# APPLICATION NOTE # 104

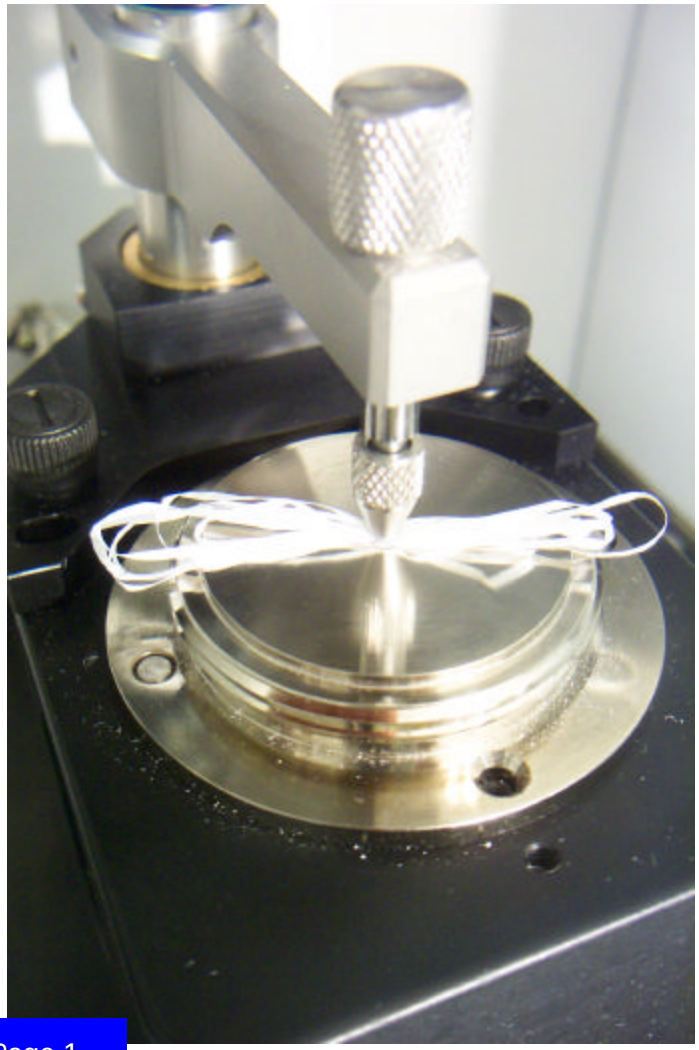
March 2004

# Measurement of Fibers with Miracle™ Single-Bounce HATR

## Introduction

Fiber samples have traditionally presented a challenge for transmission spectroscopic measurements due to the fact that they are usually too thick for the light to pass through the fiber and also for leaving uncontrolled gaps in between the fibers for the light to escape without interacting with the sample. Larger area multi-bounce ATR has poor contact with fibrous materials due to the lesser pressure that can be applied.

Single-bounce horizontal ATR, such as the PIKE MIRacle™ family[1,2], have become the most commonly used sample presentation technique in the mid-infrared. The versatility of this sampling technique for fibers is illustrated in this application article.



## Experimental Conditions

Fiber samples can be presented as ordered or disordered bundles. The fibers, such as dental floss, were wound in a small loop, twisted to provide enough material to cover the measuring crystal (Fig.1). Coverage of the available sampling surface was achieved by applying over 10,000 psi pressure on the approximately 2 mm diameter sampling area of a ZnSe MIRacle™ accessory. The PET fibers were wound around a core oriented in the same direction.

## Results

Fibers can be differentiated, identified or the fiber ratio calculated in mixed yarns. In this example we measured a wax coated dental floss (Fig. 2) and compared it to spectra of uncoated fibers. Relative to the PTFE yarn, some of the commercial samples had additional aliphatic hydrocarbon bands such as the CH stretching bands at 2919 and 2853 cm-1 which can be used for quantitative measurements.

Working with fibers, one needs to bear in mind that the unidirectional stretching during manufacture can introduce strong molecular orientation within the fibers. The interferometer and the optics can produce a partially polarized beam and the ATR electric vector signal strengths are different for the different polarization components[3,4], both effects could result in unwanted measurable spectral differences depending on how the fibers are aligned relative to the probing beam. In order to test the effect of orientation of fibers, PET fibers were wound around a one inch square cardboard holder and the fibers were pressed

**Fig.1 Fiber sample on ZnSe MIRacle™ Single-Bounce HATR**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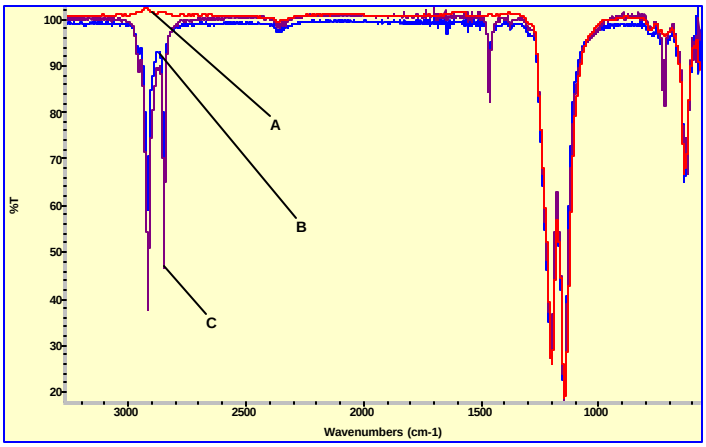


**Fig.2 PTFE yarn (A) and commercial dental floss samples (B and C) on ZnSe MIRacle™ Single-Bounce HATR**

against the ATR element in parallel with the direction of the light traveling through the accessory and perpendicular to it. The resultant difference is shown on Fig.3.

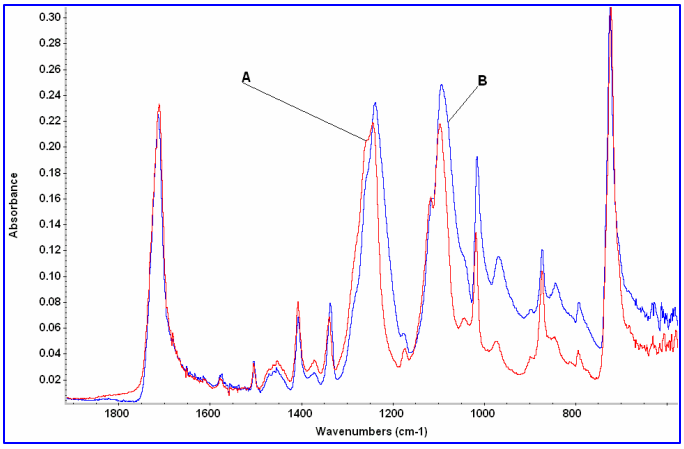


**Fig.3 PET yarn on ZnSe Single-Bounce HATR, parallel with the beam in the sample compart-**

The differences were spectrally significant, although smaller than using fully polarized light in either transmission mode or in an ATR measurement.

## Conclusions

Single-bounce ATR is a versatile technique allowing the use of different crystal materials such as silicon, germanium, AMTIR, ZnSe and diamond for both solid, paste and liquid samples. Due to the small sampling surface, very small samples can be easily measured. Temperature control of the sampling area is also easily added to the basic setup. Measurement of fibers for identification, for coating or molecular orientation is one of the practical applications of this device.

## References:

1. US Patent 5,965,889
2. US Patent 6,128,075
3. Kliger, D.S. “Polarized Light in Optics and Spectroscopy”, Academic Press,1990
4. Tim Klots, S.C.Johnson: Personal communication

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