, the sample solution is transformed into an aerosol by a so-called nebuliser. The bigger droplets are separated from the smallest in a special spray chamber. The smallest droplets are transferred by an argon flow into the argon plasma. The bigger droplets are pumped to waste. To produce strong atomic emission from all chemical elements it is necessary to attain temperatures considerably above those available from simple flames. A convenient means of obtaining these temperatures is to generate inert gas plasma. Plasma is very effective medium for volatilization and atomization of liquid droplets. In the plasma, more energy is transferred to the atoms and ions, promoting the excitation of their electrons to higher energy levels. When these excited atoms and ions return to lower excitation states they emit electromagnetic radiation which are studied by the spectrometer. Each excited element emits specific wavelengths. With the help of spectrometer, an emission spectrum is obtained. In plasma predominantly singly charged ions are produced, but also free atoms are present. Both will be excited and emit radiation. So emission spectrum can be complicated. The different wavelengths emitted by the atoms and ions can overlap with wavelengths produced by other elements.

#### Applications

It is used to determine the presence of arsenic in food, metals in wine and to study trace elements that are bound to proteins. It is frequently used for analyzing trace elements present in the soil. It is used for analyzing motor oils. The results from such studies help in determining the life of the oil, as well as assist in quality control and help in functional efficiency of automobile engines. It helps to understand the processes involved in the loss of raw material in formation of glass in glass oven. In glass factories, during the formation of glass, material is lost due to evaporation and the formation of dust clouds. The origin of such dust clouds the atmosphere of the melting tank is determined by making solution of dust clouds. It helps to determine the corrosion behavior of metal compounds. As during corrosion the main components (Fe and Ni) dissolve, their concentration in the water can be analyzed using ICP-AES after different periods of time [4, 5].

### Spark and Arc Atomic Emission Spectroscopy

#### Principle

Spark or arc atomic emission spectroscopy is a procedure used for analyzing solid samples for metallic and non-conductive substances. In the arc spectroscopy an electric spark or arc is passed through the sample. The high temperature excites the atoms which emit light that is detected using a mono-chromator.

#### Working

In sparks emission spectroscopy samples are excited in the gap between a pair of electrodes connected to a high potential power supply. If the sample is conductive then it can be directly used as one of the two electrodes. Otherwise, powdered solid samples are mixed with fine graphite and made into a paste. Upon drying, this solid composite can be used as an electrode. The high potential applied forces a discharge between the two electrodes to occur. The discharge caused by arcs and sparks interacts with the surface of the solid sample creating a plume of very fine particulates and atoms. The very high temperature (4000-5000°C) realized in the vicinity between the two electrodes provide enough energy for atomization and excitation of the samples. The emission from atoms in an arc or spark is directed to a mono-chromator and the diffracted beams are allowed to hit a photographic film. The blackness of the lines on the photographic film is an indication of the intensity of the atomic line and thus the concentration of the component. The location of emission lines as compared to standard lines on a film serves to identify the wavelengths of emission lines of component [4,6].

#### Applications

In the past, the spark or arc conditions were typically not well controlled, the analysis for the elements in the sample was only qualitative. However, modern spark sources with controlled discharges can be considered quantitative. Both qualitative and quantitative spark analysis are widely used for production quality control in foundries and steel mills [7].

### CONCLUSIONS

Atomic emission spectroscopy is an important technique to analyze the components of a material. Flame emission and spark & arc emission based atomic emission spectroscopy can be used for quantitative as well as qualitative applications. Atomic emission based on emission from plasma was introduced as very high temperature can be attained with the help of plasma.

### REFERENCES

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