Atomic absorption spectrometry (AAS) detects elements in either liquid or solid samples through the application of characteristic wavelengths of electromagnetic radiation from a light source. Individual elements will absorb wavelengths differently, and these absorbances are measured against standards

Atomic absorption spectrometry (AAS) is an easy, high-throughput, and inexpensive technology used primarily to analyze compounds in solution. As such, AAS is used in food and beverage, water, clinical, and pharmaceutical analysis. It is also used in mining operations, such as to determine the percentage of precious metal in rocks.

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In AAS, analytes are first atomized so that their characteristic wavelengths are emitted and recorded. Then, during excitation, electrons move up one energy level in their respective atoms (figure 1) when those atoms absorb a specific energy.

As electrons return to their original energy state, they emit energy in the form of light (figure 2). This light has a wavelength that is characteristic of the element. Depending on the light wavelenth and its intensity, specific elements can be detected and their concentrations measured.

AAS has an unlimited number of applications and is still a popular choice for uncomplicated trace elemental analysis. Flame atomic absorption spectrometry (FAAS) is widely accepted in many industries, which continue to utilize the unique and specific benefits of this technology. Graphite furnace atomic absorption spectrometry (GFAAS) is an established technology for measuring elements at parts per billion (ppb or ng/l) concentrations with incredibly low sample volumes

Sample preparation and introduction involve rendering a liquid or solid sample into a state that the instrument can process for elemental analysis. In the case of flame AAS, this involves atomizing the sample, which involves the creation of a fine mist dispersion. Afterwards, this mist is fed into a flame to break up any remaining molecular bonds. In graphite furnace AAS, the liquid sample is introduced into the cuvette directly, where it is transformed into a fine mist.

The sample is then exposed to a source of radiation, which typically originates - from a light source. This light source has been set to defined wavelengths, and the metal atoms in the sample absorb these wavelengths (or not). When absorption occurs, the result is a light spectrum that has reduced light intensity in one or more of its areas. This reduced intensity is characteristic of a given element and helps to identify it, as well as to determine its concentration.

AAS takes advantage of different radiation wavelengths that are absorbed by different atoms. The instrument is most reliable when a simple line can relate absorption to concentration. Atomizer and monochromator instruments are key to making the AAS device work.

Afterwards, the analyte is excited by different light sources and emits a mixture of wavelengths. Following dispersion of these wavelengths (including the characteristic wavelength of the analyte), the AAS instrument detector measures wavelength intensity. Because element concentration is a function of its wavelength intensity, the concentration of the target element can be determined. Also, by establishing a reference system from standards of known concentration, unknown samples can be analyzed quantitatively.

Flame Atomic Absorption Spectrometry (FAAS)

Flame atomic absorption spectrometry (FAAS) is a globally recognized analytical technique used for analyzing over 60 elements including sodium, potassium, calcium, magnesium, zinc, and iron. It is widely accepted in many industries, which continue to utilize the unique and specific benefits of this technology.

During the analysis, liquid samples are aspirated and introduced into the flame via a spray chamber, which breaks the aspirated liquid into fine droplets. The flame is typically created using air/acetylene or nitrous oxide/acetylene gases, and this results in desolvation, vaporization, and atomization of the sample. Hollow cathode lamps emit light that is specific to the element, and this light is directed through the flame to allow for measurement during atomization. High-performance optics and precise monochromator operation ensure that the light path is always perfectly aligned for analysis.
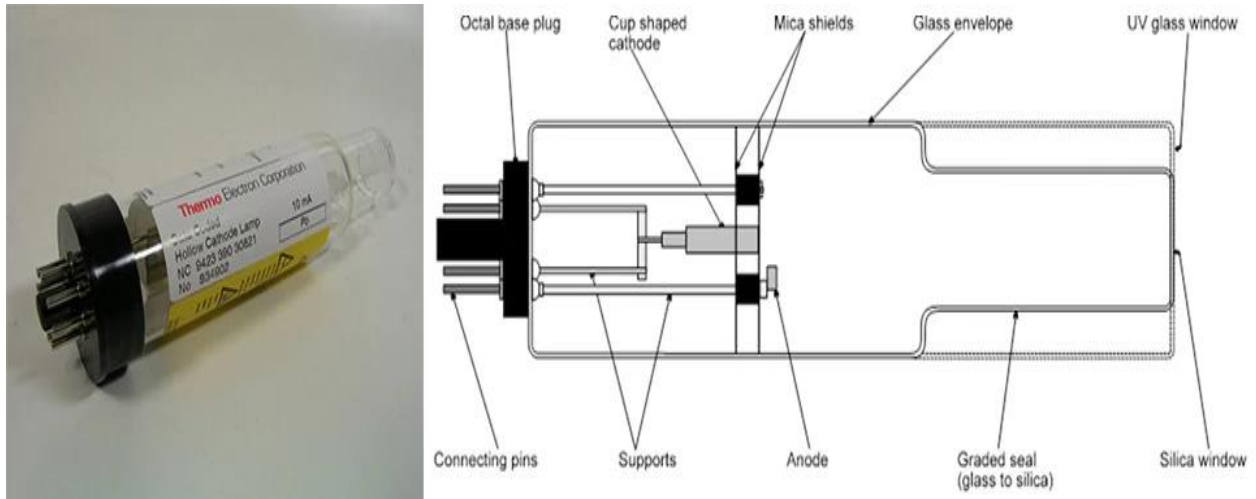
Data analysis in atomic absorption spectrometry (AAS) is a multi-step process, with the user having to select the correct method and wavelengths in order to obtain optimal results. Background correction is also a key component of successful AAS data analysis. There are two typical correction methods that are widely used with AAS technology: deuterium and Zeeman background correction.

Deuterium background correction

Deuterium background correction is the oldest and still most commonly used technique, particularly in flame AAS. In this technique, a separate source (deuterium lamp) with broad emission is used to measure background absorption over the entire width of the exit slit of the spectrometer. The use of a separate lamp makes this technique the least accurate one because it cannot correct for any structured background. It also cannot be used at wavelengths above 320 nm because the emission intensity of the deuterium lamp is very weak beyond that wavelength.

Zeeman background correction

With Zeeman background correction, an alternating magnetic field is applied at the atomizer (graphite furnace) to split the absorption line into three components: the π component, which remains at the same position as the original absorption line, and two σ components, which are moved to higher and lower wavelengths.

Total absorption is first measured without the magnetic field turned on, after which the background absorption is measured with the magnetic field turned on. The π component must be removed during this set of measurements so that the σ components do not overlap with the emission profile of the lamp. In this way, only the background absorption is measured. This step is often performed using a polarizer.

The advantage of using such a process is that the total and background absorption are measured within the same emission profile of the same lamp, so any kind of background (including fine structure background) is corrected. This process cannot be used if the molecule responsible for the background is also affected by the magnetic field. A more powerful spectrometer is needed for such background correction, complete with its own increased power supply (to operate the magnet that splits the absorption line).

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There are other methods available in AAS data analysis and optimization, including using an internal standard, and the standard addition method.

Internal standards

In analytical chemistry, an internal standard is a chemical substance that is added at a constant amount to the samples, the blank, and the calibration standards during chemical analysis. This substance can then be used for calibration by plotting the

ratio of the analyte signal to the internal standard signal as a function of the analyte concentration in the standards. This is performed in order to correct for the loss of analyte during sample preparation or intake.

The internal standard is a compound that is very similar, but not identical to, the chemical species of interest in the samples. As such, the effects of sample preparation should be the same for both the internal standard and the chemical species of interest (relative to the concentration of each species).

The standard AAS instrument consists of four components: the sample introduction area, the light (radiation) source, the monochromator or polychromator, and the detector

AAS accessories

The standard AAS instrument consists of four components: the sample introduction area, the light (radiation) source, the monochromator or polychromator, and the detector

Light
source
Absorption

Liquid

Gas

Solid

Emission

Excitation

Fore optics:
Focusing

Mono-
/Polychromator

| Sample introduction | → | Excitation source | → | Spectrometer for wavelength selection | → | Detector |