AAS

APPLICATION NOTES

The GBC high performance nitrous oxide-acetylene burner and spray chamber system

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Introduction

Obtaining excellent performance with any flame atomic absorption spectrometer is largely dependent on the design of the nebuliser, spray chamber and burner system. Burners can be susceptible to blockage which may adversely affect the signal, producing invalid analytical results. Cleaning a blocked burner is a time consuming process requiring shutdown, a cooling period, cleaning, and then re-calibration. The purpose of this paper is to evaluate the GBC atomisation system, incorporating the nebuliser, spray chamber and high performance nitrous oxide-acetylene burner.

Spray chamber and nebuliser

GBC has designed a range of atomic absorption spectrometers that achieve superior performance. Using an air-acetylene burner, a sensitivity of 0.9 absorbance with less than 0.5% RSD for 5 mg/L copper. Indeed, during the final testing of all GBC atomic absorption spectrometers, around 1.0 absorbance unit or greater is often achieved with precision of better than 0.5%. This performance is due in part to the improved nebuliser and spray chamber design (see Figure 1).

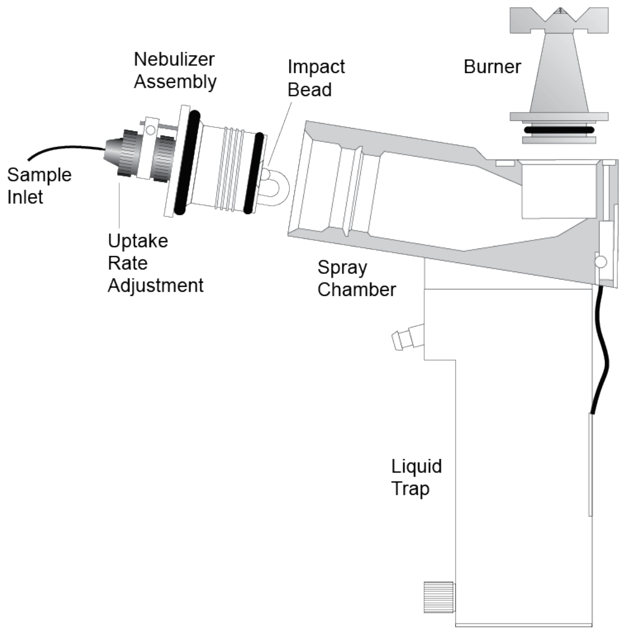

Figure 1: Schematic of the GBC nebuliser and spray chamber assembly with major components highlighted

In the GBC spray chamber, aerosol formation begins with a high efficiency pneumatic nebuliser. The GBC SavantAA Σ nebuliser has a platinum-iridium capillary with an inert venturi for resistance to corrosion. The adjustable glass bead shatters the larger droplets into an aerosol. The spray chamber assembly is machined from solid inert polypropylene. Its interior is triple sand blasted to ensure that the chamber drains smoothly and produces a stable flame and hence a stable signal. The polypropylene spray chamber allows a vast range of chemicals to be aspirated and analysed without any deleterious effects.

Safe operation is ensured by a comprehensive series of interlocks which monitor the nebuliser bung, the pressure relief bung, the liquid trap and the burner presence.

High performance nitrous oxide-acetylene burner

Whenever a nitrous oxide-acetylene flame is used, especially with acetylene-rich flames, the increased fuel flow can cause a build-up of carbon on the burner jaw edges due to the thermal breakdown of acetylene molecules. The carbon deposits may then act as nuclei for the precipitation of any dissolved salts and solids in a sample, causing further blockages.

GBC has designed a unique burner (Figure 2) made entirely from corrosion-resistant titanium that virtually eliminates carbon formation and build up and allows interference-free analysis for hours. The design of the burner allows better heat transfer along the length of the burner, preventing carbon build up on the jaw edges. The unique and compact design of the GBC burner allows relatively low fuel rates to be used to obtain maximum sensitivity. This leads to substantial savings in operating costs over other AA designs.

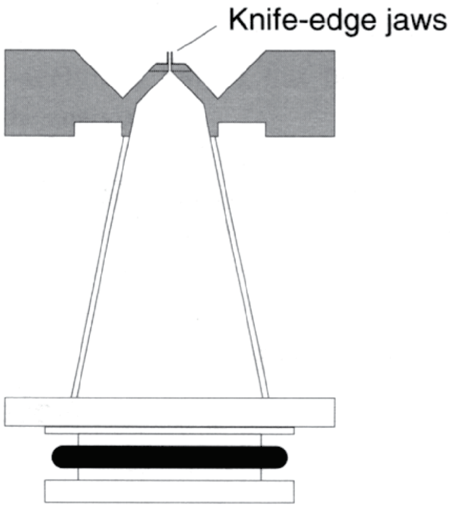

Figure 2: Schematic of the GBC high performance nitrous oxide-acetylene burner highlighting the knife edge jaws

Experimental

Instrumentation

A GBC double beam atomic absorption spectrometer, equipped with the unique Hyper-Pulse deuterium arc background correction system and a GBC flame autosampler were used. GBC software was used for developing applications and collecting and storing the data and graphics. Conditions, such as nebuliser uptake rate, burner height and fuel-to-oxidant ratio, were optimised unless stated.

Cleaning the glassware

All containers and glassware were soaked in a 10% v/v detergent solution for three days followed by rinsing with reverse osmosis, deionized water. All glassware was soaked for a minimum of three days in 10% nitric acid and then rinsed with reverse osmosis, deionized water.

Reagent and sample preparation

All chemicals were analytical grade. Nitric acid (HNO_3) was used. Sodium Chloride (NaCl), Sucrose and Atomic Absorption Standards (Aluminium, Silicon and Chromium each of 1000 µg/mL) were used.

Deionized water for washing and rinsing was obtained from a mixed-bed deionizing unit. Deionized water used for reagent preparation and analysis was from a reverse osmosis, mixed-bed deionizing unit that supplies Type 1 ultra pure water. Analytical standards were freshly prepared each day.

Results and discussion

The design of the GBC spray chamber and burner allows relatively low nitrous oxide and acetylene flows for maximum sensitivity in comparison to the published figures of other manufacturers. Table 1 compares the gas flow rates required for maximum sensitivity for various elements, and as can be seen for vanadium, a 24% lower gas flow is required. The lower flows translate not only to much lower running costs but the lower acetylene flow will also aid in reducing any carbon formation.

Element	Nitrous Oxide-Acetylene Flow Rates (L/min)	
	GBC AAS	Conventional AAS
V	10.0/4.9	11–13/7.5–8.5
Al	10.0/4.9	11–13/7.0–8.0
Si	10.0/5.5	11–15/7.0–9.0

Table 1: Comparison of gas flows (L/min) required for maximum sensitivity

To demonstrate the performance of the burner a 100 µg/mL Si solution was continuously aspirated for three hours. During this time, no blockage or disruption to the flame system occurred, (as is clearly shown by the signal graphics in Figure 3), nor were carbon deposits observed on the burner.

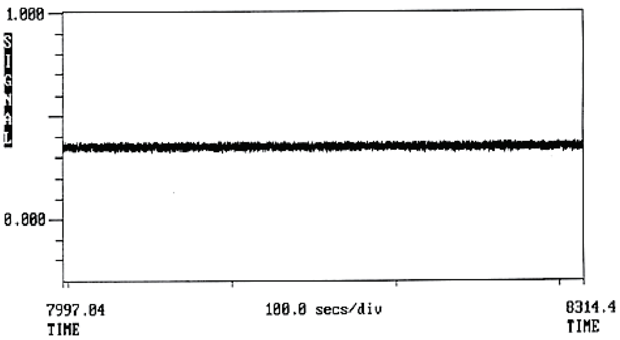

Figure 3: Signal graphics for 100 µg/mL Si, after continuous aspiration for three hours

Reduced burner blockages

Besides carbon formation on the burner jaws, there is also the potential problem of the burner blocking from the sample matrix itself. Solutions with a high concentration of dissolved solids such as salts or sugars can cause the burner to block because, as the solvent evaporates, solid material is deposited inside the burner jaw edges. As more of these deposits occur, the flame becomes disrupted and the process is accelerated.

The GBC high performance burner has a contoured, highly polished internal surface ensuring a consistent flame stoichiometry across the burner jaws. This surface is also resistant to the build-up of deposited materials. In conjunction with an adjustable sample uptake rate, the GBC high performance nitrous oxide-acetylene burner can run solutions with high concentrations of dissolved solids.

Determination of Si in 5% w/v NaCl solution

The concentration of NaCl in sea water is about 3.5% w/v. A test solution was prepared containing 5% w/v NaCl and spiked with 100 µg/mL silicon. Silicon was chosen as it traditionally requires a relatively fuel-rich nitrous oxide-acetylene flame for maximum sensitivity. This solution was aspirated for 30 minutes. The maximum signal deviation during that time was less than 10% (see Figure 4). This is an excellent result, showing the GBC nitrous oxide-acetylene burner's ability to run solutions with high concentrations of dissolved solids without blockage.

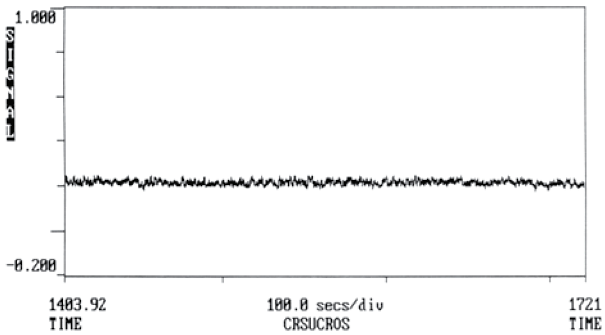

Figure 4: 100 µg/mL Si in 5% w/v NaCl

Determination of Cr in 5% w/v sucrose solution

The GBC high performance nitrous oxide-acetylene burner's performance was also evaluated using a 5% w/v sucrose solution containing 10 µg/mL Cr. As can be seen below (Figure 5), the signal did not deviate by more than 10% for the first 30 minutes. Note that the sucrose was continuously aspirated. In practical operations, rinsing with distilled water is recommended and this would substantially increase the total number of samples that could be analysed.

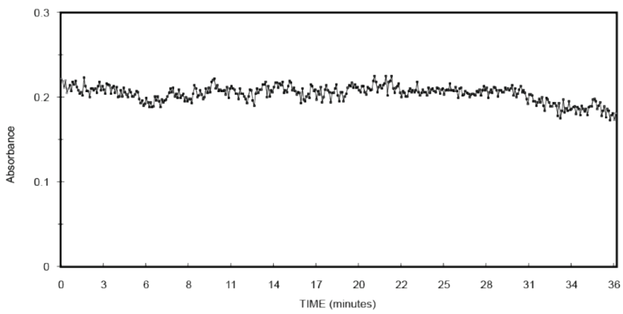

Figure 5: Cr in 5% w/v sucrose

Determination of 50 µg/mL Al in a soft drink

Aluminium is routinely analysed in soft drinks by beverage manufacturers to ascertain whether aluminium has leached into the drink from the can. Problems exist with conventional burners with the sugar blocking the burner in less than 10 minutes. The GBC high performance nitrous oxide-acetylene burner was evaluated by aspirating a soft drink with a known concentration of aluminium. The soft drink was de-gassed by placing it in an ultrasonic bath. The drink was then spiked to give an aluminium concentration of 50 µg/mL. Figure 6 shows the aluminium absorbance signal over the period 0 to 1.5 hours. The absorbance signal did not vary by more than 10% over the first 54 minutes and by only 30% over the entire period.

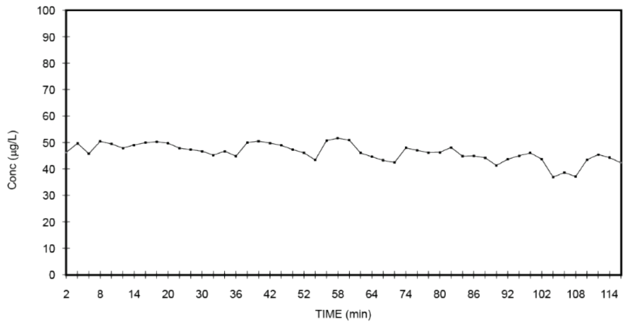

Figure 6: Aluminium in a soft drink

During this experiment no carbon was observed on the burner jaws. The main cause of signal deterioration is from sugar deposits inside the burner jaws. Note that for the majority of this experiment the soft drink was continuously aspirated. Every 30 minutes, water was aspirated for 60 seconds to rinse the burner. Rinsing between samples would greatly extend the analysis time and reduce the variation of analytical signal.

Burner cleaning

The efficiency of the GBC burner will depend on how clean it is. It is recommended that burners, particularly nitrous oxide-acetylene burners, be cleaned before use. The procedure adopted and recommended is outlined below:

1. Place the burner in a detergent solution in an ultrasonic bath for 15 minutes. (If an ultrasonic bath is unavailable then insert a wet thin cloth in the burner jaws and move it in an up and down and sideways motion.)

2. Rinse the burner with warm tap water.

3. While the burner is still wet, rub the burner jaws with a GBC cleaning card in an up and down and sideways motion.

4. Rinse the burner with distilled water.

5. The burner may be rinsed with ethanol to accelerate the drying process.

6. Before using the burner, ensure that any moisture on the outside of the burner, especially around the top of the burner and around the burner jaws, is wiped away.

Conclusion

The GBC nebuliser, spray chamber and high performance nitrous oxide-acetylene burner has been evaluated. The advantages to the analyst are:

1. The GBC high performance burner uses much lower gas flows in comparison with other systems. For maximum V sensitivity, a 24% lower gas flow is required. The lower flows translate not only to much lower running costs but the lower acetylene flow also aids in reducing carbon formation.

2. The GBC high performance nitrous oxide-acetylene burner's ability to run for at least three hours with no carbon formation means fewer system shut downs to clean the burner. This means higher laboratory productivity.

3. The ability to run difficult matrices for a relatively long time with very low signal noise ensures that these matrices can be analysed with precision and with minimal down time.

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