Examining detection sensitivity of EI/FI and PI ion sources using nitrogen as a GC carrier gas

Product: Mass spectrometer (MS)

[General]

The global helium shortage is a very serious issue that is affecting a variety of scientific research organizations that utilize this gas for their work. In particular, gas chromatography-mass spectrometry (GC-MS) is a widely used analytical technique that traditionally uses helium as the GC carrier gas. Consequently, it has become critical to identify other carrier gases for GC-MS in order to minimize the effects of the helium shortage. Previously, we changed the GC-MS carrier gas from helium (He) to nitrogen (N_2) to determine how this affects sensitivity when using the dedicated EI ion source. The results showed that the detection sensitivity for N_2 as the GC carrier gas was 1/18 of the level when compared to He.

In this work, we compare sensitivity levels when using the combination EI/FI and EI/PI ion sources when He and N_2 are used as the GC carrier gas.

[Experiment]

Table 1 shows the measurement conditions. The GC column used for the analysis was a DB-5MS (30 m x 0.25 mm x 0.25 µm). He and N_2 carrier gases were used for the measurements. Samples used were octafluoronaphthalene (OFN 100 pg/µL), hexadecane (10 ng/µL), and benzophenone (100 pg/µL). One µL of each was injected to evaluate the EI/FI ion source in EI+ and FI+ modes and the EI/PI ion source in the PI+ mode, respectively.

Table 1. Measurement conditions

Instrument	JMS-T200GC
Injection mode	Splitless
Injection Volume	1 µL
Column	DB-5MS (Agilent Technologies), 30m x 0.25mm, 0.25µm
Oven temp.	40°C (1 min)- 30°C/min– 250°C (2 min)
Carrier Flow	He 1.0 mL/min, N_2 0.55 mL/min
Ion Source temp.	250℃

[Results]

As a starting point, the EI/FI combination ion source was tested with both He and N_2 to determine their affects on sensitivity. Figure 1 shows the extracted ion chromatogram for 100 pg of OFN (m/z 271.976±0.01) for each carrier gas when using EI+ mode for this combination EI/FI source. Interestingly, the OFN S/N ratio was nearly equal for both gases, which was different from the findings reported previously for the dedicated EI ion source in which the sensitivity level declined when the N_2 carrier gas was used. These results suggest that the EI/FI ion source, with its open ion volume design, reduces space charging from nitrogen ions inside the ion source, which in turn prevents a decline in sensitivity.

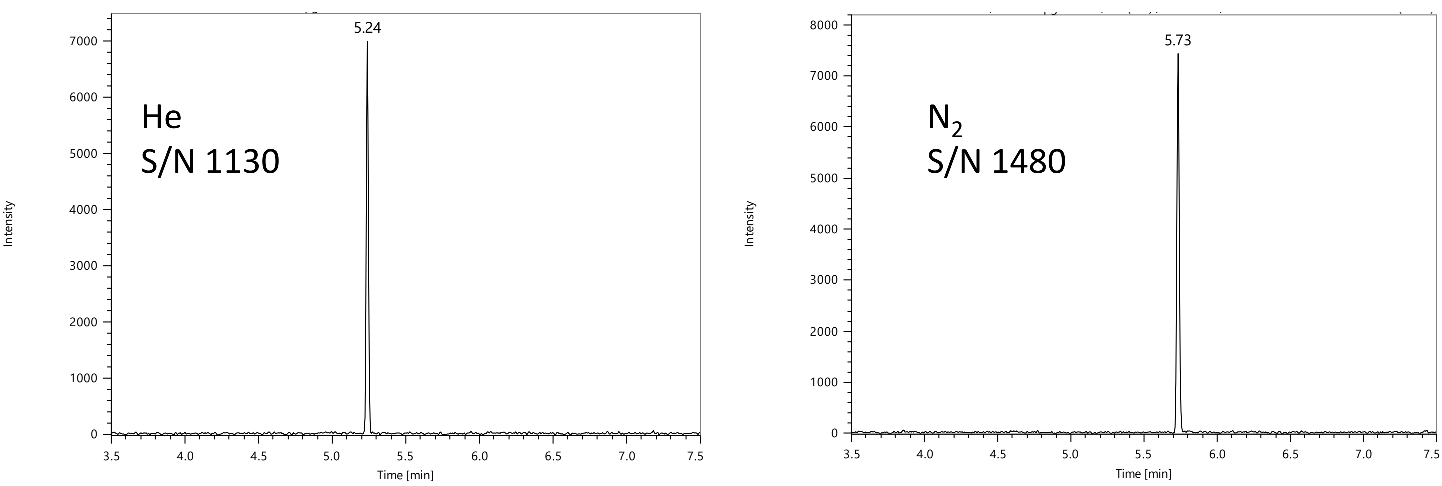

Figure 1. EIC for 100 pg of OFN in EI+ mode with EI/FI ion source using He and N_2 as the GC carrier gas

Figure 2 shows the extracted ion chromatogram for 10 ng of hexadecane (m/z 182.073±0.01) when He and N_2 carrier gases were used in the FI+ mode for the EI/FI ion source. The S/N ratio of hexadecane was nearly equal for both gases and this observation is again likely related to the open design of the EI/FI ion source as well as to the fact that FI does not ionize N_2.

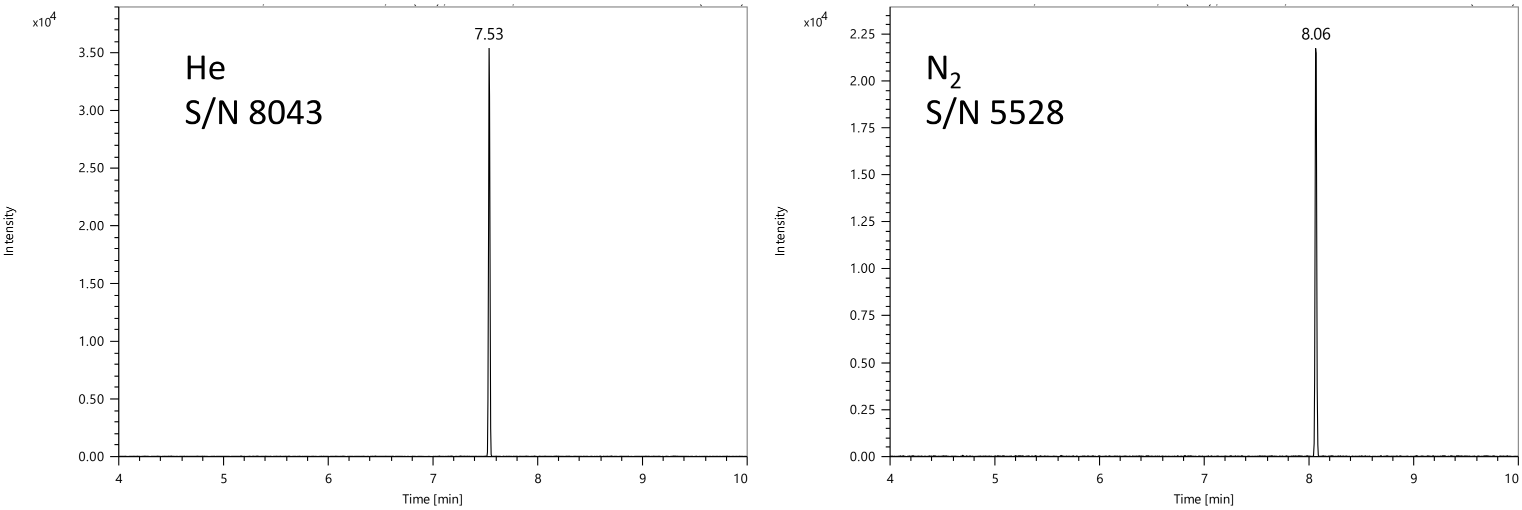

Figure 2. EIC for 10 ng of hexadecane in FI+ mode with EI/FI ion source using He and N_2 as the GC carrier gas

Finally, Figure 3 shows the extracted ion chromatogram for 100 pg of benzophenone (m/z 226.265±0.01) when He and N_2 carrier gases were used in the PI+ mode for the EI/PI ion source. The S/N ratio for both carrier gases was nearly equal for this measurement as well. In this case, despite the EI/PI source having an enclosed ion volume design, PI+ mode does not ionize N_2, thus minimizing space charging effects from the nitrogen ions that would result in poor sensitivity.

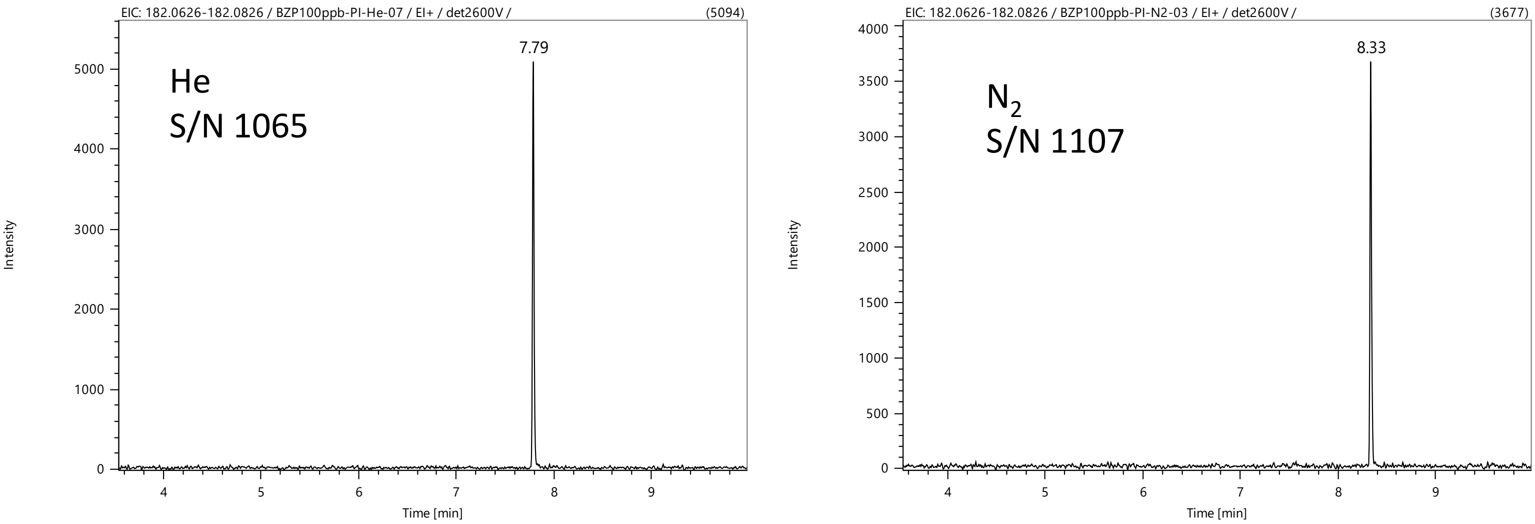

Figure 3. EIC for 100pg of benzophenone in PI+ mode with EI/PI ion source using He and N_2 as the GC carrier gas

[Summary]

Sensitivity levels were examined for the EI/FI ion source in EI+ and FI+ modes and for the EI/PI ion source in PI+ mode when He and N_2 were used as the GC carrier gas. For the open EI/FI ion source, there was little or no difference in sensitivity in the FI+ mode, where ionization efficiency of the carrier gas was low. There was also no difference in sensitivity in the EI+ mode, where charge accumulation/space charging could be a concern from nitrogen ion formation. With the closed design of the EI/PI ion source, there was also little or no difference in sensitivity when He and N_2 were used as a GC carrier gas due to the fact that N_2 ionization efficiency is low in PI+ mode. These results indicate that N_2 can be used as an alternative GC carrier gas for the EI/FI and EI/PI combination sources with minimal loss in sensitivity for EI+, FI+, and PI+ modes.

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