

Application Note

Keywords

- Machining
- Cutting oils
- Polycyclic aromatic hydrocarbons

Techniques

- Fluorescence
- Emission

Applications

- Environmental monitoring
- Leak detection
- Cutting oils analysis

Fluorescence of Cutting Oils

Written by Yvette Mattley, PhD

Cutting tools generate heat and friction during the machining process. To improve the speed of machining and reduce tool wear, the cutting tool is bathed with cutting fluids that cool and lubricate the tools and machined parts during use. While these cutting fluids are critical to the machining process, they can be harmful to workers and the environment. The Occupational Safety and Health Administration (OSHA) has established guidelines for exposure limits with a detection method based on the inherent fluorescence of cutting oils. In this application note, fluorescence is measured using a high sensitivity QE series spectrometer to determine if inherent fluorescence techniques are viable for detecting and identifying cutting oils.

Introduction

Without cutting oils to cool and lubricate cutting tools and machined parts, the heat and friction produced during machining would slow the machining process, increase tool wear and potentially damage the machined part. Because cutting tools are critical components of machining processes but are associated with occupational and environmental exposure concerns, a method for assessing and detecting cutting oils ensures proper performance and helps to detect leaks to avoid environmental contamination. Oils contain polycyclic aromatic hydrocarbons (PAHs) that have inherent fluorescence, with emission spectra and optimal excitation and emission wavelengths dependent on the chemical composition of the oil. The OSHA method for detecting oil mist in workplace atmospheres is based on the inherent fluorescence properties of cutting oils.



In this application note, fluorescence spectra were measured for five samples of typical cutting oils using a QE series high sensitivity spectrometer and a pulsed xenon light source for excitation. The measurements were done to characterize the excitation and emission characteristics for the cutting oils and to determine if the cutting oils could be detected and identified based on their inherent fluorescence properties.

Measurement Conditions

All measurements were performed using a QE65 Pro spectrometer (grating HC1, 200 μm slit, 350-1100 nm wavelength range with ~ 6.4 nm FWHM optical resolution), MonoScan2000 scanning monochromator (300-700 nm), PX-2 pulsed xenon light source, CUV-ALL-UV 4-way cuvette holder and 1 cm quartz cuvettes (CVFL-Q-10). The MonoScan2000 was used to filter the broadband PX-2 light source to provide narrow bands of excitation energy (~ 4.0 nm FWHM) across the range from 300-700 nm. The monochromator was tuned to multiple wavelength bands across the range from 300-700 nm and fluorescence emission was measured to determine the optimal wavelength for fluorescence excitation of each sample. The CUV-ALL-UV 4-way cuvette holder was used to measure the samples in 1 cm quartz cuvettes containing 3.5 mL of each sample. The illumination and detection fibers were arranged at 90° to avoid detection of the excitation energy, and two mirrored screw plugs (74-MSP) were added to the cuvette holder to increase the sensitivity of the measurement. All measurements utilized the same acquisition parameters of 4 second integration time, continuous strobe setting of 4 milliseconds, 1 scan to average and 0 boxcar smoothing. The setup used for the measurements is shown in Figure 1.

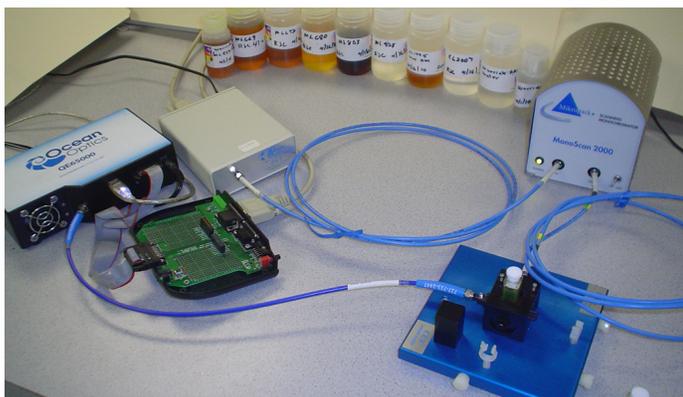


Figure 1: A spectrometer modular setup was used to determine the feasibility of inherent fluorescence properties for identifying cutting oils.

Results

The fluorescence spectra measured for the cutting oil samples are shown in Figure 2. All the spectra show differences in their inherent fluorescence response. These spectral differences are related to differences in the chemical composition of the cutting oils.

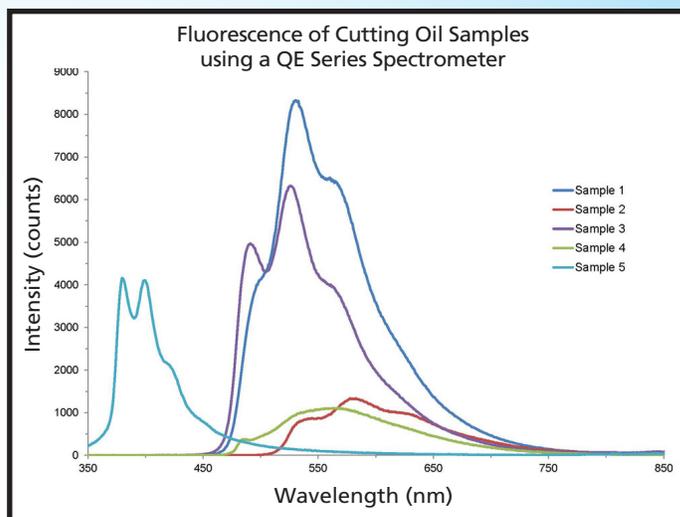


Figure 2: Differences in the chemical composition of cutting oil samples are demonstrated using fluorescence techniques.

Table 1 summarizes the fluorescence characteristics for the cutting oil samples. The optimal excitation wavelength was determined by scanning the monochromator across the wavelength range from 300-700 nm until the highest fluorescence emission was achieved. The unique fluorescence spectra -- along with the differences in excitation wavelengths, emission wavelengths and fluorescence intensities -- could be used to detect the various cutting oil samples and distinguish them from each other. This ability to differentiate the cutting oils by their fluorescence properties could be used to identify the source of a leak or environmental contamination.

Sample	Excitation Wavelength (nm)	Emission Wavelength (nm)	Maximum Intensity (counts)
1	487	527	6319
2	531	577	1332
3	487	531	8319
4	487	566	1104
5	351	380	4141

As shown in the table, three of the samples (Samples 1, 3 and 4) had maximum emission with 487 nm excitation while the other samples (Samples 2 and 5) required different excitation wavelengths for maximum emission (531 and 351 nm, respectively). Note that even in the case of the samples with the same excitation wavelength, the spectral features are different enough to enable the samples to be discriminated from each other.

Conclusion

An Ocean Optics modular fluorescence setup including a high sensitivity QE series spectrometer and pulsed xenon source were used to measure the inherent fluorescence spectra for five different cutting oil samples. Each of the samples had unique fluorescence properties related to their chemical composition that would enable the cutting oil samples to be identified and distinguished. These spectral differences also could be used to identify a cutting oil leak and determine the source of workplace or environmental contamination. With the availability of modular spectroscopy components such as described in this application note, the instrumentation could be taken to the site of the leak or environmental contamination, thus saving precious time and enabling more thorough characterization of the extent of the contamination. 🔄

References

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OSHA fluorescence method for detecting cutting oils can be found at www.osha.gov/dts/sltc/methods/partial/id128/id128.html

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