SHIMADZU
Excellence in Science

Application Data Sheet

No.191

System Gas Chromatograph

# Determination of aliphatic and aromatic contents in aviation kerosene by GC-VUV

A method is proposed in this paper for determination of aliphatic, total aromatic, monoaromatic, and diaromatic hydrocarbon content in aviation kerosene by GC-VUV. The results showed that the analysis process can be completed in 14 minutes. The analytes were identified by their specific VUV absorption spectra in the VUVision software platform and the coeluting species were effectively separated by the time interval deconvolution (TID) method in the data processing software VUVAnalyze. Results were valid and reliable. The relative standard deviation in 5 replicate tests was less than 1%, indicating good repeatability.

Key words: gas chromatograph, VUV detector, aviation kerosene, aromatic hydrocarbons, ASTM D8267

Aviation kerosene is commonly used as the fuel for gas turbine engines and ramjet engines mainly consists of a variety of hydrocarbon distillation cuts in the boiling point range of 150-290° C. The content of aromatic hydrocarbons in aviation kerosene directly affects the fuel's combustion performance, compatibility with elastomeric seals and formation of contrails. It may also increase the discharge of nitrogen oxides and solid particulate matters in exhaust gas, giving rise to adverse impact on the environment to varying degrees. As a result, there is an increasing scrutiny on the contents and types of aromatic hydrocarbons in aviation kerosene in recent years.

Currently available methods for the analysis of aromatic hydrocarbons in aviation kerosene include the widely-adopted fluorescent indicator adsorption (FIA) method (ASTM D1319), gas chromatography (GC) method (ASTM 3606, ASTM D5580, ASTM D5769), ultraviolet spectrophotometry (UV-VIS) method (ASTM D1840), high-performance chromatography (HPLC) method (ASTM D6379), and supercritical fluid chromatography (SFC) method (ASTM D8305). However, all of the above methods suffer from the disadvantages of high operational costs, time-consuming and laborious procedures, and, in some cases, daily preparation of samples and calibration of instruments. Moreover, the original indicator dye used for FIA method has been phased out and the new substitute indicator dye generated unsatisfactory results. A working replacement dye has been created and interlaboratory tests for the new indicator dye formulation are ongoing as of 2020. In light of this, it is imperative to find alternatives for ASTM D1319, such as ASTM D8267, for the analysis of aliphatic and aromatic hydrocarbons in aviation kerosene. Currently, there is a call for the preparation of a Chinese national standard for Gas Chromatography with Vacuum Ultraviolet Absorption Spectroscopy Detection (GC-VUV) method.

An analytical method was proposed in this paper for the analysis of aliphatic and aromatic content in aviation kerosene with Shimadzu gas chromatograph (GC-2030) and VUV detector (VGA 101). The method has significantly reduced requirements for chromatographic separation and increased accuracy of final calculation results by the application of fully automatic software for unique fingerprint spectrum and retention time based qualitative analysis.

## Analyzer Information

**System Configuration:**
Nexis GC-2030 with VUV detector: VGA-101

**Sample Information:**
Aviation kerosene

**Methods met:**
ASTM D8267

**Conditions of analysis:**

| | |
|---|---|
| Column: SH-Rtx-1(30 m×0.25 mm×0.25 μm) | Injector temperature: 250 ℃ |
| Column temperature program: 50 ℃(0.1 min)_15 ℃/min_260 ℃ | Transfer line temperature: 275 ℃ |
| Column pressure: 139.9 kPa | Flow cell temperature: 275 ℃ |
| Column flow: 2 mL/min | Make-up gas pressure: 0.35 psi |
| Injection mode: split (split ratio 100:1) | Spectral acquisition range: 125-430 nm |
| Injection volume: 1 μL | Spectral acquisition frequency: 4 Hz |

## Typical Chromatograms and spectrograms

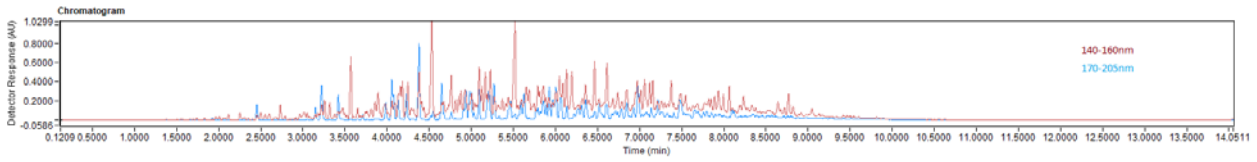


Fig. 1 A typical chromatogram of aviation kerosene

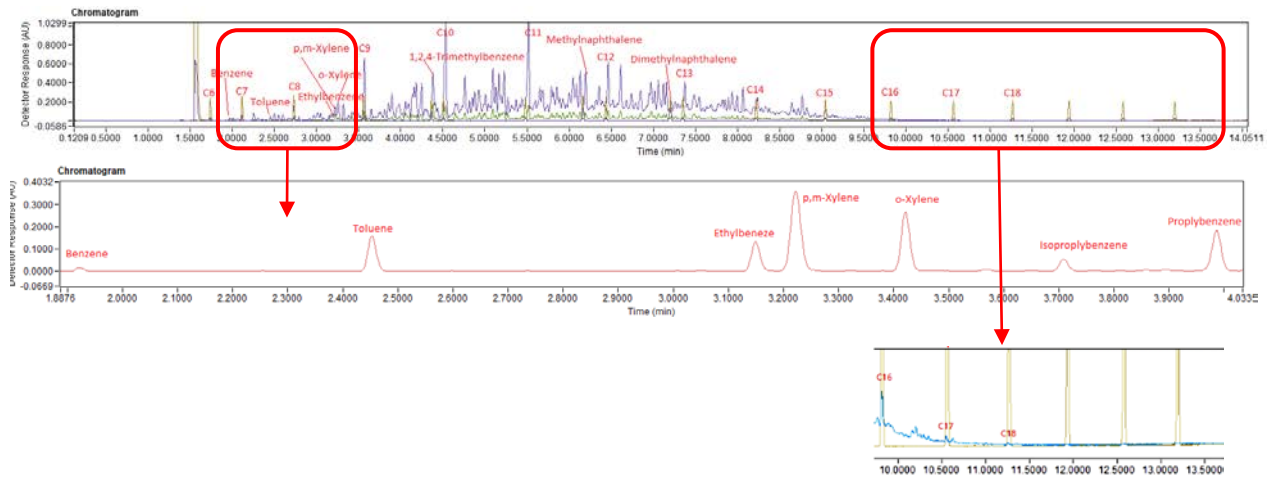


Fig. 2 Segments of the chromatogram of aviation kerosene

## Overlaid spectra of constituent hydrocarbons

It is recommended on the basis of ASTM D8267 Standard Test Method for Determination of Total Aromatic, Monoaromatic, and Diaromatic Content of Aviation Turbine Fuels Using Gas Chromatography with Vacuum Ultraviolet Absorption Spectroscopy Detection (GC-VUV) and in reference to the chromatogram/spectrogram database available in the VUV Analyze software that the proposed method is suitable for determining total aromatic(0.487 %- 27.876 %), monoaromatic(0.49 % to 27.537 %) and diaromatic(0.027 % to 2.523 %) content in aviation kerosene. A sample of a commercially available aviation kerosene was analyzed by the proposed method. Fig. 3 - Fig. 5 are the overlaid spectra of the constituents and Table 1 shows the mass fractions and volume fractions of them.

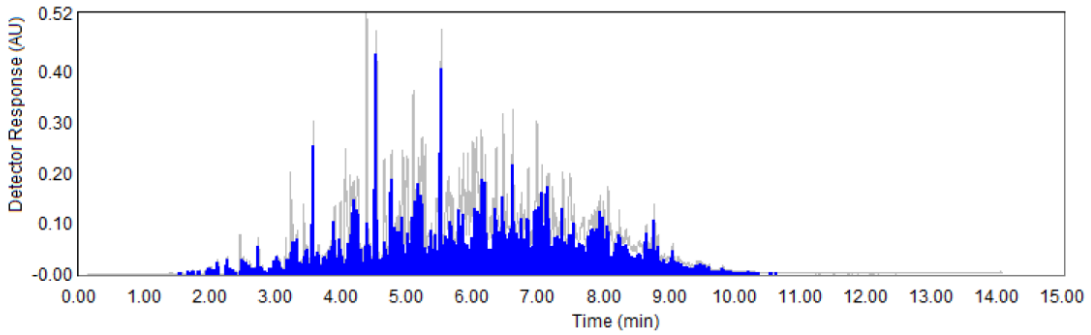


Fig. 3 An overlaid spectrum of aliphatic hydrocarbons

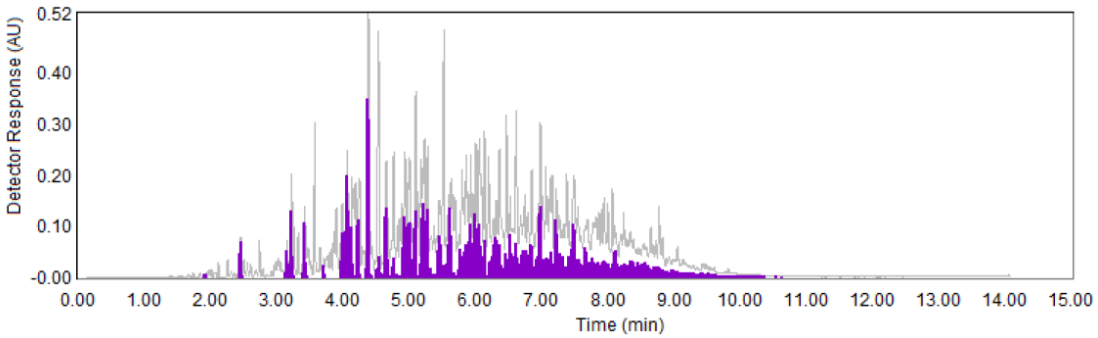


Fig. 4 An overlaid spectrum of monoaromatic hydrocarbons

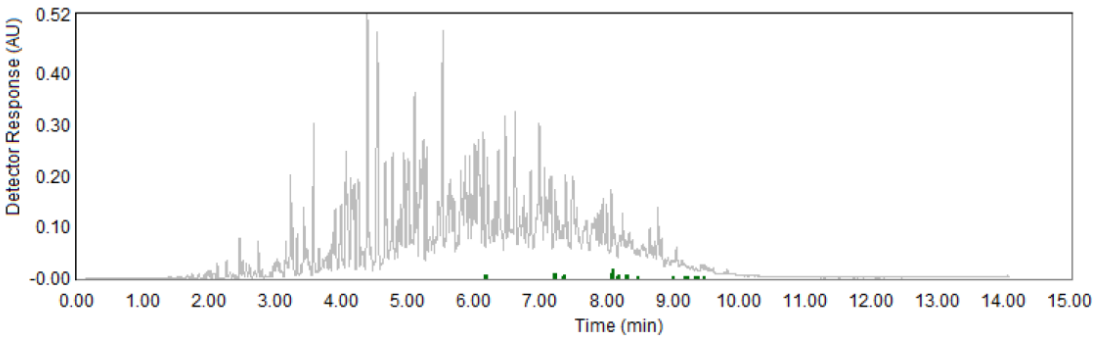


Fig. 5 An overlaid spectrum of diaromatic hydrocarbons

Table 1 Mass and volume fractions of the constituents

| Category | Mass % | Volume % | Comments |
|---|---|---|---|
| Total Saturates | 82.513 | 84.177 | |
| Total Aromatics | 17.487 | 15.823 | |
| Total Mono-Aromatics | 17.424 | 15.774 | |
| Total Di-Aromatics | 0.063 | 0.049 | |

## Repeatability

1 uL of a commercially available aviation kerosene was directly injected for repeatability test. The RSD of 5 replicate injections was less than 1 %, indicating good repeatability. For detailed results, refer to Table 2 and Table 3.

Table 2 Repeatability - mass fraction

| | Mass fraction % | | | | | RSD/n=5(%) |
|---|---|---|---|---|---|---|
| Aliphatic hydrocarbon | 82.513 | 82.492 | 82.438 | 82.517 | 82.525 | 0.0315 |
| Total aromatic hydrocarbons | 17.487 | 17.509 | 17.562 | 17.483 | 17.475 | 0.0315 |
| Monocyclic aromatic hydrocarbon | 17.424 | 17.445 | 17.499 | 17.421 | 17.415 | 0.0308 |
| PAHs | 0.063 | 0.064 | 0.063 | 0.061 | 0.059 | 0.0018 |

Table 3 Repeatability - volume fraction

| | Volume fraction % | | | | | RSD/n=5(%) |
|---|---|---|---|---|---|---|
| Aliphatic hydrocarbon | 84.177 | 84.163 | 84.119 | 84.186 | 84.195 | 0.0267 |
| Total aromatic hydrocarbons | 15.823 | 15.837 | 15.881 | 15.814 | 15.805 | 0.0267 |
| Monocyclic aromatic hydrocarbon | 15.774 | 15.787 | 15.832 | 15.766 | 15.759 | 0.0259 |
| PAHs | 0.049 | 0.050 | 0.049 | 0.048 | 0.046 | 0.0014 |

## Conclusion

A method was proposed in this paper for determination of aliphatic, total aromatic, monoaromatic, and diaromatic hydrocarbon contents in aviation kerosene by GC-VUV. The method was used for analysis in reference to the procedures specified in ASTM D8267 and the results showed the analysis could be completed within 14 minutes, which is significantly faster than the traditional FIA method (D1319). The analytes were identified by their specific VUV absorption spectra in VUVision and the coeluting species were effectively separated by time interval deconvolution (TID) method in the full automatic data processing software VUVAnalyze and the qualitative results of the analytes by their VUV characteristic absorption spectra were effective and reliable. Considering the volatility of aviation kerosene exposed in air, the repeatability of the method was assessed by 5 replicate tests and the RSD of the results was less than 1%, indicating good repeatability. The method can be used as an analytical method for determining the aliphatic, total aromatic, monoaromatic and diaromatic content in aviation kerosene.

First Edition: April 2021

Shimadzu Corporation
www.shimadzu.com/an/