Field Raman Spectrograph for Environmental Analysis

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Abstract

This project entails the development of a compact Raman spectrograph for field measurement applications at hazardous waste sites. The Raman instrument provides rapid, on-site, *in situ* analysis, and can improve the quality, reduce the costs, and enhance the safety of characterization and monitoring activities. Analytical advantages of the Raman technique include its ability to produce a unique, spectral "fingerprint" for each contaminant and its ability to analyze samples such as solids, liquids, and sludges directly, without the need for isolation or cleanup.

The EIC Raman spectrograph is unique in its optical configuration and, with no moving parts, is well suited for field work. Key components in the spectrograph are cross-dispersing prisms and an echelle grating which disperse the Raman spectrum from a sample in two-dimensions onto a CCD detector array. This allows a full Raman spectrum to be collected without repositioning the grating and with high resolution (better than 1 cm^{-1}). No other spectrograph provides this powerful combination of high resolution and wide spectral range. The echelle spectrograph is also very efficient, generally providing detectability to sub-percent concentrations. This level of sensitivity is especially suited for *in situ* identification and monitoring of major components in waste mixtures found in tanks or drums.

Another important component of a Raman system is the laser source. The echelle spectrograph assembled in this project is designed to be used with near-IR laser sources. The advantage of this approach is that for many samples interference from fluorescence is reduced in the near-IR. Several new, high-power lasers have been evaluated as part of this program. A wavelength-stabilized diode laser from Spectra Diode Labs has proven to be the best laser for our instrument in terms of optical power (300mW), wavelength stability, portability (the laser is the size of a shoebox), and low electrical power requirement.

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Thirdly, a series of fiber-optic probes have been developed for use with the Raman spectrograph in specific field applications. These probes are much smaller than commercially available probes and

utilize microfilters to provide "clean" spectra over long fiber lengths. We are currently testing these probes under radiation conditions in anticipation of future deployment in high-level waste tanks such as those found at Hanford and Savannah River. We have also conducted tests at Oak Ridge National Laboratory on real samples collected from waste tanks there, demonstrating capability for detecting key analytes such as nitrate and nitrite.

Finally, a collection of 200 Raman spectra for important DOE (and EPA) contaminants has been compiled and will serve as a valuable resource for environmental Raman spectroscopists.

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