

Clinical Analysis of Metals in Biological Fluids and Tissues

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Description

Using the absorption of optical radiation (light) by free atoms in the gaseous state, Atomic Absorption Spectroscopy (AAS) and Atomic Emission Spectroscopy (AES) are spectro analytical methods for the quantitative determination of chemical elements. The absorption of light by free metallic ions is the foundation of atomic absorption spectroscopy. The method is used in analytical chemistry to determine the concentration of a particular element (analyze) in a sample that is going to be analyzed. In pharmacology, biophysics, archaeology, and toxicology, AAS is utilized to determine over 70 distinct elements in solution or directly in solid samples *via* electro thermal vaporization.

Numerous Applications in Various Fields of Chemistry

The principles of atomic emission spectroscopy were established in the second half of the 19th century by professors Robert Wilhelm Bunsen and Gustav Robert Kirchhoff at the University of Heidelberg, Germany. The modern form of AAS was largely developed during the 1950s by a group of Australian chemists. It was first used as an analytical technique. They were led by Sir Alan Walsh at the Division of Chemical Physics of the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Melbourne, Australia. Atomic absorption spectrometry has numerous applications in various fields of chemistry, including the clinical analysis of metals in biological fluids and tissues like whole blood, plasma, urine, saliva, brain tissue, liver, hair, and muscle tissue. Both qualitative and quantitative analysis can be carried out with atomic absorption spectrometry. Flames primarily the air-acetylene flame with a temperature of approximately 2300 °C and the nitrous oxide system (N₂O)-acetylene flame with a temperature of approximately 2700 °C are the oldest and most widely used atomizers in AAS. Additionally, the latter flame provides a more reducing atmosphere, making it an excellent choice for analyses with a high affinity for oxygen. Flame atomizers typically use dissolved or liquid samples. A pneumatic analytical nebulizer aspirates the sample solution and transforms it into an aerosol before introducing it into a spray chamber. There, it is mixed with the flame gases and conditioned so that only the finest aerosol droplets (less than 10 m) enter the flame. Only about 5%

of the aerosolized solution reaches the flame as a result of this conditioning process, which reduces interference. A burner head that produces a flame that is only a few millimeters deep and laterally long is located on top of the spray chamber. The flame gas flow rates can be adjusted to produce the highest concentration of free atoms, and the radiation beam travels through this flame along its longest axis. Additionally, the burner height can be altered to direct the radiation beam through the flame's region of highest atom cloud density, maximizing sensitivity. The stages of desolvation (drying), in which the solvent is evaporated and the dry sample nanoparticles remain, vaporization (transfer to the gaseous phase), in which the solid particles are transformed into gaseous molecules, atomization, in which the molecules are dissociated into free atoms, and ionization, in which atoms may be partially transformed into gaseous ions (depending on the ionization potential of the analytic atoms. In the event that the degree of phase transfer between analyzes in the calibration standard and the sample differs, there is a possibility of interference at each of these stages. Because it reduces the number of atoms that can be measured, or the sensitivity, ionization is generally undesirable. During the aspiration phase of the sample in flame AAS, a steady-state signal is produced. Most of the time, this method is used for measurements in the mg L⁻¹ range, but it can be extended to a few g L⁻¹ for some elements.

Absorbance for Quantification, Integration of the Transient Absorption

Since the late 1950s, Boris at the Saint Petersburg Poly-Technical Institute in Russia pioneered the use of Electro Thermal AAS (ET AAS) atomizers made of graphite tubes. Hans Massmann at the Institute of Spectro chemistry and Applied Spectroscopy (ISAS) in Dortmund, Germany, conducted parallel research. Although a wide variety of graphite tube designs have been utilized over the years, the dimensions that Liquid/dissolved, solid, and gaseous samples can all be directly analyzed using this method. The graphite tube is filled with a solid sample with a measured volume (typically 10 L–50 L) or weighed mass (typically around 1 mg) and subjected to a temperature program. This usually takes place in stages, like drying, where the solvent is evaporated; pyrolysis, in which the majority of the components of the matrix are destroyed; atomization: The element of analyze is moved into the gaseous phase and

cleaning: eventual residues in the graphite tube are removed at high temperature. Using a low-voltage, high-current power supply, the ohmic resistance of the graphite tubes is heated; Temperature ramps between stages make it easier to separate sample components, and each stage's temperature can be controlled very precisely. Tubes can be heated longitudinally or transversely, with the former providing a more uniform temperature distribution over its length. The atomization of the sample from a graphite platform inserted into the graphite tube (L'vov platform) rather than from the tube wall in order to delay atomization until the gas phase in the atomizer has reached a stable temperature is the primary component of the so-called Stabilized Temperature Platform Furnace (STPF) concept, which was proposed by Walter Slavin and based on research conducted by Boris. Use of a chemical modifier to bring the

analyze to a pyrolysis temperature high enough to get rid of most of the matrix's components and instead of using peak height absorbance for quantification, integration of the transient absorption signal's absorbance over time. The area of the transient signal produced by ET AAS is directly proportional to the mass of analyze that is introduced into the graphite tube, not its concentration. The advantage of this method is that any kind of sample solid, liquid, or gaseous can be directly analyzed. It is possible to make measurements in the low g L1 range (for a typical sample volume of 20 mL) and ng g1 range (for a typical sample mass of 1 mg) thanks to its sensitivity, which is 2-3 orders of magnitude higher than that of flame AAS. ET AAS may be regarded as the most reliable method currently available for determining trace elements in complex matrices due to its high degree of interference freedom.