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A REVIEW ON ATOMIC ABSORPTION SPECTROSCOPY

Gayathri G.A.[1] , Mrs. A.S. Athira[2], Dr.R.Xavier Arulappa[3]

[1]Student, Seventh Semester B. Pharm, Sree Krishna College of Pharmacy and Research Centre Parassala, Thiruvanthapuram, Kerala, India- 695502.

[2]Assistant Professor, Department of Pharmaceutical Chemistry, Sree Krishna College of Pharmacy and Research Centre Parassala, Thiruvanthapuram,Kerala, India-695502.

[3]HOD and Professor, Department of Pharmaceutical Chemistry, , Sree Krishna College of Pharmacy and Research Centre Parassala, Thiruvanthapuram,Kerala, India-695502.

Abstract:

Absorption spectroscopy is one of the most widely used techniques employed for determining the concentrations of absorbing species (chromophores) in solutions. It is a non-destructive technique which biologists and biochemists and now systems biologist to quantify the cellular components and characteristic parameters of functional molecules. This quantification is most relevant in the context of systems biology. For creating a quantitative depiction of a metabolic pathway, number of parameters and variables are important and these need to be determined experimentally. In this review it consists of history, instrumentations, detectors and applications of AAS.

Corresponding author:

Gayathri.G. A,

Student, Seventh Semester Pharm,
Sree Krishna College of Pharmacy and Research Centre Parassala,
Thiruvanthapuram,Kerala, India-695502.
Ph…No:0471-2224747
E-mail:gayathriga6@gmail.com

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INTRODUCTION:

1953 Alan Wash showed that AAS can be used as an analytical tool. Atomic absorption spectroscopy is an analytical technique used for determining the concentration of a in 1802 phenomenon of atomic absorption spectroscopy first observed by Woolaston. In particular metal element within a sample. [6]
It utilizes the absorption of light to measure the concentration of gas-phase atoms. [7]
AAS is highly sensitive and can detect concentrations as low as parts per million. (ppb)

Atomic Absorption Spectroscopy (AAS) is an analytical technique used for the quantitative determination of chemical elements present in samples by measuring the absorbed radiation by free atoms in the gaseous state.

This method leverages the principle that ground-state atoms absorb light of a specific wavelength, which corresponds to the energy needed to excite an electron from a lower energy level to a higher one.

The amount of light absorbed is proportional to the concentration of the element in the sample, making AAS a valuable tool in various fields such as environmental analysis, clinical chemistry, and metallurgy for trace element analysis and quality control. [8]

Atomic absorption spectroscopy used for the quantitative determination of the trace metals in liquids. This method provides a total metal content of the sample and is almost independent of the molecular form of the liquid. For example, one can determine the sodium content of a water sample and in most of the cases it does not matter in what molecular form the sodium exists.

Fig no:1 Atomic Absorption Spectroscopy

PRINCIPLE

- It utilises the principle that elements in the gas phase absorb light at every specific wavelength which gives the technique excellent specificity and detection limits.
- When a liquid sample containing metal is heated in a flame, the metal gets vapourised.
- Some of the atoms of the sample get excited to higher state while major portion of the sample remains in the ground state.
- Now, light of a particular wavelength is passed through a flame having such metallic atoms, some part of light gets absorbed which is directly proportional to the concentration of the atoms in the flame.

Total amount of light absorbed = $\pi e^2/mc$ x Nf

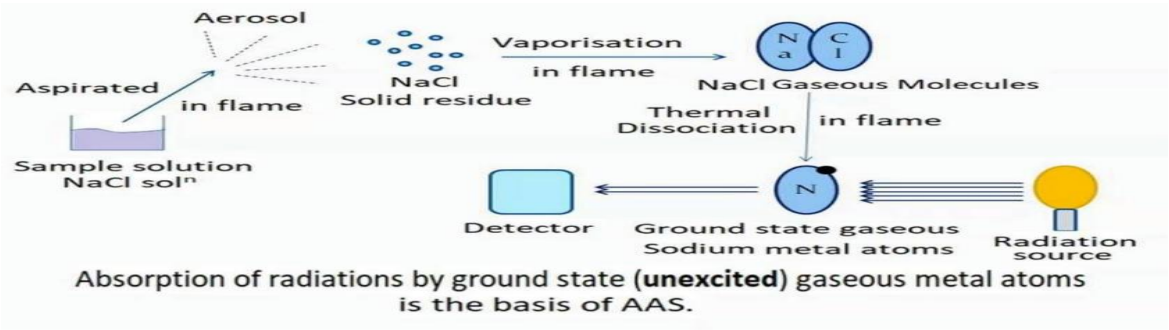


Fig no:2 Absorption of radiations

INSTRUMENTATION

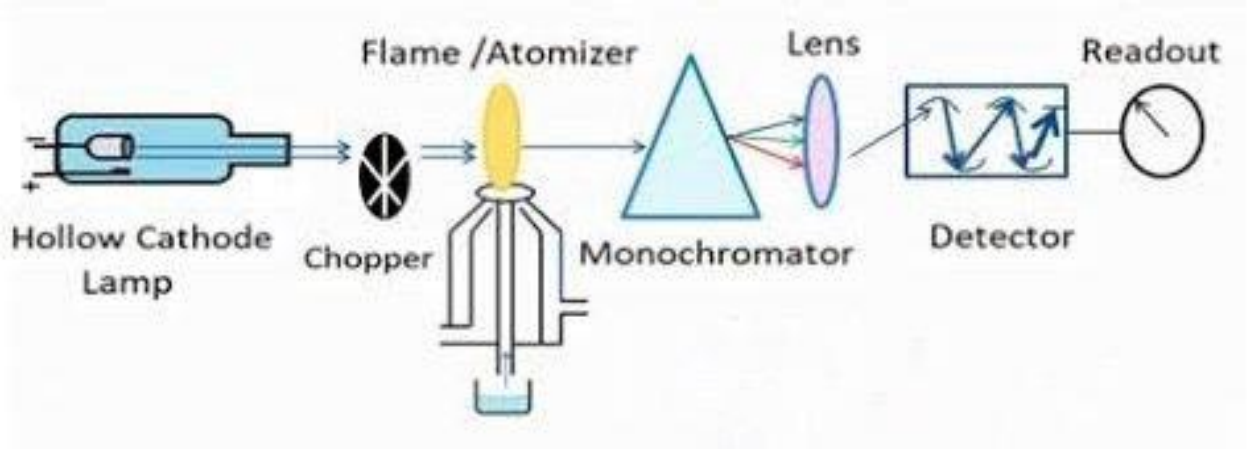


Fig no:3 Instrumentation

For all types of atomic absorption spectrometer, the following components are required:

1. RADIATION SOURCE

The radiation source for atomic absorption spectrophotometer should emit, stable, intense radiation of the element to be determined, usually a resonance line of the element.

a) Hollow cathode lamp

When current is applied between anode and cathode, metal-atoms emerge from hollow cup and collide with filter gas, which is normally argon or neon. Due to these collisions, number of metal atoms are excited and emit their characteristic radiation. This characteristic radiation is absorbed by neutral atoms of the same element in ground state, which occur in the flame, when sample solution is sprayed.

b) Electrode discharge lamp

It is difficult to make stable hollow cathodes from certain element particularly those that are volatile, such as arsenic, germanium, or selenium. An alternative light source has been developed in the electrodeless discharge lamp (EDL). It consists of an evacuated tube in which the metal of interest is placed.

2. Chopper

A rotating wheel is interposed between the hollow cathode lamp and the flame. This rotating wheel is known as chopper and it rotate like fan and is interposed to break the steady light from the lamp and flame into an intermittent or pulsating light.

3. Atomizer

Atomizers may use flame to convert liquid samples into gaseous state. Atomizers are of two types:

a) Flame atomizers

i) Total consumption burner

In this burner the entire sample enters into the flame hence known as total consumption burner as all the sample is consumed. Hydrogen and oxygen are used is fuel and oxidant respectively.

ii) Premix laminar flow burner

As the name indicates sample, fuel and oxidant are mixed before entering the flame. All the gases move in a laminar flow. In this burner only a small amount of the sample reaches the fame and gets decomposed.

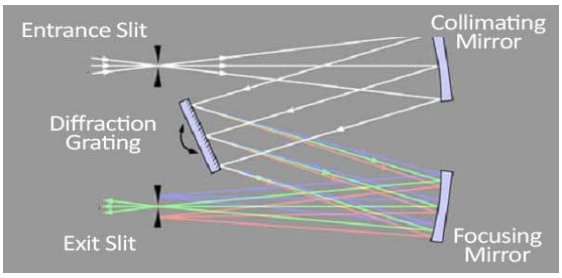
b) Non-Atomizer

Carbon atomizer

This is a non- flame atomizer. It uses carbon rod which is heated with the help of an electrical discharge. In this, sample is placed into the carbon atomizer and then heated under controlled temperature so that the entire sample gets converted into ash. Then it is again heated to cause atomization of the sample.

4. Monochromator

Monochromators are better and more efficient than filters in converting a polychromatic light or heterochromatic light into a monochromatic light.



Monochromators are of two types:

a) Prisms

The prisms disperse the light radiation into individual colours or wavelength. The resolution depends upon the size and refractive index of the prism. The material of the prism is normally glass.

i) Refractive type

The prism shows where the source of light, through entrance slit falls on a collimator.

The parallel radiations from collimator are dispersed into different colours or wavelengths, and by using another collimator, the images of entrance slit are reformed.

The required radiation on exit slit can be selected by rotating the prism or by keeping the prism stationary and moving the exit slit.

ii) Refractive type (Littrow type monitoring)

A reflective source is present on one side of the prism. Hence the dispersed radiation gets reflected and can be collected on the same side as the source of light.

b) Gratings

Gratings are the most efficient one in converting polychromatic light to monochromatic light.

Grafting's are of two types:

a) Diffraction gratings

The mechanism is that diffraction produces reinforcement. The rays which are incident upon the grating get reinforced with reflected rays and hence the resulting radiation has wave length can be determined by the equation:

$m \lambda = b (\sin i \pm \sin r)$

b) Transmission grating

Transmission grating is similar to diffraction grating, but refraction takes place instead of reflection. Refraction produces reinforcement.

The wavelength of radiation produced by transmission grating can be determined by the equation:

$\lambda = d \sin\theta \div m$

5. Detector

In these detectors, the light energy is converted to electrical signal which can be read or recorded. The most commonly used detectors are:

a) Barrier layer cell or photo voltaic cell.

The detector has a thin metallic layer coated with silver or gold and act as an electrode. It also has a metal base plate which acts as another electrode. These two layers are separated by a semiconductor layer of selenium. When light radiation falls on the selenium layer, these electron become mobile and are taken up by the transparent metal layer. This creates a potential difference between the two electrodes and causes the flow of current.

b) Photo tubes or Photo emissive cells

This detector is composed of an evacuated glass tube, which consist of photo cathode coated with elements of high atomic volume like caesium, potassium, silver oxide, which can liberate electrons, when light radiation falls on it.

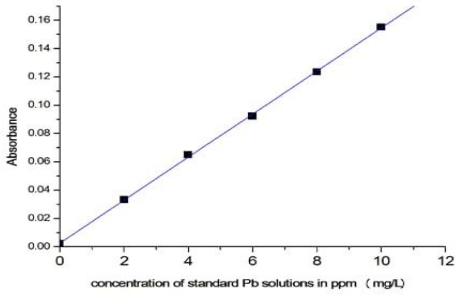
This flow of electrons towards anode produces a current proportional the intensity of light radiation.

6. Amplifier and read out device

Detector produces pulsating current which is fed to an AC amplifier which amplifies the electric current and chart recorders are used as read out devices.

Working of Atomic Absorption Spectroscopy

- 100% transmittance or zero absorbance is adjusted by keeping hollow cathode lamp on.
- Zero transmittance is adjusted by putting Hollow cathode lamp off. Standard solutions of element to be analysed are prepared.
- Absorbance of each standard solution is measured. Calibration curve (absorbance vs concentration is plotted.
- Absorbance of unknown solution is measured and its concentration is found out by using calibration curve.



INTERFERENCES OF ATOMIC ABSORPTION SPECTROSCOPY

Common types of interferences include spectral, chemical, and physical interferences.

1. Spectral Interference

Spectral interference occurs when the absorption line of the analyte overlaps with the absorption lines of other elements or molecular species present in the sample.

Remedy: Using a high-resolution monochromator or selecting an alternative absorption line that is free from interference can help reduce spectral interference.

2. Chemical Interference

Chemical interference occurs due to the formation of compounds that are not easily dissociated in the flame or furnace, thus affecting the atomization efficiency of the analyte.

Remedy: Adding releasing agents (e.g., lanthanum or strontium salts) that preferentially bind to the interfering species can help free the analyte for atomization.

3. Physical Interference

It occurs when components of sample matrix other than analyte react to form molecular species and sample background.

APPLICATIONS OF ATOMIC ABSORPTION SPECTROSCOPY

1. Quantitative analysis of trace metals

Quantitative determination is done by using calibration curve method. In this a series of samples are taken and their % absorption are measured. Agrapha is plotted between concentration and % absorption is measured. If a linear line is obtained, one can easily calculate the concentration of unknown solution.

2. Qualitative analysis

For qualitative analysis different type of radiation source is to be used each time. This process is very laborious and time consuming. So, AAS is rarely used for qualitative analysis of the metal.

3. Analysis of blood serum

For diagnosis of various pathological conditions AAS is commonly used. Ca, Na, Mg and K can be determined in blood serum by using AAS. It also helps in diagnosis of various diseases like diabetes and aldosteronism.

Advantages of Atomic Absorption Spectroscopy

- Spectral interference does not occur because atom of a particular element can only absorb radiation of their wavelength.
- Technique is specific because the atom of particular element can only absorb radiation of their own characteristic wavelength.
- Is independent of flame temperature.

Disadvantages of Atomic Absorption Spectroscopy

- Analysis does not simultaneous.
- Fragment have to form ready measure solution.
- Limit types of cathode.

CONCLUSION:

It can be concluded from entire review that atomic absorption spectroscopy (AAS) has established itself as an indispensable tool in analytical chemistry, providing high sensitivity and specificity for the determination of elemental concentrations in diverse sample matrices. Atomic Absorption Spectroscopy is mainly used to determine trace elements in soil samples, water, petrol etc. Not just qualitatively manly quantitative determination of metals is done. In case of isolation and purification of herbal drugs or phytochemicals from crude form.

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