Specialists in Spectroscopy
Optical Spectroscopy Division

APPLICATION NOTE # 102 TRIBOLUMINESCENCE

Introduction:

Triboluminescence is emission of light triggered by mechanical energy from friction or, more commonly, fracture. The exact reasons why particular materials show triboluminescence can vary for different materials, but it is probable that crystal structure and impurities are primary determinants of whether or not a material is triboluminescent. The most commonly known triboluminescent materials are wintergreen candies and quartz. Other minerals, such as calcite and mica, are known to exhibit triboluminescence when struck or rubbed. Using triboluminescent compounds that glow when struck, researchers are trying to make impact damage in composites easier to detect.

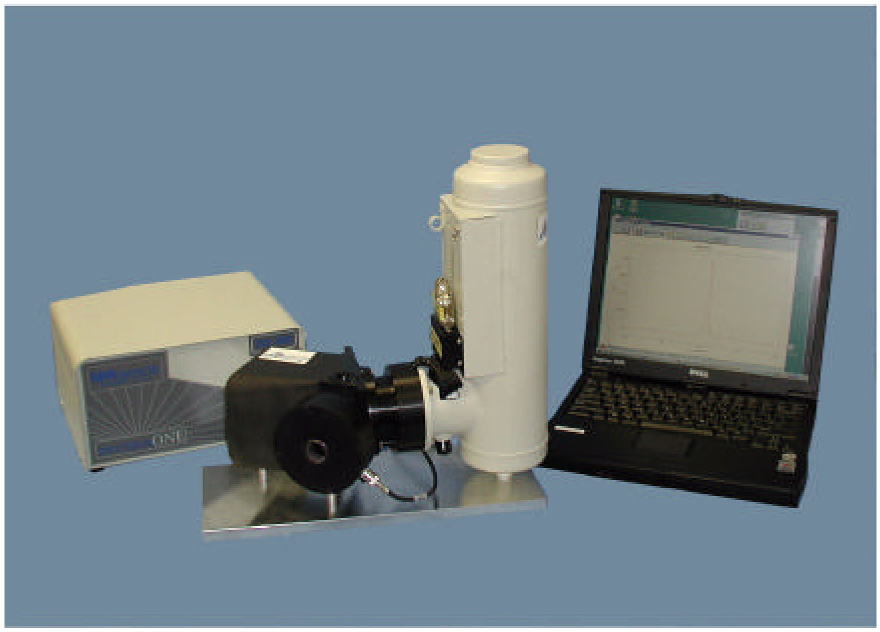
Experiment:

Samples were placed into a glass test tube and ground with a glass rod at the beginning of acquisition to create triboluminescence. The test tube with the sample was placed in front of the spectrograph with a 2 nm bandpass. The system was based on a CP 140-104 fixed Imaging Spectrograph equipped with a high-efficiency concave holographic grating, optimized for 200 – 850 nm. This spectrograph focuses diffracted light onto the focal plane of an array detector.

A LN_2-cooled Spectrum One CCD detector with a back-illuminated 1024 x 256 array was used with a high sensitivity, low noise 16-bit acquisition controller. Liquid nitrogen cooling (140 K) effectively eliminates dark noise contributions and allows integration on time scales for several hours.

Integration of these components together as a complete spectroscopy system to maximum signal throughput and minimize noise effects results in a fully-optimized system for detecting weak triboluminescent signals.

Experimental Setup:



CP140 equipped with a back-illuminated CCD detector

Features	Benefits
High Throughput	Improves Signal-to-Noise Ratio
Back Illuminated Detector	Relatively flat response in UV-Vis regions
High Quantum Efficiency	Detects Extremely Weak Signals
Low Read & Dark Noise	Long Signal Integration Times

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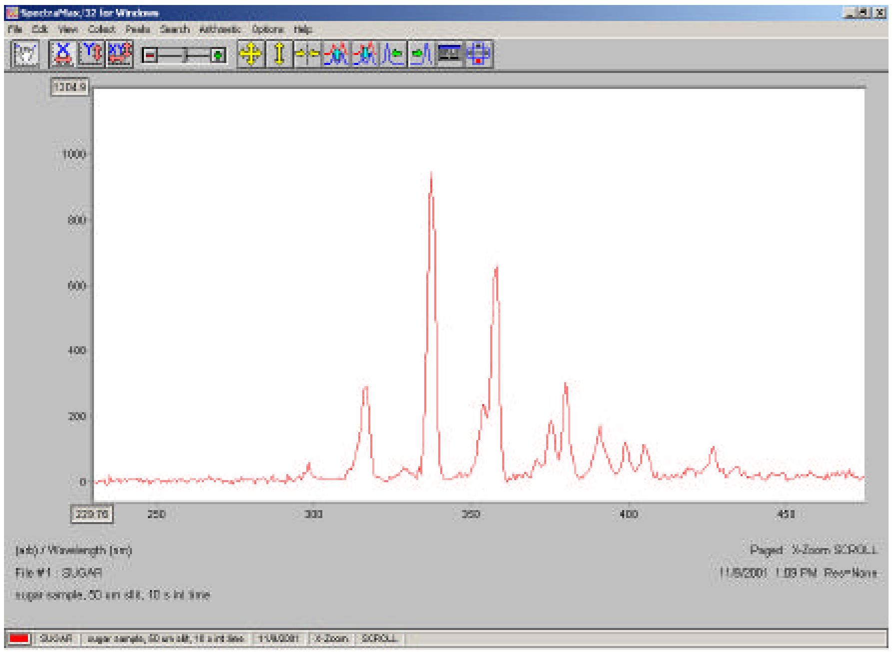
Results:

The emission spectrum produced by the triboluminescence of sugar is essentially the same as the spectrum of lightning (See spectrum). Lightning originates from electrons passing through air under the influence of an electric field, which excites the nitrogen molecules, and causes the emission of the UV and blue light between 295 and 450 nm on relaxation. When a piezoelectric sugar crystal is stressed, positive and negative charges are separated, generating an electric field.

If enough charge has accumulated, the electrons jump across a fracture in the crystal, colliding with and exciting electrons in the nitrogen (the primary component of air).

FWHM resolution of the 1-0 and 0-0 transitions of nitrogen at 318 nm and 337 nm was about 2 nm. The 0-1 and 1-2 transitions at 354 and 358 nm were resolved.

In past experiments, spectra similar in sensitivity were obtained with a photodiode array detector (PDA) with acquisition time of 50 seconds. Incorporating new developments in detector technology such as a CCD detector, led to a factor of five increase in S/N and a subsequent decrease in acquisition times. Using a Back-illuminated CCD takes advantage of their higher quantum efficiency (90% at 650 nm) to detect more signal when compared to front illuminated. Antireflection coatings are further used to optimize the detector's response in UV and NIR regions.



Conclusion:

CP 140-based compact and cost-effective spectrograph coupling with Jobin Yvon Back Illuminated CCD detector was successfully used for the collection of very weak triboluminescence spectra. The demonstrated. Triboluminescence system was developed from standard Jobin Yvon components and optimized for maximum performance.

Acknowledgements:

The experimental work was conducted by Dr. Linda Sweeting of Towson University, MD.

References:

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Sweeting, L.M. In *Spectroscopic Characterization of Minerals and Their Surfaces*; Coyne, L.M., McKeever, S.W.S., Blake, D.F., Eds.; Am. Chem. Soc.: Washington, DC, **1990**; 415, 247 – 260.

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