Tech Note
novAA 800 F/D with LPG burner

Flame AAS with Liquefied Petroleum Gas (LPG)

Introduction

Flame atomic absorption spectrometry (F-AAS) is a widely used technique for elemental analysis and can be flexibly applied to analyze many different elements and matrices. It is simple and robust, easy to handle, and offers a very high reproducibility.

In addition to the burner head for acetylene/air and acetylene/nitrous oxide, Analytik Jena offers an alternative burner head for the novAA 800 F/D, which works with liquefied petroleum gas (LPG) instead of acetylene. LPG is often used for cooking, heating, and as automotive gas. Therefore, it is usually much more readily available even in remote regions. In addition, LPG is cheaper and can be applied with a lower flow rate in the AAS burner than acetylene.

Your Benefits

- Simple elemental analysis in remote areas without regular supply of acetylene
- LPG gas is cheaper and more easily available than acetylene
- Suitable for elements with low atomization energy

Flame types in AAS

The most used flame in Flame-AAS is the acetylene/air flame, which is suitable for the analysis of more than 30 different elements. For certain elements with a higher atomization energy, like chromium, the hotter acetylene/nitrous oxide flame is used. However, the regular supply of acetylene needed for both flame types can be difficult in remote areas. The LPG/air flame has a maximum temperature of 1900 °C, compared to 2250 °C of the acetylene/air flame and even 2700 °C of the acetylene/nitrous oxide flame (Table 1).[1] Consequently, LPG is only suitable for elements with a low to moderate atomization temperature. However, the lower temperature can also be an advantage for certain elements, e.g., Na, K, and Mg, which tend to ionize in the hotter acetylene flame.

Table 1: Maximum temperatures of the different flame types used in Flame-AAS[1]

Flame type	Temperature
LPG / air	1900 °C
Acetylene / air	2250 °C
Acetylene / nitrous oxide	2700 °C

Analytik Jena GmbH
Konrad-Zuse-Strasse 1
07745 Jena · Germany

Phone +49 3641 77 70
Fax +49 3641 77 9279
info@analytik-jena.com
www.analytik-jena.com

Version 1.0 · Author: InHe
en · 03/2021

Design of the LPG burner head

While the burner head for acetylene/air by Analytik Jena has one 100 mm burner slot, the LPG burner head has two parallel 100 mm slots with a distance of a few millimeters (Figure 1). The reason for this design is the lower burning rate of LPG with only 82 cm/s compared to 158 cm/s for acetylene.[1] To maintain a stable flame, the gas must escape at a lower speed, which can be achieved by the larger outlet area of the double slot. For stabilization reasons, the two slots are divided into three parts, so it appears like six slots.

Figure 1: Design of the LPG burner head with two 100 mm long double slots, which are divided into three parts

AAS application with LPG flame

The LPG burner is specifically designed for the safe and efficient use of LPG fuel and can be used with any novAA 800 Flame-AAS. This combination allows easy and cost-effective elemental analysis. Since the maximum temperature of the LPG flame is 1900 °C, elements requiring a higher atomization temperature are difficult to atomize and analyze quantitatively. The recommended atomization temperature in graphite furnace AAS can be used as a guide which elements can be analyzed, although analytical performance also depends on specific matrix effects. However, the lower temperature of the LPG flame can also be an advantage when analyzing elements that tend to ionize.

To evaluate the applicability of LPG flame AAS, typical quality control methods such as determination of certified reference material and QC spike recovery rates were applied. Figure 2 provides an overview over the mean recovery rates for the analysis of different certified reference materials for a range of analytes. Figure 4 shows the mean relative standard deviations (RSDs) for the different analytes. Na, Ka, Mg, and Ca were analyzed in drinking water, river water, and wastewater, while Li, Cr, Fe, Co, Ni, Cu, Ag, Au, Zn, Cd, and Pb were analyzed in soil samples. For more details regarding the analysis please refer to Table 2 at the end of this document and to the Application Note.[2]

Analytik Jena GmbH
Konrad-Zuse-Strasse 1
07745 Jena · Germany

Phone +49 3641 77 70
Fax +49 3641 77 9279
info@analytik-jena.com
www.analytik-jena.com

Version 1.0 · Author: InHe
en · 03/2021

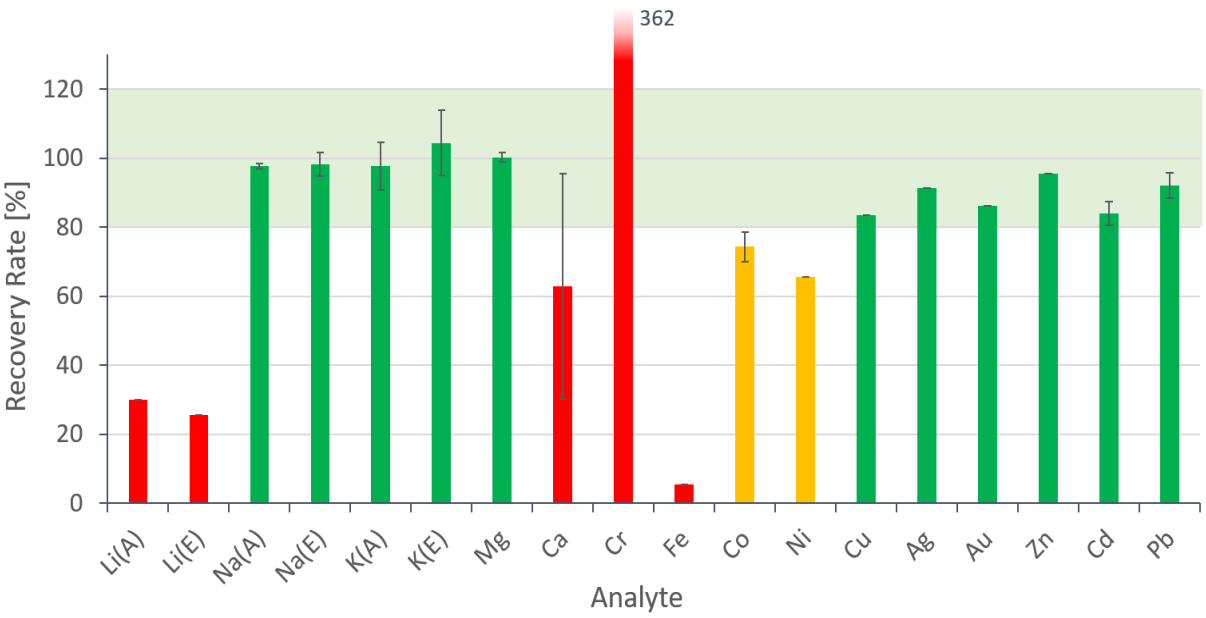

Figure 2: Mean recovery rates for the analysis of certified reference materials for different analytes. (A) stands for absorption mode, (E) for emission mode.

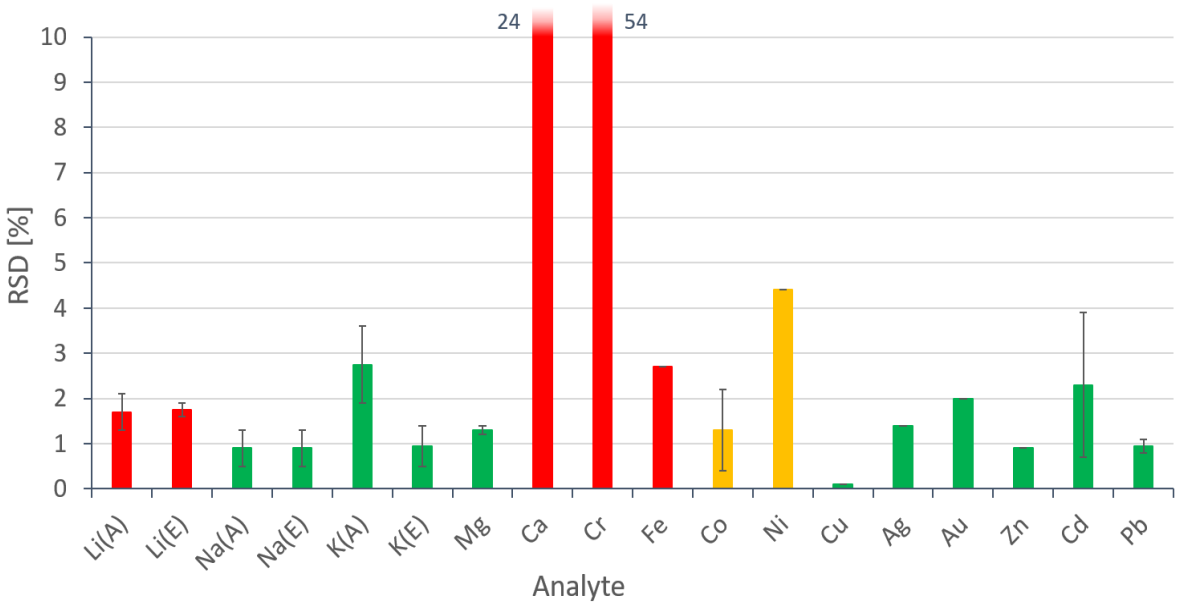

Figure 3: Mean relative standard deviations (RSDs) for different analytes. (A) stands for absorption mode, (E) for emission mode.

Analytik Jena GmbH
Konrad-Zuse-Strasse 1
07745 Jena · Germany

Phone +49 3641 77 70
Fax +49 3641 77 9279
info@analytik-jena.com
www.analytik-jena.com

Version 1.0 · Author: InHe
en · 03/2021

Analysis of Na, K, Mg, and Ca in water samples

The elements Na, K, Mg, and Ca were analyzed in drinking water, surface water, and industrial waste water.[2] The results of the drinking water analysis for Na, K, Mg and Ca were in accordance with the expected concentrations given by the water supplier. The recovery rates of the QC spikes, ranging from 97.5 to 110.1%, were excellent and indicate almost no matrix influence. In absorption mode, the limits of detection were lower, and the results were slightly closer to the values stated by the supplier than those obtained in emission mode.

For river water and industrial wastewater, no certified concentrations were available. Therefore, the quality of the analysis was estimated via a recovery experiment. The wastewater samples required a high dilution factor of 50,000. Alternatively, the burner head could be rotated by 90° to work with lower dilution factors. The recovery rates of the QC spikes for Na, K, and Mg in both sample types with values from 90.9 to 104.6% in absorption mode and 94.8 to 113.8% in emission mode show that the analysis was largely unaffected by the matrix and gave reliable results. The precision was very good with RSDs from 0.5 to 1.9%.

For Ca, on the other hand, the recovery rates of the spiked concentrations were 77.3% for river water and only 30.3% for industrial wastewater, and RSDs of 13.5 to 33.8% show unsatisfying precision. Calcium forms a stable carbide in the flame, which requires a higher temperature for atomization. When combined with a stronger matrix, like in industrial wastewater, the LPG flame does not provide enough energy to quantitatively atomize this calcium carbide. Usually, the hotter acetylene/nitrous oxide flame is applied for calcium analysis. The LPG flame can be recommended with limitations for the analysis of calcium in samples without matrix effects, such as drinking water, but not for samples with higher matrix.

Analysis of Li, Cr, Fe, Co, Ni, Cu, Ag, Au, Zn, Cd, and Pb in soil samples

A wide range of elements were analyzed in a certified reference material for contaminated soil. For analytes without certified concentration (Li, Ag, Au) or with certified concentrations close to the detection limit (Co, Cd, Pb), additional spike experiments were performed. The results for Cu, Ag, Au, Zn, Cd, and Pb were satisfactory with recovery rates above 80% (83.5–95.8% recovery of the certified values and 80.5–91.2% recovery of the QC spikes). The precision for these elements was very good with RSDs ranging from 0.1 to 2.1%.

Significant underdetermination occurred for Co and Ni with recoveries in the range of 65.5 to 78.6% and especially for Li with a recovery of only 30%. These observations can be explained by the fact that Co, Ni, and Li have a higher atomization energy than the other elements and therefore require a higher flame temperature. The atomization temperature applied in graphite furnace AAS can be used for orientation, as shown in Figure 2. The LPG flame with a maximum temperature of 1900 °C does not provide enough energy to quantitatively atomize elements with a higher atomization temperature. Similarly, Cr is usually analyzed with the hotter acetylene/nitrous oxide flame and cannot be recommended for analysis with the LPG flame. Although the atomization temperature of Fe is almost equal to that of Cu, it also cannot be recommended

Analytik Jena GmbH
Konrad-Zuse-Strasse 1
07745 Jena · Germany

Phone +49 3641 77 70
Fax +49 3641 77 9279
info@analytik-jena.com
www.analytik-jena.com

Version 1.0 · Author: InHe
en · 03/2021

for analysis with the LPG flame. The reason is that Fe forms stable oxides in the flame, which cannot be atomized by the LPG flame.

Conclusion

In remote areas, a regular supply of acetylene often cannot be ensured, while liquefied petroleum gas (LPG) is more readily available. Very good results were obtained for the analysis of Na, K, and Mg in water samples and satisfactory results for the analysis of Cu, Ag, Au, Zn, Cd, and Pb in soil samples. These elements have a low to medium atomization energy and thus can be easily atomized by the LPG flame. For analytes with an atomization energy between 1900 °C and 2000 °C, whether they can be satisfactorily analyzed with an LPG burner depends on the sample matrix. Elements that require a higher atomization temperature and are typically analyzed with the hotter acetylene/nitrous oxide flame, such as Ca or Cr, cannot be quantitatively atomized with an LPG flame. Also, elements that tend to form refractory compounds in the flame, such as Fe, may show interference or reduced sensitivity in this flame. In conclusion, the novAA 800 with LPG burner is a suitable solution for elemental analysis of readily atomizable elements in remote areas where a regular supply of acetylene cannot be assured.

Analytik Jena GmbH
Konrad-Zuse-Strasse 1
07745 Jena · Germany

Phone +49 3641 77 70
Fax +49 3641 77 9279
info@analytik-jena.com
www.analytik-jena.com

Version 1.0 · Author: InHe
en · 03/2021

Tech Note
novAA 800 F/D with LPG burner

Table 2: Overview of element determination with LPG flame AAS

Element	Wave-length [nm]	Mode	Recom-mended	Calibration range [mg/L]	R^2	Recovery rates* [%]	RSDs* [%]	LOD [µg/L]
Li	670.8	Absorption	No	0–5	0.9996	30.0	1.3–2.1	24.7
	670.8	Emission	No	0–5	0.9998	25.5	1.6–1.9	4.4
Na	589.0	Absorption	Yes	0–1	0.9999	97.0–98.5	0.5–1.3	0.6
	589.0	Emission	Yes	0–1	0.9999	94.8–101.6	0.5–1.3	5.2
K	766.5	Absorption	Yes	0–2.5	0.9999	90.9–104.6	1.9–3.6	8.3
	766.5	Emission	Yes	0–2.5	0.9998	94.9–113.8	0.5–1.4	10.2
Mg	285.2	Absorption	Yes	0–0.5	0.9999	99.0–101.5	1.2–1.4	1.3
Ca	422.7	Absorption	No	0–5	0.9994	30.3–95.5	13.5–33.8	328
Cr	357.9	Absorption	No	0–5	0.8959	362	54.3	820
Fe	248.3	Absorption	No	0–10	0.9869	5.3	2.7	6.7
Co	240.7	Absorption	Limited	0–10	0.9978	70.0–78.6	0.4–2.2	22.4
Ni	232.0	Absorption	Limited	0–10	0.9958	65.5	4.4	13.9
Cu	324.8	Absorption	Yes	0–5	0.9997	83.5	0.1	8.9
Ag	328.1	Absorption	Yes	0–5	0.9998	91.2	1.4	13.5
Au	242.8	Absorption	Yes	0–50	0.9998	86.1	2.0	21.3
Zn	213.9	Absorption	Yes	0–2.5	0.9997	95.5	0.9	1.4
Cd	228.8	Absorption	Yes	0–2.5	0.9999	80.5–87.5	0.7–3.9	2.3
Pb	283.3	Absorption	Yes	0–50	0.9999	88.3–95.8	0.8–1.1	47.9

* The recovery rates and RSDs have been determined in different water samples (drinking water, river water, and wastewater) for Na, Ka, Mg, and Ca and in soil samples for Li, Cr, Fe, Co, Ni, Cu, Ag, Au, Zn, Cd, and Pb. Please refer to Application Note[2] for details.

References

[1] Welz, B.; Sperling, M. *Atomic Absorption Spectrometry*; 3rd edition, Wiley-VCH, 1999, p. 151.

[2] Analytik Jena, *Simple and cost-efficient analysis of easily atomizable elements with an LPG flame AAS*; AppNote_AAS_0018, 2021.

Analytik Jena GmbH
Konrad-Zuse-Strasse 1
07745 Jena · Germany

Phone +49 3641 77 70
Fax +49 3641 77 9279
info@analytik-jena.com
www.analytik-jena.com

Version 1.0 · Author: InHe
en · 03/2021