2007 TAIWAN INTERNATIONAL SCIENCE FAIR

CATEGORY : Physics

PROJECT : Development of an Inexpensive Raman System and a Littrow Spectrograph

AWARDS : Physics First Award

SCHOOL : Westmoore High School

FINALISTS : Mary Masterman

COUNTRY : United Statese

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Title: Development of an Inexpensive Raman System and a Littrow Spectrograph
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Country: United States of America

Abstract

a. Purpose

The purpose of this project was to construct a relatively inexpensive Raman system and examine the feasibility of identification of compounds and their concentrations. A low-resolution, classical spectrograph was constructed in 2003 and initially used for the project. It had a resolution of 700, with a spectral range of about 2000 &#65533;. When molecules interact with incident radiation, most of the radiation is scattered elastically (Rayleigh scattering). However, certain molecules channel some of the incident radiation into vibrational modes, resulting in the scattering of a small part of the radiation (on the order of 10-7) at different, longer wavelengths (this is called Stokes Raman scattering). Since Raman spectra are unique, they provide a sort of chemical fingerprint for unknown compounds.

b. Procedures

A Raman head was built using the previously constructed classical spectrograph to gather and analyze the Raman scattering. The Raman head used a green 5320 &#65533;, 5 mW laser. The light was then purified by a laser-line excitation filter and directed onto the sample with a dichroic mirror. The collected Raman scattering was collected with a microscope lens. A low-pass barrier filter was used to remove of most of the laser light, after which a 50 mm camera lens was used to focus the radiation onto the spectrograph slit. A procedure for alignment of the optics was developed, with some difficulty. After many tests and modifications, a successful configuration was discovered; it used a 48 mm focal length microscope objective to focus laser light to the sample and gather the backscattering.

A Littrow configuration spectrograph (a spectrograph with only > > one collimation / camera lens) to replace the low-resolution

> > spectrograph was then constructed. Housing for the spectrograph,
> > including the slit and a diagonal directing light to the grating, as
> > well as a grating holder, were constructed using aluminum tubing.
> > The grating could be flipped between 0th and 1st order. The 0th
> > order configuration, which does not disperse the spectrum, was used
> > as a conventional microscope to line up the sample. The 1st order
> > configuration, with the spectrum dispersed, enabled imaging the
> > spectrum.
> >
> > c. Data
> >
> > First tests of the Littrow Spectrograph were done
> > astronomically to verify spectrograph performance. Raman spectra of
> > several Raman-active household solvents, including acetone and
> > toluene, were successfully observed with excellent correlation to
> > published wavenumbers. Teflon, diamond, and other household
> > materials were also analyzed.
> >
> > d. Conclusions
> >
> > The Littrow spectrograph's resolution with a 1200 l/mm grating
> > was about 8000, with an 800 &#65533; spectral range. The Raman
> > system and its Littrow spectrograph were successfully constructed,
> > aligned, and tested for a relatively low cost. It was much more
> > difficult to align the systems than anticipated. The 532 nm laser
> > caused florescence that masked resonances in some samples, including
> > alcohol and commercial gasoline.

評語

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