The application of a handheld Raman spectrometer for the classification of synthetic- and petroleum-based hydrocarbon fluids

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INTRODUCTION

Handheld Raman spectrometers offer a rapid and field-deployable platform for chemical tests of physical evidence. In the case of testing pure chemicals, identification can be achieved by comparing unknown and known spectra. In the case of mixture analysis, the chemical signatures of major components may be detected. In this work, we investigated the capability of Raman spectroscopy for hydrocarbon fluid sample classification. Hydrocarbon fluids are common in our daily lives. They are used for heating, cooking, drying, transportation, and as engine fuel[1]. These fluids can be made using petroleum- or synthetic-based manufacturing processes. While petroleum-based hydrocarbon fluids are refined, synthetic-based hydrocarbon fluids are manufactured by organic synthesis, enabling these products to achieve higher performance. Overall, synthetic-based hydrocarbon fluids are chemically engineered for a specific molecular composition with a more tailored and uniform chemical structure[2]. To differentiate hydrocarbon fluids with different manufacturing processes, expensive and time-consuming analyses are typically required. As an alternative, this work analyzed hydrocarbon fluids with different manufacturing processes using a handheld Raman spectrometer.

MATERIALS & METHODS

Five different aviation hydraulic fluids, three synthetic-based and two petroleum-based, were used in this study. Each hydraulic fluid was separated into 10 different aliquots of 1 mL each, resulting in a total of 50 different samples between the five hydraulic fluids. **Table 1** below contains information regarding each hydraulic fluid.

Hydraulic Fluid	Classification	Additional
MIL-PRF-87257C	Synthetic	-
MIL-PRF-87252C	Synthetic	Contains PAO additives
MIL-PRF-83282D	Synthetic	Contains PAO additives
MIL-PRF-5606H	Petroleum	Mineral oil-based
MIL-PRF-5606J	Petroleum	Mineral oil-based

Table 1. Classifications and additional information for the six hydraulic fluids used in this work.

RESULTS & DISCUSSION

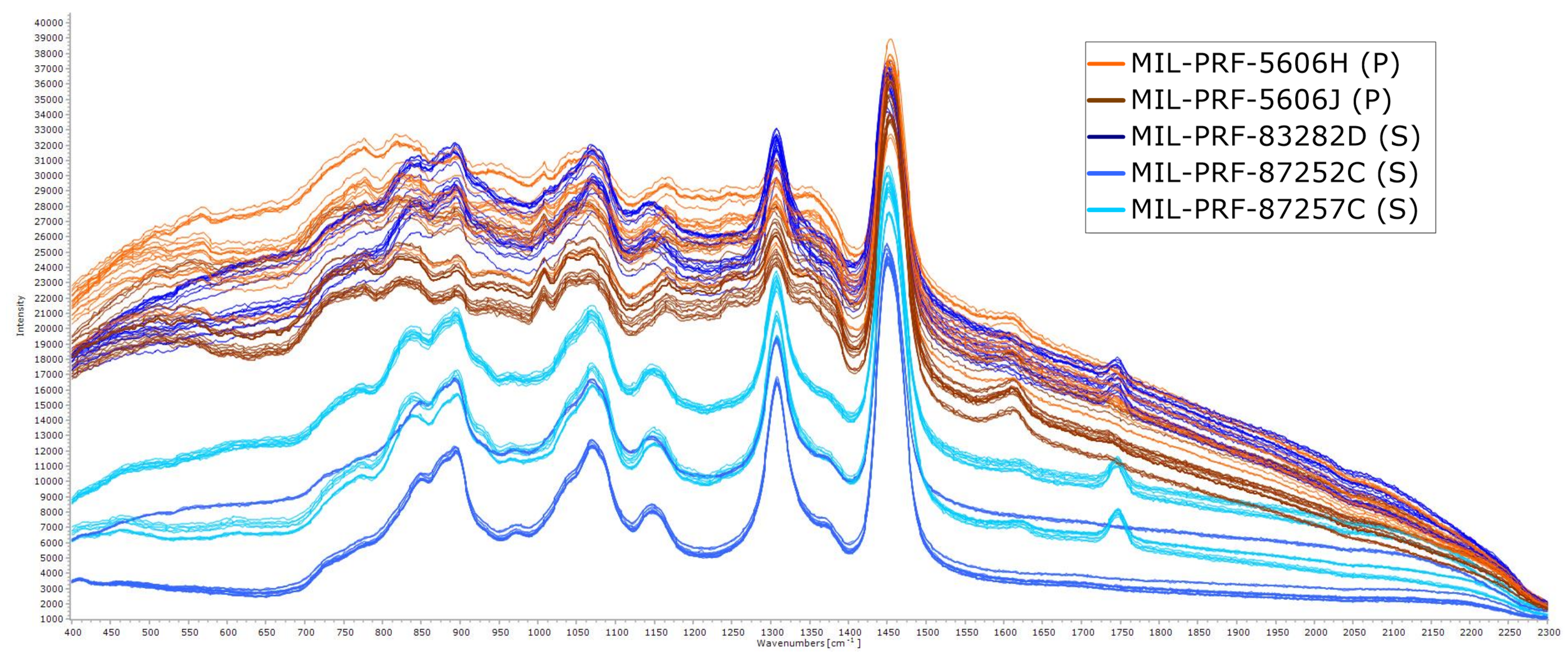

Figure 1. 20 non-baselined spectra from each hydraulic fluid.

Figure 1 above displays five raw spectra from each hydraulic fluid. The petroleum fluid spectra have a significantly higher baseline intensity throughout the graph until all the spectra approach zero intensity above 2200 cm^{-1}. Baseline intensity is not considered a characterizing feature in spectra, so it was not considered for comparison purposes in this work. Instead, peak shape differences between the spectra were identified and used for comparison. The most notable differences are summarized in **Table 2** below.

Wavenumber (cm^{-1})	Spectra difference
860 - 895	Synthetic-based fluid has a sharper minimum at 860 cm^{-1} and a larger peak at 895 cm^{-1}
1010	Petroleum-based fluid has a small peak at 1010 cm^{-1} not present in synthetic-based fluid
1070	Synthetic-based fluid has a larger, sharper peak at 1070 cm^{-1}
1150 - 1170	Synthetic fluid has an 1150 cm^{-1} peak while petroleum fluid has a smaller 1170 cm^{-1} peak
1305	Synthetic-based fluid has a significantly larger peak at 1305 cm^{-1}
1615	Petroleum-based fluid has a peak at 1615 cm^{-1} not present in synthetic-based fluid
1745	Synthetic-based fluid has a peak at 1745 cm^{-1} not present in petroleum-based fluid

Table 2. Notable observed spectral differences between the synthetic- and petroleum-based hydraulic fluid samples.

The spectral similarity between different hydraulic fluids of the same classification demonstrates this method's versatility; it is reliable beyond a single, specific hydraulic fluid product. Beyond the similarities, there are also differences within the classifications that could be used for further discrimination, which will be investigated in future work.

REFERENCES

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MATERIALS & METHODS

A handheld Raman spectrometer (HandyRam, Field Forensic Inc., St. Petersburg, FL, USA) with a 785 nm laser was employed for spectral collection. The samples were placed in 2 mL amber vials for analysis in the instrument's vial compartment. The integration time of 5.0 seconds for each spectrum was determined by the autointegration feature. Automatic baselining was not used due to the unknown method of baselining employed by the software. The spectral range was recorded from 400 to 2300 cm^{-1} at 1 cm^{-1} intervals. Spectral data acquisition was performed using the Peak software (V1.01.0068, Snowy Range Instruments, Wyoming, USA). **Figure 1** was created using Spectragryph 1.2 software. The spectra were collected across four sessions on separate days. **Figure 2** below shows each of the hydraulic fluids in clear 20 mL vials.

Figure 2. Photographs of the five hydraulic fluids.

CONCLUSIONS

The HandyRam can distinguish between synthetic- and petroleum-based hydraulic fluids. We would expect similar results from a study involving different types of hydrocarbon fluids, or a different handheld spectrometer. Handheld spectrometers are worth consideration for conducting rapid field analyses.

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