

## Infrared Spectroscopy



## Using a Lithium Tantalate Detector in a High Performance FT-IR Spectrometer

### Summary

The detector is a vital element in determining the signal-to-noise performance of a well-optimized FT-IR spectrometer. Today, most FT-IR systems use deuterated triglycine sulphate (DTGS) detectors as standard.

However, the high performance levels of today's

PerkinElmer® FT-IR instruments means that a lower cost, highly robust alternative device can be used which fully satisfies the requirements of most routine FT-IR applications. Lithium tantalate detectors offer this alternative. This note describes the performance levels that can now be achieved with routine samples using this optional detector.

### Introduction

The performance of FT-IR instruments has been consistently improved over the last decade and is at a very high level today. One of the most important performance parameters for FT-IR instruments is the signal-to-noise (S/N) ratio. There are instruments today that easily achieve a peak-to-peak S/N ratio of 10 000:1 with a single scan. This means that even the most challenging samples generally require only a few seconds to get a spectrum with excellent S/N. Thanks to further improvements with the sampling accessories, high S/N can now be obtained with sampling techniques that reduce the overall throughput of the FT-IR beam. In light of this, the question arises whether an instrument with a lower cost detector option and slightly lower performance might still be adequate for most routine applications.

## Benefits of the lithium tantalate detector

All of the components in an FT-IR instrument influence its performance. The detector is particularly important. Most FT-IR instruments use a deuterated triglycine sulphate (DTGS) detector as standard. It is a thermal detector, which acts as a pyroelectric bolometer. When the modulated radiation from the instrument reaches the detector, its electrical polarizability is changed resulting in a voltage, which is measured as the detector signal.

The lithium tantalate detector ( $\text{LiTaO}_3$ ) is an alternative pyroelectric detector, which is at least as good as the DTGS detector with regard to spectral range, responsiveness, and linearity. Advantages with the  $\text{LiTaO}_3$  detector include the lower manufacturing cost of the crystal material compared to the DTGS and elimination of the need for thermostating.

Since the DTGS has a Curie point close to room temperature, its response is very sensitive to temperature changes. Thus, a DTGS detector has to be carefully Peltier-thermostatted in order to achieve best performance. The  $\text{LiTaO}_3$  detector does not need temperature control. Its associated electronics can be simpler, which further contributes to cost savings.

There is only one disadvantage of the  $\text{LiTaO}_3$  detector. It has a lower S/N performance typically by a factor of ca 2 to 4 compared to the DTGS detector. In general, use of an FT-IR instrument that has a  $\text{LiTaO}_3$  detector could be a lower cost option in cases where the ultimate instrument S/N is not required.

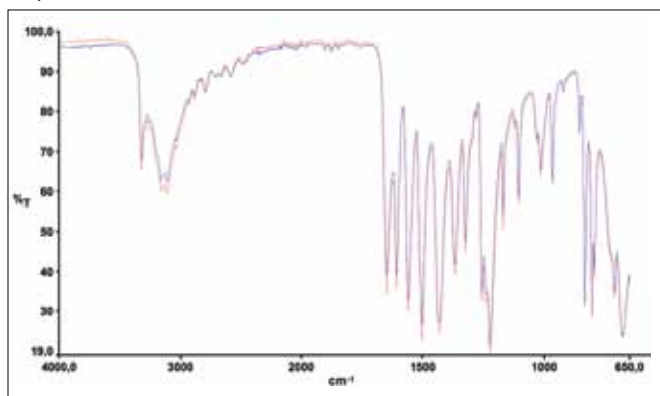


Figure 1. Phenacetin powder measured on Spectrum 100 equipped with 1 bounce UATR accessory using  $\text{LiTaO}_3$  detector (blue) or DTGS detector (red). Conditions:  $4\text{ cm}^{-1}$  resolution, 4 scans.

## Comparing the performance of a $\text{LiTaO}_3$ detector with a DTGS detector

One of the most powerful applications in mid-infrared spectroscopy these days is the Diamond ATR technique, which acquires spectra of virtually any solid or liquid sample with minimal sample preparation. Typically, the throughput with such an accessory is only 15% of the total amount of light in an FT-IR instrument. Use of this technique can show whether the reduced S/N performance of the  $\text{LiTaO}_3$  detector is still sufficient for most applications.

Figure 1 shows the results of such a comparison, where the analgesic phenacetin powder was measured with the UATR accessory on two identical Spectrum™ 100 instruments<sup>1</sup>. One was equipped with a  $\text{LiTaO}_3$  and the other with a DTGS detector. All scan conditions were the same. The spectra obtained were very similar. Small intensity differences can be observed due to minor variations in the pressures applied. The spectrum measured with the  $\text{LiTaO}_3$  detector shows a slightly higher noise level in the short wavelength range compared to the DTGS spectrum. Overall, however, this difference is negligible, and both spectra are well-suited for unambiguous identification of this material.

An even more challenging test would be to measure a micro sample on the UATR accessory.

In the spectra depicted in Figure 2, a single human hair was pressed against the diamond crystal. It is clear that due to the size of the sample, only a small fraction of the diamond surface, which, itself, is roughly  $1\text{ mm}^2$  in size, is in contact with the hair sample. Thus, a weaker total absorbance of the spectrum is expected.

In order to compensate for the lower S/N performance, 16 scans were measured with the  $\text{LiTaO}_3$  detector and 1 scan with the DTGS detector. The spectra received are comparable regarding S/N. They show that, even in such a demanding application, a  $\text{LiTaO}_3$  detector is suitable to generate spectra with excellent performance if a few seconds of additional measurement time are spent.

1. Similar data may be obtained using the PerkinElmer Frontier FT-IR or Spectrum Two FT-IR systems.

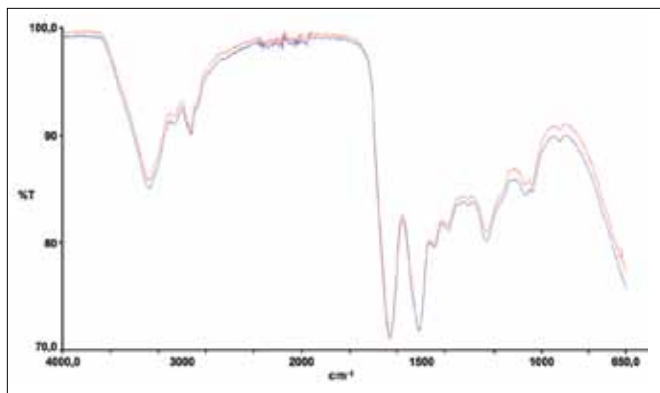


Figure 2. Single hair measured on Spectrum 100 instrument with 1 bounce UATR accessory using LiTaO<sub>3</sub> detector (blue) or DTGS detector (red). Conditions: 4 cm<sup>-1</sup> resolution, LiTaO<sub>3</sub>: 16 scans, DTGS: 1 scan).



## Conclusion

With high performance FT-IR instruments, a LiTaO<sub>3</sub> detector is a valid option and well suited for most routine applications. In cases for which ultimate performance is required, a slight increase of the total measurement time, which is often still small compared to the total analysis time, is sufficient to get spectra with excellent S/N ratio.