SHIMADZU
Excellence in Science

Application News

No. AD-0235

Pharmaceutical/ HS-20 Nexis GC-2030

Determination of Alcohol Content in Hand Sanitizers by Headspace GC-FID

❑ Introduction

Since the outbreak of COVID-19 the sales of hand sanitizer products have increased rapidly. Even though hand washing with soap and water is the preferred way to clean hands, hand sanitizers are recommended when clean water and soap are not available.
The U.S. Centers for Disease Control and Prevention (CDC) recommends the use of an alcohol-based hand sanitizer that contain at least 60 % ethanol or 70 % isopropanol (IPA) [1].
The determination of alcohol contents in hand sanitizers has been demonstrated using GC-FID with liquid injection [2]. However, some hand sanitizers contain other ingredients, such as colorants and thickening agents [3], which could potentially contaminate the GC. Here, we describe a headspace-GC-FID method using nitrogen as the carrier gas to analyze alcohol content in hand sanitizers.

❑ Experiment

Analytical system and conditions

HS-20 headspace autosampler and Nexis™ GC-2030 (Shimadzu Corporation, Japan) were used in this work (Figure 1). Details of analytical conditions are shown in Table 1. The use of nitrogen as carrier gas was selected as an alternative to the expensive helium.

Chemicals and samples preparation

Acetonitrile, ethanol and IPA were purchased from Kanto Chemical Co, Inc. n-Butanol and sodium chloride (NaCl) were purchased from Millipore Sigma. Alcohol stock solutions containing ethanol and IPA were prepared at 0.1, 0.2, 0.5, 1.0, 2.0 and 5.0% (v/v) in Milli-Q® water. Acetonitrile (internal standard) and n-butanol (surrogate standard) were mixed and diluted with Milli-Q® water to 2% (v/v). A matrix modifier solution was prepared by adding 180 g of NaCl to 500 mL of Milli-Q® water. The matrix modifier solution was used in accordance to EPA 5021A method to reduce the partition coefficient of the analyte and hence to reduce the solubility of analyte in the matrix [4,5]. This was carried out to increase analysis sensitivity.

Calibration standards were prepared by adding 5 mL of the matrix modifier solution into a 20 mL headspace vial, followed by 1 mL of the alcohol stock solution and 1 mL of water containing acetonitrile and n-butanol at 2% each. Ethanol- and IPA-based hand sanitizers from different brands were used for the analysis.

To prepare a diluted hand sanitizer solution, 1 mL of hand sanitizer was measured and topped up to 35 mL with Milli-Q® water. Samples were prepared by adding 5 mL of the matrix modifier solution to a 20 mL headspace vial, followed by 1 mL of the diluted hand sanitizer solution and 1 mL of water containing acetonitrile and n-butanol at 2% each.

Table 1: HS-GC-FID analytical conditions for analysis of alcohol in hand sanitizer.

Analytical System	
GC-FID	Nexis™ GC-2030AF
Headspace Autosampler	HS-20
Column	SH-Rxi™-624Sil MS 30 m x 0.32 mm I.D., df = 1.80 µm
HS parameters	
Oven Temperature	85 °C
Sample Line Temperature	100 °C
Transfer Line Temperature	110 °C
Injection Time	1 min
Pressurizing Gas Pressure	90 kPa (N_2)
Equilibrating Time	20 mins
Shaking Level	2
GC-FID parameters	
Injection Mode	Split mode Split ratio 50
Carrier Gas	Nitrogen
Gas Flow Condition	Constant linear velocity mode Linear velocity 27.3 cm/s
Oven Temperature Programming	50 °C (1 min) →20 °C/min to 250 °C (4 mins)
Detector Temperature	250 °C

Figure 1: Nexis™ GC-2030 and HS-20

❑ Results and Discussions

Using a headspace technique, the standards and samples were heated to extract the volatiles from the matrix. The volatiles were then introduced to GC-FID for subsequent analysis. Figure 2 shows that using nitrogen carrier gas, the separation of the alcohols and acetonitrile from the 2 % standard solution could be performed successfully.

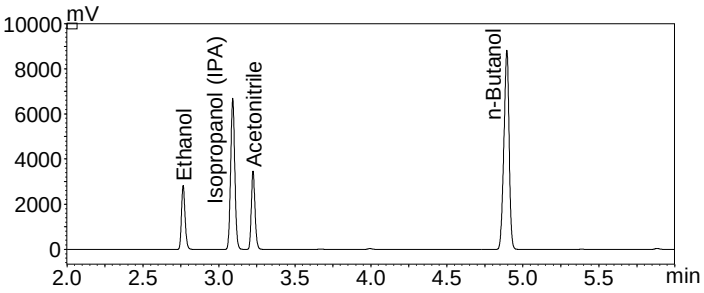

Figure 2: Separation of the alcohols from the acetonitrile (IS) both at 2 % (v/v) with SH-Rxi™-624Sil MS column.

The calibration curves of ethanol and IPA standards are shown in Figure 3. Excellent linearity was achieved for both ethanol and IPA (R^2 of 0.99994 and 0.99982, respectively). Repeatability was conducted with a standard solution containing 0.1 % (v/v) of ethanol and IPA. The repeatability (n=6) results are listed in Table 2.

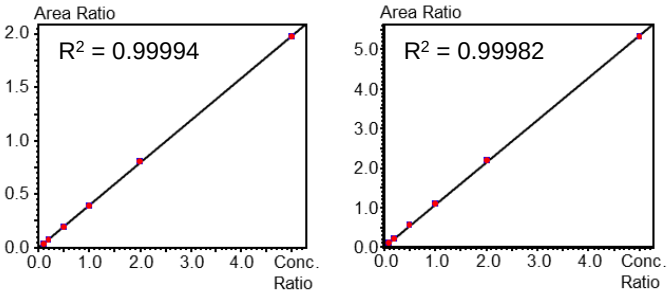

Figure 3: Calibration curves of ethanol and IPA at 0.1 – 5 % (v/v).

Table 2: Peak area repeatability (n=6) for standard solution containing ethanol and IPA at 0.1 % (v/v) each.

	Peak Area	
	Ethanol	IPA
Run 1	186446	551889
Run 2	185886	549640
Run 3	186282	552462
Run 4	185672	549472
Run 5	185806	551775
Run 6	184778	542381
Average	186208	551383
%RSD	0.30	0.27

The alcohol concentration of three different hand sanitizers were analysed. Sample 1 was gel-based while sample 2 and 3 were liquid-based. The obtained chromatograms of the sample solutions are shown in Figure 4. The quantitative results and repeatability (n=3) are listed in Table 3.

Matrix effect and extraction efficiency were monitored using the surrogate compound, n-butanol. This was carried out by calculating the recovery of n-butanol in the samples (Table 4). Since the recovery results were close to 100 %, the internal standard method was considered to be accurate for these samples.

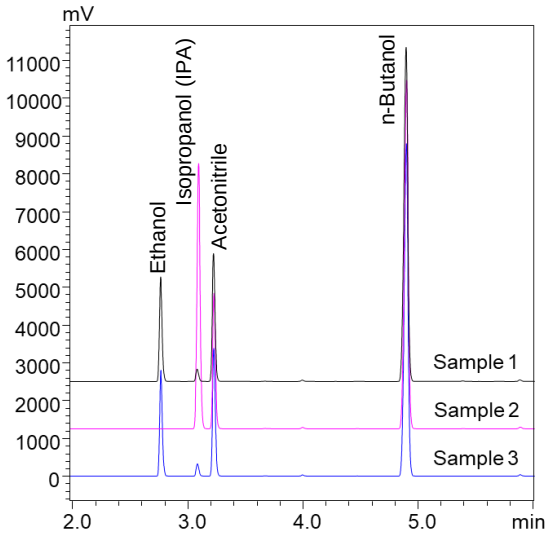

Figure 4: Overlaid chromatograms of the hand sanitizer samples.

Table 3: Quantitative values and repeatability (n=3) of the hand sanitizer samples.

	Ethanol		IPA	
	Quantitative value (%)		Quantitative value (%)	
	Average	%RSD	Average	%RSD
Sample 1	69.125	0.6	2.835	1.2
Sample 2	ND	ND	72.252	0.6
Sample 3	70.257	0.1	2.882	0.7

ND = Not detected

Table 4: Surrogate Recovery (n=3) in Sample 1, 2 and 3.

	n-Butanol Recovery (%)			
	Run 1	Run 2	Run 3	Average
Sample 1	99.5	101.2	100.4	100.4
Sample 2	99.2	99.0	100.6	99.6
Sample 3	99.3	99.2	99.3	99.3

❑ Conclusion

This study demonstrated the feasibility of using HS-GC-FID for the analysis of alcohol in hand sanitizers. The robustness of this method was proven with good repeatability and linearity in both standard and sample solutions.

Last but not least, it should also be noted here that the use of nitrogen instead of helium as the carried gas has the potential to lower the operational cost while maintaining compound resolutions.

❑ References

1. https://www.cdc.gov/coronavirus/2019-ncov/hcp/hand-hygiene.html.
2. Shimadzu Application News No. G333, Alcohol Determination of Sanitizer Gel in accordance with USP<611>.
3. Lee, J., et al, Hand Sanitizers: A Review on Formulation Aspects, Adverse Affects and Regulations, Int J Environ Res Public Health, 2020 May 11; 17(9):3326.
4. US EPA METHOD 5021A, VOLATILE ORGANIC COMPOUNDS IN VARIOUS SAMPLE MATRICES USING EQUILIBRIUM HEADSPACE ANALYSIS, 2014.
5. Ettre, L.S., Kolb, B., (2006), STATIC HEADSPACE-GAS CHROMATOGRAPHY. Canada: John Wiley & Sons.

SHIMADZU

SHIMADZU (Asia Pacific) Pte. Ltd
79 Science Park Drive, #02-01/08 Cintech IV, Singapore 118264,
www.shimadzu.com.sg; Tel: +65-6778 6280 Fax: +65-6778 2050