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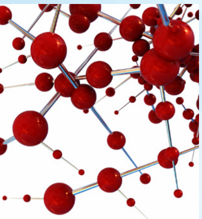

MacroRAM: Remote Raman Measurements Using an External Probe

RA-TN06

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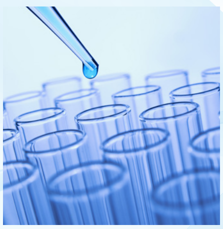

Perform remote macroscopic measurements from bulky objects and samples within large containers

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Abstract

Raman spectroscopy is a commonly used technique to study the chemical composition of materials. The sampling for a Raman measurement can be guided in a number of ways such that materials from macroscopic to nanometric scales can be studied. In this note, the ability to perform macroscopic measurements remotely, i.e. external to the spectrometer, from bulky objects and samples within large containers, is demonstrated using an external handheld probe.

Keywords

Raman spectroscopy, remote sampling, fiber probe, MacroRAM

Introduction

Raman spectroscopic measurements can be made from a wide range of samples using a number of sampling methods. For example, the spectrometer can be coupled with an optical microscope or an Atomic Force Microscope in order to limit the sampling to microscopic or nanometric areas. The conventional method however, is to study samples macroscopically in the form of solids, liquids or gases using appropriate sampling methods.

One of the ways to collect macroscopic data is to use an external probe fiber-coupled with the spectrometer in order to conduct remote measurements, in case the samples are too large or are contained within large containers. In this technical note, the ability to make measurements using the MacroRAM Raman spectrometer external to the instrument using a fiber-coupled probe is shown.

Method

The internal sample compartment of the MacroRAM can be used to make measurements from both liquids in cuvettes and small solid samples. Alternatively, an external probe can be fiber-coupled to it for remote measurements of bulky samples. In this work, Raman spectra were measured using a SuperHead fiber-coupled to the MacroRAM. The SuperHead uses FC/PC terminated fibers for delivering 785 nm laser excitation and for signal collection. High efficiency filters incorporated within the probe provide effective laser and Raman filtering.

Results

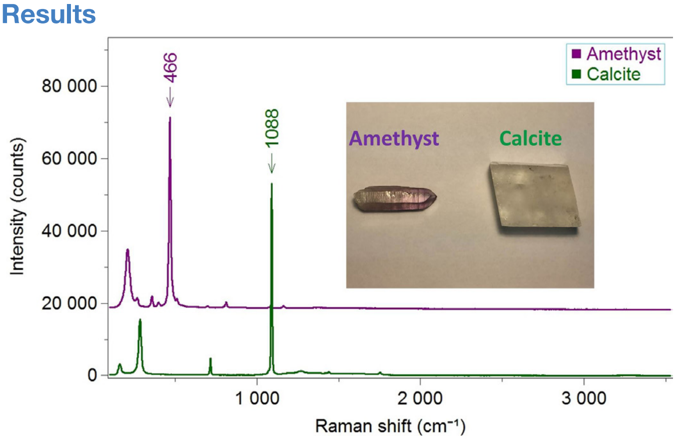

Figure 1: Raman spectra of amethyst and calcite crystals.

In this work, objects that were somewhat bulky, and inappropriate for the sampling chamber were chosen. Measurements were made external to the sample compartment. Typical measurement times ranged from 2 to 5 seconds with 2 averaged accumulations.

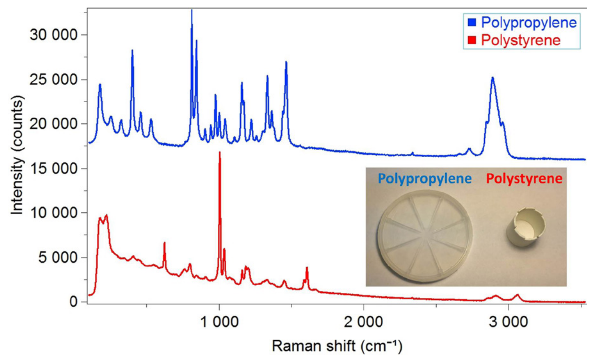

Figure 2: Raman spectra of materials containing polymers such as polypropylene and polystyrene.

Raman spectra measured from large crystals such as amethyst, which is a type of quartz, and calcite, which is composed of carbonate, are shown in Figure 1. Among other bands, strong bands at 466 cm^{-1} from amethyst and 1088 cm^{-1} from calcite were observed. Raman spectra were also measured from objects containing polymer materials, which are shown in Figure 2.

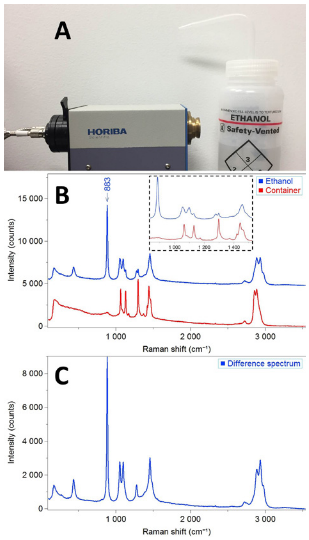

Figure 3: (A) SuperHead used to measure spectrum from ethanol directly in its container. (B) Spectra from ethanol and the container are shown. Inset: Enlarged spectrum from ~800 – 1550 cm^{-1} range is shown, from which Raman bands of ethanol and container could be easily distinguished, especially with the help of the ~883 cm^{-1} peak from ethanol. (C) Difference spectrum obtained after substracting out the container spectrum.

The SuperHead used in this work also makes it possible to collect Raman spectra directly from materials through the exterior of large containers. Thus, there is no need to remove these materials to prepare them for measurements. For example, in an industrial setting, one can exploit such Raman measurements for routine identification of incoming materials. An example of the SuperHead used to make measurements from ethanol directly in its container is shown in Figure 3.

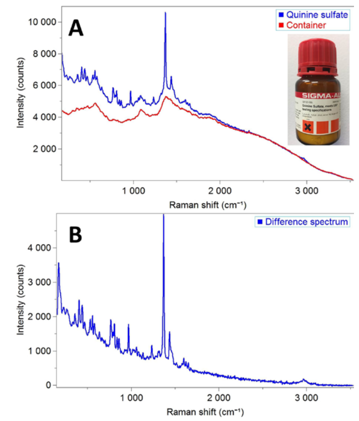

Figure 4: (A) Raman spectra of quinine sulfate and that of the container. (B) Difference spectrum obtained after subtracting out the container spectrum.

Raman spectra can be collected in this fashion from powders also, without the need for any sample preparation. An example of a Raman spectrum collected from quinine sulfate powder directly in its container is shown in Figure 4. Apart from organic solvents and chemicals, this method of remote collection of Raman spectra can also be applied to other materials that one might encounter in the industrial setting. An example of a Raman spectrum collected from baby oil is shown in Figure 5. Note that, since the laser is focused through the containers onto the samples in these measurements, contributions to the spectra from the containers are minimal, and can be subtracted.

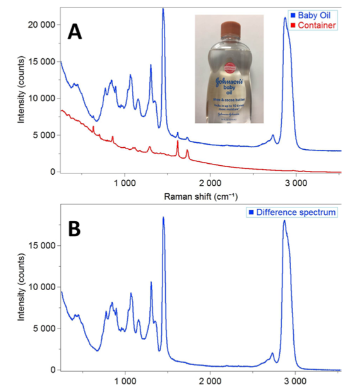

Figure 5: (A) Raman spectra of baby oil and that of the container. (B) Difference spectrum obtained after subtracting out the container spectrum.

Summary

In this technical note, the ability to perform remote Raman spectroscopic measurements using the MacroRAM with a fiber-coupled external probe is demonstrated. This sampling method is suitable for studying bulky objects, and for studying solids and liquids directly within large containers without perturbing them. In addition to remote sampling, this can also eliminate the need for extensive sample preparation.

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