Lambda Solutions, Inc.

Raman Spectroscopy

Advantages and Applications

Raman spectroscopy has found increasing use in recent years due to the convergence of several technologies: CCD detection systems with high sensitivity in the near infrared regions, small powerful diode-based lasers, and fiber optic probes with integrated laser-and-signal filtering. These products, along with high-aperture short-focal-length spectrographs, provide quality Raman spectra with low fluorescence interference in compact, easy-to-use packages.

What is Raman Spectroscopy?

Raman spectroscopy involves the interaction of light with matter. It is a non-destructive technique based on inelastic light scattering, i.e., the energy, or the frequency, of the incident laser light is changed, or shifted. The difference between the incident and scattered frequencies corresponds to an excitation of the molecular system, most often an excitation of a vibrational mode. By measuring the intensity of the scattered light as a function of the frequency difference, we obtain a Raman spectrum, which reveals information about a sample's chemical structure and physical state. Raman spectrum is similar to an infrared spectrum (IR/NIR), though different vibrational modes are observed in these two complementary techniques.

What is a Raman Instrument?

A Raman instrument is made up of three basic components: 1) the laser to excite the sample, 2) the spectrograph which channels the light and separates the component frequencies delivered to 3) the detector that measures the energy, or intensity, of each component frequency. Many complete Raman systems also include an operating software for instrument control, data acquisition, data processing and analysis.

What are the Advantages of the Raman Technique?

Raman spectroscopy now provides quick, easy, and most importantly, non-contact and non-destructive analysis, both qualitative and quantitative, with no sample preparation required. Samples may be tested directly with fiber probes or through glass, quartz, sapphire cells, and fibers. Other advantages include:

1. Raman is ideal for the studies of biological samples and chemical compounds in aqueous solutions, as water is only a weak Raman scatterer and adds little interference.
2. Raman can cover a broad range, 50 – 4000 cm^{-1}, in a single recording, which allows for characterization of both organic and inorganic compounds. In contrast, gratings, beam splitters, filters, and detectors must be changed to cover the same range by IR.
3. Raman spectra are cleaner and sharper, and thus are more amenable to quantitative studies such as quantification of isolated Raman bands as well as qualitative studies such as database searching.
4. As the diameter of the laser beam at its focal point is normally 0.2 – 2 mm, Raman spectra can be obtained with only a small quantity of sample. This is a great advantage over conventional IR. Furthermore, Raman microscope objectives can focus the laser beam down to 20 μm or even smaller, thus distinct small sample areas can be analyzed.

5. Resonance Raman effects can be used to selectively enhance vibrations of a particular group in large biological molecules, where the intensities of Raman signals originating in this chromophore can be selectively enhanced by a factor of 10^3 to 10^5.

What are the Applications of Raman Spectroscopy?

Raman spectroscopy has increasingly significant applications in a variety of industrial and academic fields, and has experienced dramatic growth in new disciplines.

1. *Chemical Systems*
   e.g., identification, analysis, and characterization of organics, inorganics, including solvents, petrochemicals, carbon materials and films.

2. *Chemical Processes*
   e.g., following polymer formulations and polymerization processes, measuring/quantification of multiple components in a mixture (including solvent mixture and aqueous solutions) in real time, identification of organic contaminants, following immediate and final product of a hydrogenation reaction, predicting the morphological properties of polymers.

3. *Polymers and Plastics*
   e.g., quality control of incoming/outgoing products, identification of contaminants during manufacturing, real time monitoring of polymerization reactions, multivariate analysis/Chemometrics to predict physical properties such as birefringence, crystallinity, glass transition temperature, crystallization temperature etc.

4. *Pharmaceuticals*
   e.g., identification and analysis of drug constituents, critical additives, excipients, drugs of abuse, quality control of the purity and quality of pharmaceuticals.

5. *Biological and Medical Systems*
   e.g., measuring the concentrations of total protein and biological analytes in blood and serum, determining metabolic concentrations, measuring blood and tissue oxygenation, molecular-level cancer (cervical, lung, etc.) and cardiovascular disease (such as atherosclerosis) diagnosis.

6. *Food Products*
   e.g., measuring the fatty acid unsaturation in food oils, detecting bacteria/contaminants in food products, identification of additive drugs in nutraceuticals and fruit drinks.

7. *Forensic applications*
   e.g., identification and analysis of explosives, inflammables, toxic solvents, additive drugs, drugs of abuse, bio-warfare agents, and inks from documents.

8. *Materials, Semiconductors, Gemological, Geological, Archaeological*, *and Environmental Sciences, etc.*

Who Can Own a Raman Instrument?

The major technological advances in Raman spectroscopy and the proprietary optical and software design of Lambda Solutions' high efficiency, compact, easy-to-use Raman systems means that not only research centers, but *YOU* can own one!