Possibilities to increase sensitivity for flame and furnace atomic absorption spectroscopy using AA-7000

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Nowadays, the aspect of "sensitivity" is accompanied by the elemental analysis. For example, the requirements for environmental protection or quality assurance are constantly increasing. For instance, analysing the elements cesium and cadmium, there are various ways to improve the methodological parameters such as the detection and quantitation limit. These subjects are highlighted within this poster, applying the AA-7000 dual atomizer atomic absorption spectrophotometer (Fig. 1).

Table 1: AA-7000F – Limits of detection of cesium and cadmium before and after individual optimizations and after using the Atomic Booster (calculated according to DIN 32645).

<table>
<thead>
<tr>
<th>Atomizer</th>
<th>Cesium</th>
<th>Cadmium</th>
</tr>
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<tbody>
<tr>
<td>Without</td>
<td>0.013 mg/l</td>
<td>0.00051 mg/l</td>
</tr>
<tr>
<td>With booster</td>
<td>0.011 mg/l</td>
<td>0.00086 mg/l</td>
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</table>

**Overview**

The sample matrix can additionally affect the detection and quantitation limit. These subjects are highlighted within this poster.

**Flame AAS – Burner Height & Gas Flows**

Depending on the characteristics of the element being investigated, the atoms are present at different heights (temperature zones) within the flame. If the flame observation height is too low, the elements have not yet been atomized and cannot be detected correctly. If the flame observation height is too high, the elements may be present in their excited/ionized state, whereby they are no longer detected.

Two different gas mixtures are mainly used for the flame. In both cases, acetylene (C2H2) is the flame gas but different so-called oxidants are used: air for low flame temperatures and nitrous oxide (N2O) for higher flame temperatures. For most elements, air will be sufficient to generate free atoms or molecules. For refractory elements with high dissociation energies, higher flame temperatures are required (like for aluminum or titanium). Fig. 2a indicates the optimization of fuel gas composition observing the sensitivity for Cs.

**Furnace AAS – Omega Platform Tube**

Using graphite furnace atomic absorption technique, typically the furnace temperature program requires optimization steps, mainly depending on sample matrix. But there are several more options for method optimization available, like changing to a platform tube (omega tube) instead of using conventional tubes, to increase the methods sensitivity.

**Furnace AAS – Argon Flowrate Control**

In addition to change to a platform tube, the way how the graphite furnace is designed plays an important role for stable and sensitive measurements. With the GFA-7000A (Shimadzu), the digital controlled furnace enables higher long term stability due to intelligent temperature control and gas flow control; during atomization the upper plenum remains a longer time in the optical pathway, increasing the absorption values (compare Fig. 5).

**Flame AAS – Atomic Booster**

The Atomic Booster is a quartz tube that is positioned in the optical path over the exit slot of the burner. The tube has two slit-shaped openings opposite of each other that are different in length. The flame enters the quartz tube through the longer (larger) opening. A part of the flame can subsequently leave the quartz tube through the shorter opening. However, since the exit opening is smaller, a portion of the flame is held within the optical path or leaves the quartz tube through both open ends. This way, the dwell time of the atoms in the optical path as well as the 'thickness' of the flame can be increased (Fig. 3). As a consequence, the method sensitivity (LOD) falls within the ppt-range (Tab. 1).

**Conventional Graphite Furnace technique**

![Conventional Graphite Furnace technique](image1)

**Argon Flow Control of GFA-7000A (Shimadzu)**

![Argon Flow Control of GFA-7000A (Shimadzu)](image2)

Thanks to an additional 3-way valve, the vaporized atoms are better focused within the optical pathway. As a result, the detection limit in comparison to the conventional argon flow-line technique can be increased by a factor of 4-5. According to DIN 32645 the LOD is 0.004 µg/L using this option in comparison to 0.019 µg/L in conventional mode.

**Summary**

Several ways can be followed to increase the sensitivity of your atomic absorption method, whether it is flame or furnace or both, which enables a very fast method (flame) and an excellent matrix separation (furnace) within one instrument (Fig. 1).