Performance Comparison for Tri-Glycine Sulfate and Lithium Tantalate Detectors

Bonnie Leimer, Nicolet Spectroscopy Research Center, Madison, WI, 53711, USA

INTRODUCTION

Most mid infrared analysis is accomplished with a tri-glycine sulfate (TGS) detector. This detector remains the detector of choice due to its excellent linearity, ease of use, and good sensitivity. The Lithium Tantalate ($LiTaO_3$) detector provides the same ease of use and linearity with only a slight decrease in sensitivity.

$LiTaO_3$ and TGS detectors take advantage of the pyroelectric effect. When infrared radiation reaches the detector crystal there is a change in temperature. This temperature change in turn causes polarization to occur, which is detected as current. The magnitude of the current is dependent on the size and type of the crystal.

For routine IR sampling, such as thin films and pellets, the detector chosen is not critical. Either detector works well if the analysis does not limit the light reaching the detector by a significant amount. However, the TGS detector will provide superior data in all cases. This note will describe the performance differences between the TGS and $LiTaO_3$ detectors.

EXPERIMENTAL

An Impact™420 spectrometer equipped with a KBr beamsplitter, and either $LiTaO_3$ or TGS detectors was used for all measurements. All spectra were collected at 4 cm^{-1} resolution. Numbers of scans differ for each experiment and are noted with the spectral figures.

100% LINE COMPARISONS

No comparison would be complete without a 100% line. It evaluates many characteristics of an FT-IR instrument including; sensitivity, stability, and electronics. The sensitivity of the two detectors will be explored by comparing the peak-to-peak noise found in the 100% lines.

Figure 1 shows open beam 100% lines for the two detectors. This figure shows the spectra over a wide spectral region as well as a more selective region where the noise is calculated. The TGS detector has visibly less noise over the entire spectrum. The ratio of signal-to-noise ratios (SNR) for the two detectors was calculated to be 3.2. In other words, the TGS is 3 times more sensitive to infrared signal than the $LiTaO_3$. Both spectra were collected using 72 scans at a mirror velocity of 0.63 cm/sec.

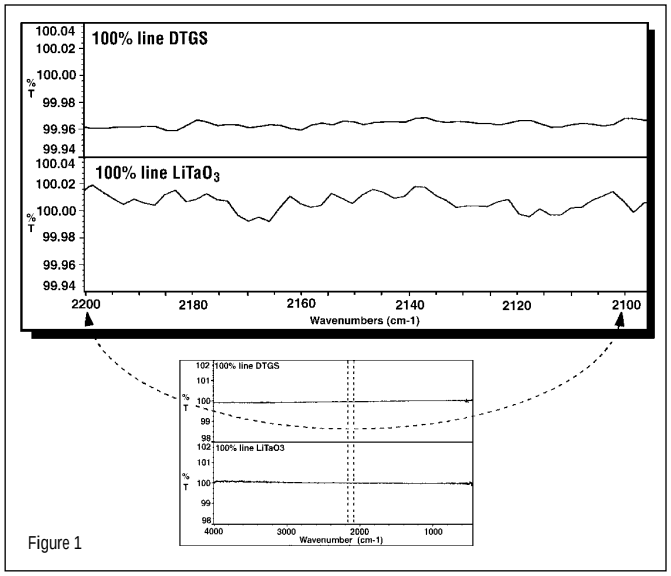

Figure 1

A set of neutral density filters (1, 3, 10, and 30%) was then used to block the signal reaching the detector during background and sample collection. The filters were placed into the focused beam of the sample compartment and provide a highly reproducible means of simulating light limiting sampling accessories in the FT-IR. Spectra were collected using 64 scans. A plot of the ratio of SNR Vs. the percentage of throughput allowed can be seen in figure 2.

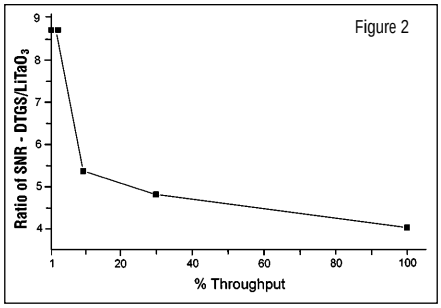

Figure 2

From this plot the TGS detector is roughly 4.5 times* more sensitive for most samples until there is less than 10% throughput. Below 10% throughput TGS becomes increasingly more sensitive than $LiTaO_3$.

SAMPLE COMPARISONS

The set of screens showed that as the signal reaching the detector decreases, the gap in performance of the two detectors increases. TGS becomes increasingly more sensitive when compared to $LiTaO_3$.

To verify these results, three sampling techniques will be evaluated using each of the detectors. The sampling techniques that are discussed include thin films, attenuated total reflectance (ATR), and diffuse reflectance (DRIFTS).

The first technique, thin films, involves high energy throughput. Figure 3 shows a 3.0 mil (75 micron) matted polystyrene film measured with 36 scans for each of the detectors. This film allows approximately 75% of the total energy through to the detector. A factor of 4 difference is expected based on the data in figure 2; however, differences are not apparent at this scale. The 3.0 mil polystyrene is commonly used to check the linearity of a spectrometer. Comparison of the six polystyrene "zeros" shows LiTaO3 matches the linearity of the TGS detector. For more information on this test see Nicolet TN 8931, *The 100% Line and You.*

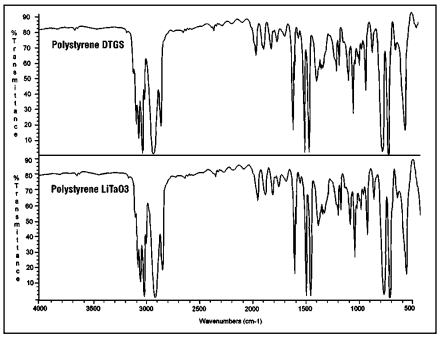

Figure 3

Acetophenone sampled on a single bounce horizontal ATR cell can be seen in figure 4. Both spectra were collected using 64 scans at a mirror velocity of 0.63 cm/sec. The throughput of this HATR is about 40%. The two spectra show no apparent difference at this scaling.

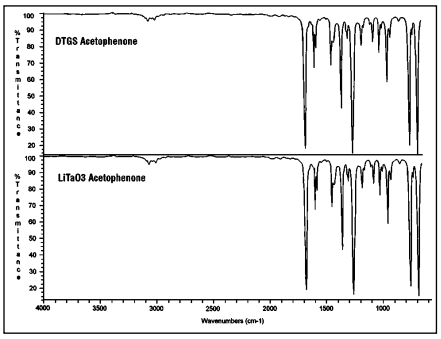

Figure 4

Differences in the baseline noise become more prevalent with the diffuse reflectance accessory. This accessory simplifies sample analysis of powders considerably. However, energy throughput will vary from 7-20% using KBr powder diluent. Figure 5 shows the spectra of 1% caffeine in KBr using the DRIFTS accessory. These spectra were collected using 36 scans. Baseline noise is readily apparent in the spectrum from the $LiTaO_3$ detector, but not in the TGS spectrum.

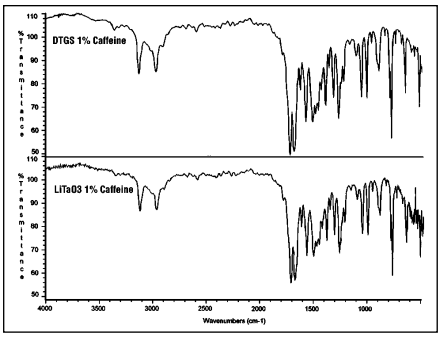

Figure 5

CONCLUSIONS

In all spectral measurements the TGS has a higher SNR than the $LiTaO_3$ detector. The detector you choose depends upon the application and time requirements for the measurement. When sampling throughput is lower than 10% the TGS detector is recommended. $LiTaO_3$ is a good choice for samples with strong absorbances and high energy throughput. For experiments involving small absorbances a TGS detector will be necessary to avoid losing information in the baseline noise.

** This number differs from the number stated previously. The difference is due to a change in the number of background and sample scans.*

Nicolet Instrument Corporation

5225 Verona Road • Madison, WI 53711-4495 • U.S.A. • TEL: 800-232-1472, 608-276-6100 • FAX: 608-273-5046 • E-MAIL: nicinfo@nicolet.com