

Raman Analysis of Low Concentration Ions in Water

Enwave Optronics

High sensitivity Raman analyzers could provide solutions for continuous and automated measurements of low concentration ions or molecules in aqueous solutions for applications in industries including biomedical, mining, agricultural, pharmaceutical, cleaning, and environmental. As an example for similar applications, the quantitative analysis of low concentration sulfate ion in aqueous solution down to as low as 2.5 ppm by conventional (Non-SERS) Raman is demonstrated.

Experiment

Solutions of sulfate with concentration below 100 ppm were prepared by dissolving sodium sulfate in distilled water. One ppm is defined as one milligram of SO_4 in one liter of water. An Enwave ProRaman instrument with a wavelength-stabilized 785 nm laser, a high throughput TEC-controlled CCD spectrograph, and a fiber optics probe was used for the measurements. All solutions were kept in quartz cuvette during the measurements.

Results and Discussion

Figure 1 shows the ν_1 (SO_4^{2-}) Raman peaks at $\sim 980 \text{ cm}^{-1}$ for sulfate aqueous solutions with concentrations of 2.5, 5, 10, 25, 50, and 100 ppm. The spectra are background corrected. Notably the water O-H bending mode at around 1640 cm^{-1} is very strong compared to the sulfate ν_1 peak in these solutions. The close-up view of the sulfate ν_1 peak with increasing concentration from 2.5 to 100 ppm is shown in the inset. The second inset shows the areas of the sulfate ν_1 peak scaled linearly with the concentration. The fitting parameter $R^2=0.99986$ indicates a very good correspondence in the instrument readings and the concentrations of the prepared solutions.

Conclusion

Quantitative determinations of sulfate ion concentrations down to as low as 2.5 ppm in aqueous solutions were conducted by using a high-sensitivity Raman spectrometer. Aqueous solutions of ions like nitrate, phosphate, carbonate, sulfite, nitrite, silicate, bicarbonate, and ammonium, etc, could also be analyzed to similar or lower concentrations. Quantitative analyses of these ionic species along with other molecular species to similar concentration level are important in many industrial applications.

The developments of SERS techniques in recent years gave hopes for measurements of low concentration aqueous samples with Raman spectrometers. Nevertheless, difficulties exist in the requirements of robust, continuous, and automated measurements

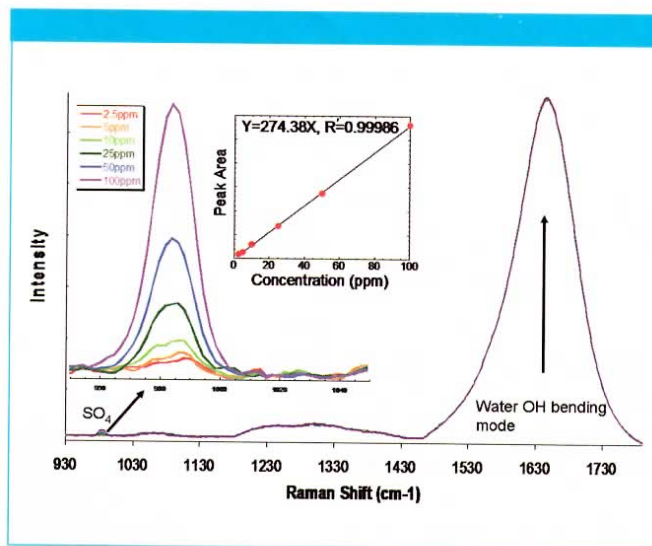


Figure 1: Raman spectra of low concentration sulfate in water.

in various industrial settings. This application note shows the possibility of analyzing low concentration ionic species in water with a state of the art conventional dispersive Raman instrument. For even lower concentration measurements, different configurations of Raman instrument, e.g. using shorter wavelength excitation lasers, could also be devised to meet the sensitivity requirements.

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