APPLICATION NOTE

No. AN53310

Hand sanitizer analysis

Ensuring product safety and efficacy of alcohol-based hand sanitizer with ATR-FTIR

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The Centers for Disease Control and Prevention (CDC) first revised its hand hygiene guidelines in 2002 to recommend alcohol-based hand sanitizer as a possible alternative to hand cleansing with soap and water for the public and health care personnel.[1] The majority of alcohol-based hand sanitizers contain either isopropanol, ethanol, n-propanol, or a combination of two of these alcohols. The antimicrobial activity of alcohols can be attributed to their ability to denature proteins. The best antimicrobial efficacy can be achieved with ethanol (60 to 85%) and isopropanol (60 to 80%) solutions.[2] Higher concentrations are less potent because proteins are not denatured easily in the absence of water, whereas solutions with lower than 60% alcohol may only reduce the growth of germs but not kill them. In response to the Coronavirus Disease 2019 (COVID-19) pandemic, the Food and Drug Administration (FDA) has recently issued guidelines[3,4] that temporarily allows compounders and certain entities that are not currently regulated by FDA as drug manufacturers to prepare and distribute hand sanitizer products for the duration of the public health emergency. Despite the relatively simple formulations and preparation protocols, it is critically important that proper quality assurance and control measures be in place to ensure the safety and efficacy of hand sanitizer products. To that end, Thermo Scientific™ Nicolet™ iS50 FTIR Spectrometer equipped with a built-in attenuated total reflectance (ATR) accessory, in combination with the powerful yet intuitive Thermo Scientific™ OMNIC™ Software platform, offers a facile solution to meet the analytical requirements.

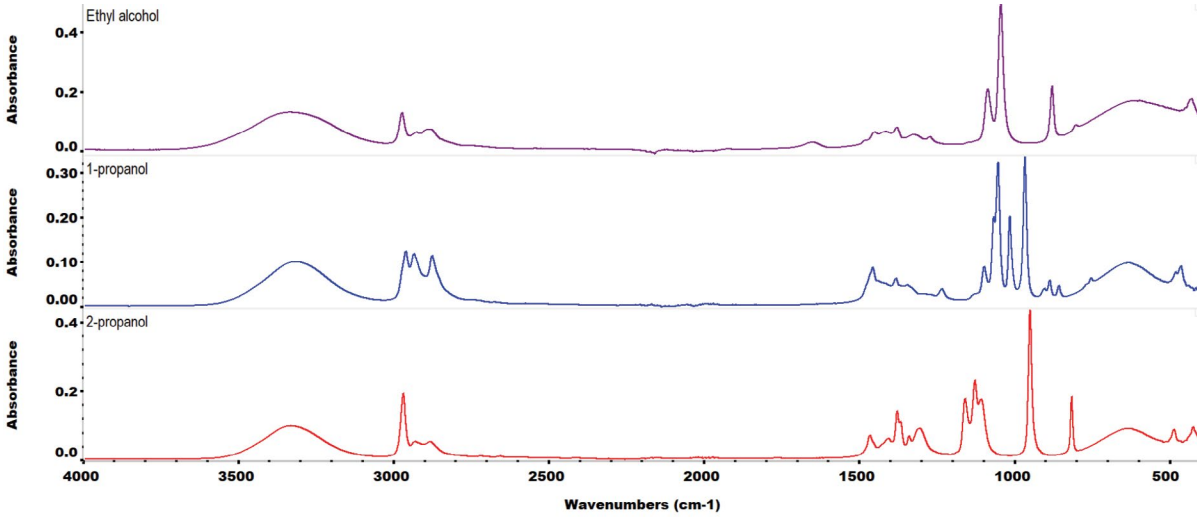

Figure 1: ATR FTIR spectra of three alcohols commonly used in alcohol-based hand sanitizers: ethanol, 2-propanol and 1-propanol. Each spectrum is 16 scans co-added at a spectral resolution of 4 cm^{-1}.

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The operation in a quality control and assurance laboratory starts with verifying that a material meets specifications. Figure 1 shows the FTIR spectra of three commonly used alcohols in hand sanitizer products: ethanol (ethyl alcohol), 2-propanol (isopropanol) and 1-propanol (n-propanol). There are noticeable differences in both C-H stretch (3000-2800 cm^{-1}) and fingerprint (1500-500 cm^{-1}) regions due to their different chemical structures. Note that although n-propanol has been used in alcohol-based hand rubs in parts of Europe for many years, it is not an approved active agent for hand sanitizer products in the United States.

QCheck™ spectral correlation is an ideal tool for the verification of incoming materials, in-process materials, or finished products. In this case, the spectrum of the denatured, industrial grade ethanol was compared against the spectrum of the non-denatured, reagent grade ethanol (Figure 2). The industrial grade-denatured ethanol contains isopropanol, evidenced by the minor peak at 950 cm^{-1}.

The "Fail" result suggests that the level of impurity is above the predefined threshold. This quality check was accomplished without the need for constructing libraries or complex spectral manipulations.

Glycerol is another ingredient in the hand sanitizer products. According to the World Health Organization (WHO) recommendations,[5] only United States Pharmacopeia (USP) or Food Chemical Codex ("food grade") glycerol should be used in the formulations. Figure 3 shows the results of the incoming inspection of two types of glycerol using the QC Compare function of OMNIC. QC Compare Search is a spectral classification technique that determines the single best match from each class and indicates how closely the unknown material matches the spectrum of the chosen standard. In this case, with a critical match value set at 90, one glycerol passed the inspection and the other one failed the test.

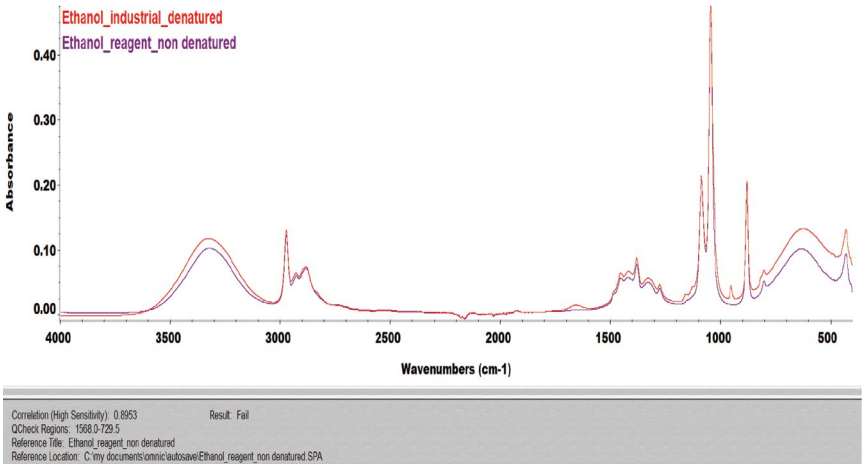

Figure 2: QCheck result of an industrial grade ethanol against a reagent grade ethanol.

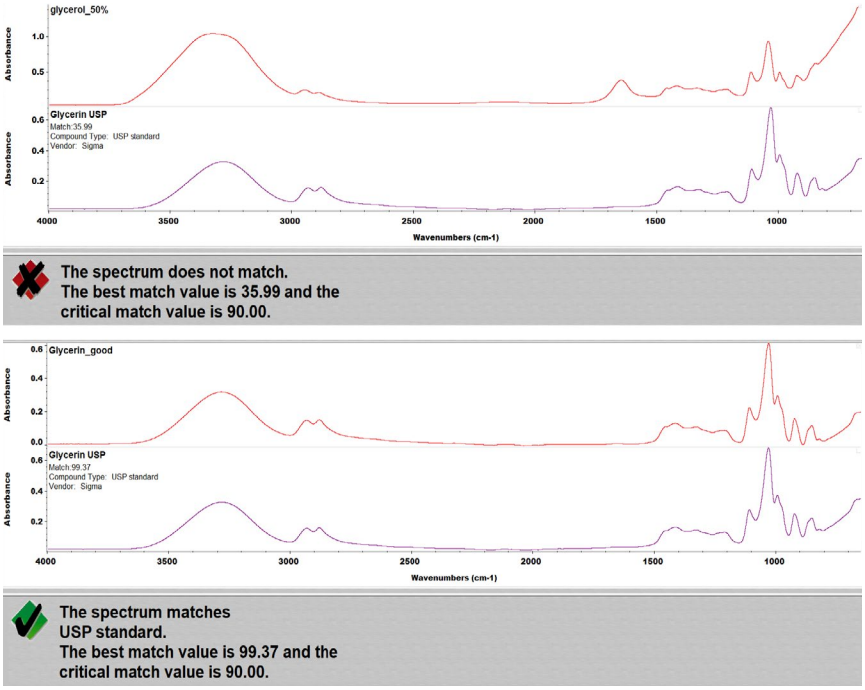

Figure 3: QC Compare results of two types of glycerol.

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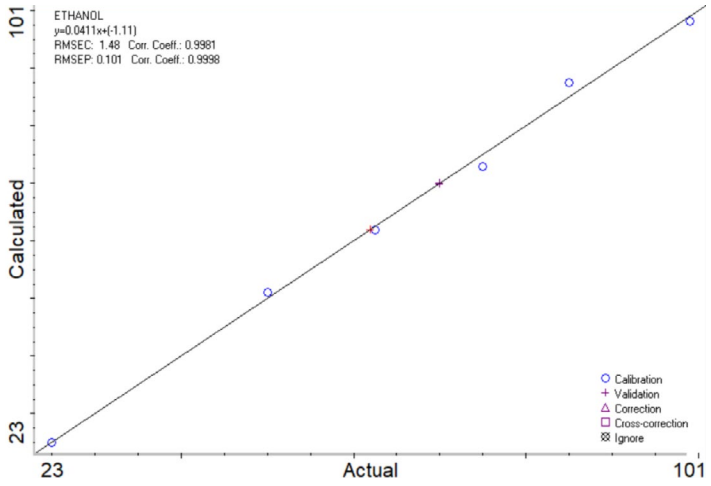
In addition to incoming material inspection, FTIR can be used for the quantitative determination of alcohol percentage in hand sanitizers. FTIR measurements of a series of ethanol/water standards with ethanol ranging from 25-99% (v/v) were carried out. The area of the peak at 878 cm^{-1} was used to construct a calibration curve using Simple Beer's Law in Thermo Scientific™ TQ Analyst™ Software (Figure 4). The calibration curve exhibits an excellent linearity with a coefficient of 0.9981. The calibration was then applied to four commercially available hand sanitizer samples to predict ethanol percentage of those products, and the results are summarized in Table 1. The predicted ethanol percentage shows superb agreement with the label claim, with deviation from expected values ranging from 0.016% to 0.28%.

To summarize, ATR FTIR measurements are straightforward with no need for sample preparation. QCheck and QC Compare allows for a rapid quality check of materials, enhancing the confidence on materials quality at different stages of the production cycle. The quantitative analysis enabled by TQ Analyst allows for accurate predictions of the alcohol content in final formulations. Thermo Scientific Nicolet iS50 FTIR Spectrometer equipped with a built-in diamond ATR, in combination with QCheck, QC Compare and TQ Analyst in the OMNIC software suite, is ideally suited for the quality assurance and control of the alcohol-based hand sanitizer products.

Sample	Predicted Ethanol%	Label	Error%
Commercial sample 1	61.99	62	0.016
Commercial sample 2	61.99	62	0.016
Commercial sample 3	69.80	70	0.28
Commercial sample 4	70.04	70	0.05

Table 1. Predicted ethanol percentage vs. label claim of four commercial hand sanitizer products.



Calibration Results Table

Index	Spectrum Title	Usage	Actual	Calculated	Measurement	Diff. x Path
1	99_ETOH	Calibration	99.00	98.15	2.9263	-0.85
2	85_ETOH	Calibration	85.00	87.56	2.4914	2.56
3	75_ETOH	Calibration	75.00	72.89	1.8888	-2.11
4	62.5_ETOH	Calibration	62.50	61.85	1.4352	-0.65
5	50_ETOH	Calibration	50.00	51.03	0.9907	1.03
6	25_ETOH	Calibration	25.00	25.02	-0.0775	0.02
7	Commercial sample 1	Validation	62.00	61.99	1.4411	-0.01
8	Commercial sample 3	Validation	70.00	69.80	1.7619	-0.20
9	commercial sample 4	Validation	70.00	70.04	1.7717	0.04
10	Commercial sample 2	Validation	62.00	61.99	1.4411	-0.01

Figure 4: Calibration result of ethanol% measurements.

References

1. J. M. Boyce and D. Pittet, Guideline for Hand Hygiene in Health-Care Settings, Morb. Mortal. Wkly. Rep. 51:1-45, 2002
2. Kampf G, Kramer A. Epidemiologic background of hand hygiene and evaluation of the most important agents for scrubs and rubs. Clin Microbiol Rev. 2004 Oct;17(4):863-93.
3. Policy for Temporary Compounding of Certain Alcohol-Based Hand Sanitizer Products During the Public Health Emergency, Immediately in Effect Guidance for Industry, https://www.fda.gov/media/136118/download
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5. Guide to Local Production: WHO-recommended Handrub Formulations https://www.who.int/gpsc/5may/Guide_to_Local_Production.pdf

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