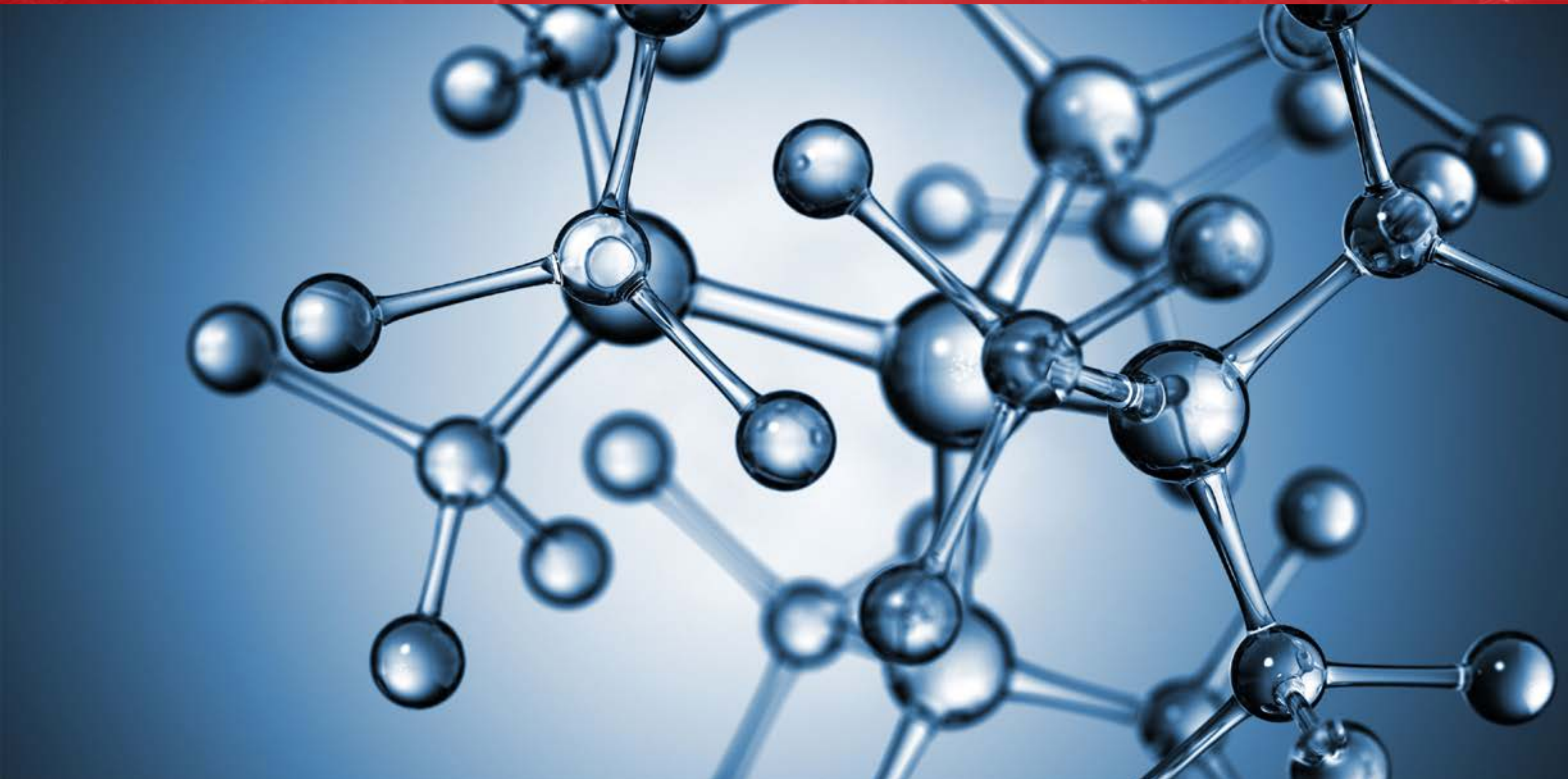

Article

Choosing Elemental Analysis Solutions for Industrial Quality Control

Introduction

Monitoring elemental concentrations is critical to ensure optimal product performance at minimal cost of operation. This is especially true for engine oils, refractories, and high temperature processes and metal alloys for advanced machinery. But, what is the ideal analytical tool for this task, and can it deliver the performance you need for your products?

Overall, we need analytical tools with flexibility. Plus, we need to meet changing requirements to ensure excellent data quality. We need analysis that adds value and can help ensure the continued stability of products.

This article will outline our tips for choosing elemental analysis instrumentation as it relates to industrial quality control.

Selecting the most appropriate tool for the job can sometimes appear to be a daunting task, especially since there are considerable overlaps of capabilities. In fact, all the techniques may be able to perform your analysis at acceptable levels of accuracy and precision. By evaluating the relative strengths and weaknesses of each of these techniques, particularly as they may apply to the practicality and performance requirements of your analysis, you will establish a rational basis for your decision-making.

Selecting the most appropriate tool for the job

Ask yourself these important questions:

- Which elements do I want to analyze?
- How many elements do I need to analyze?
- What is the lowest level of detection needed?
- How many samples per day?
- How fast do I need the result after sampling?
- What are the accuracy and precision requirements?

If your laboratory is performing elemental analysis, there are several mature, effective spectroscopic techniques that you could be using. This includes flame atomic absorption, graphite furnace atomic absorption, inductively coupled plasma mass spectrometry (ICP-MS), inductively coupled plasma optical emission spectrometry (ICP-OES), X-ray fluorescence, arc/spark OES, combustion gas analysis, and more.

All the various techniques are used broadly in similar application areas, including:: environmental, metallurgy and mining, pharmaceutical and biotech, semiconductor manufacturing, agriculture, food and beverage, chemicals, petrochemicals, and cement materials. There are some techniques that are better suited for certain applications, based on the elements to be analyzed. However, it can be generally difficult to differentiate between the techniques solely based on the application alone.

Let's take a minute to understand how each technique works. Although it isn't necessary to understand the complex technological details of each elemental analysis technique; for comparison purposes, it is helpful to have a general understanding of the basic principles.

Techniques covered:

- Combustion gas analysis (CGA or CHNOS)
- Optical emission spectrometry (OES)
- Atomic absorption spectrometry (FAAS and GFAAS)
- Inductively coupled plasma (ICP-OES, ICP-AES, ICP-MS)
- X-ray fluorescence (XRF)

In Figure 1, we outline the different elemental analysis techniques, their actual capabilities for the sample type solids and liquids, and what are their detection capabilities.

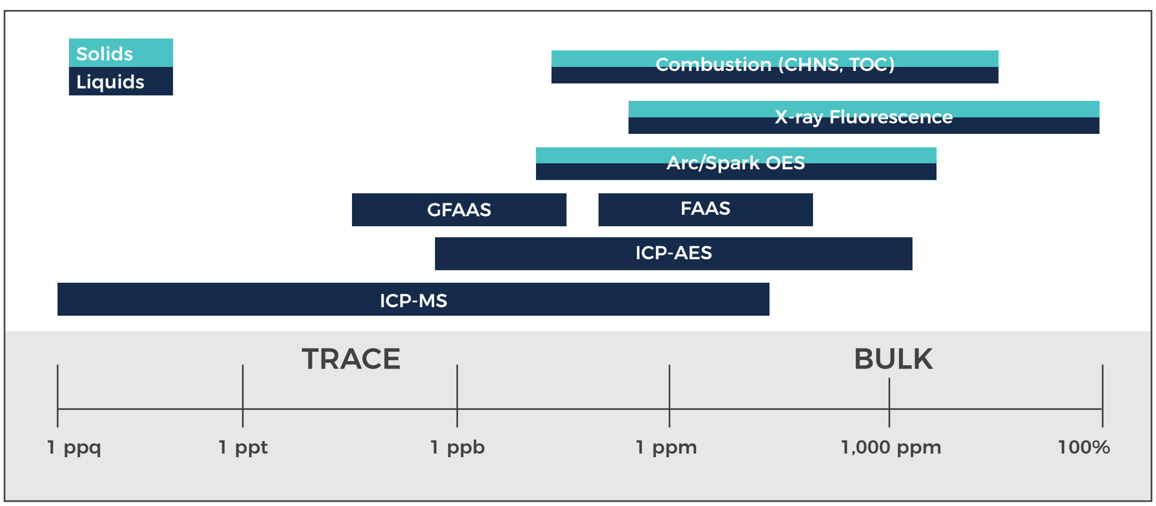

FIGURE 1 – DETECTION CAPABILITIES OF THE DIFFERENT ELEMENTAL ANALYSIS TECHNIQUES

Combustion Gas Analysis

Elemental combustion gas analysis enables highly precise quantitative determination of the absolute and relative amounts of carbon, hydrogen, nitrogen, oxygen, and sulfur (CHNOS) in a sample. The elemental components of the sample (C, H, N, S) are converted into gaseous oxidated products in a high temperature oxidation digestion step. After gas treatment and separation, the quantitative measurement is done by means of a suitable detector, like a TCD or an IR detector.

ELEMENTAR VARIO EL CUBE ANALYZER

The main advantages of combustion gas analyzers compared to other instrumental analytical methods are high-accuracy and precision. There is no need for matrix-specific standards. You have direct analysis of the original sample, liquids or solids, without time consuming pre-treatment, and you have fully-automatic determination within a few minutes. And as an added benefit, combustion gas analysis typically offers a very low cost-per-analysis.

Optical Emission Spectrometry

Optical emission spectrometry (OES) involves applying electrical energy in the form of a spark, or an arc generated between an electrode and a metal sample. The vaporized atoms are brought to a high energy state within a so-called discharged plasma. These excited atoms and ions in the discharged plasma create a unique emission spectrum specific to each element.

BRUKER Q4 TASMAN OES

Optical emission spectrometers cover analysis of chemical elements at complete range (from sub-ppm to percentage levels) for pure metals, trace metals, to even high alloy grades. With OES, all relevant elements can be analyzed simultaneously. The speed and simplicity of this equipment make them quite versatile and easy for most operators to use.

The robustness of these metal spectrometers enables several metal analysis applications, including positive material inspection, alloy identification, and quality control.

Atomic Absorption Spectrometry

There are two main types of atomic absorption spectrometry: flame atomic absorption spectrometry (FAAS) and graphite furnace atomic absorption spectrometry (GFAAS).

In FAAS, a flame is used to evaporate the solvent and disassociate the sample into its component atoms. When light from the hollow cathode lamp (selected based on the type of elements that's going to be determined) passes through a cloud of atoms, the atoms of interest absorb the light from the lamp. This is measured by a detector and is used to calculate the concentration of that element in the original sample.

The GFAAS technique is usually the same as a FAAS, except the flame is replaced by a small electrically heated graphite tube, which is heated to about 3000 °C to generate a cloud of atoms. The higher the atom density, the longer residence time in the tube. This improves GFAAS detection limits by a factor of up to a thousand times compared to a FAAS (all the way down to about sub-ppb range).

Inductively Coupled Plasma

Inductively coupled plasma (ICP-AES or ICP-OES) is a multi-element analysis technique that uses an inductively coupled plasma source to disassociate the sample into its constituent atoms or ions, exciting them to a level where they emit light of characteristic wavelength. A detector measures the intensity of the admitted light and calculates the concentration of that element.

AGILENT 5900 ICP-OES

ICP-MS utilizes plasma for sample ionization, and a mass spectrometer for ion separation and quantification. The lower detection limits and high productivity of ICP-MS makes it particularly suited for trace metal analysis and environmental testing. The common components of an ICP-MS system are a sample introduction system, the ion source, a vacuum system, collision (or a reaction cell), ion optics, a mass spectrometer (often using a quadrupole) and a detector. A triple quadrupole ICP-MS enables an MS-MS operation providing sub-ppt detection.

X-Ray Fluorescence

X-ray fluorescence (XRF) spectrometers use high energy X-rays to excite fluorescent radiation from a sample for qualitative and quantitative chemical or elemental analysis. XRF spectrometers have many industrial and research applications. Elements with an excitation energy less than the X-ray beam fluorescence can be counted by a wavelength dispersive or an energy dispersive spectrometer. One of the advantages of XRF is that there is little to no sample preparation required. The material to be analyzed can be placed right into the X-ray beam.

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XRF is a non-destructive analysis technique. Key considerations for choosing XRF spectrometers include speed, sensitivity, and ease-of-use. Like CGA, XRF is capable of analyzing liquids, solids, and loose powders. The elemental range of the XRF instruments is Beryllium (Be) to Uranium (U) in the concentration range from 100 % down to the sub-ppm-level.

Summary

There are several key questions that you need to answer when you're trying to decide on the solution for your elemental analysis needs. There may be some overlap in your techniques, and you may be following method guidelines for norm compliance. However, you may want to consider alternative solutions such as XRF or CGA, which may help improve your workflow and sample throughput, ease of use, the sample preparation and your overall investment.

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