Fiber coupled FTIR-spectroscopy for biomedical diagnostics

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Development of Mid IR fiber optics within the last decade enables biomedical applications of FTIR-spectroscopy not only for *in-vitro*, but for *in-vivo* diagnostics. While in the past fiber coupled FTIR-spectrometers were produced with LN-cooled MCT detectors, now very good S/N Ratio can be reached with room temperature DTGS-detectors. High quality Polycrystalline PIR-fibers from Silver Halide crystals and Chalcogenide As-S-glass CIR-fibers provide good throughput in optimal coupling with FTIR - making biomedical diagnostics possible using ATR absorption and reflectance spectroscopy in Mid IR - the most informative finger-print region for organic molecular vibrations.

FTIR spectrometers equipped by DTGS-detectors & coupled with ATR-fiber probes by mirror-fiber couplers installed in sample chambers.
Fig. 1. Fiber coupled FTIR from Thermo (iS5) and ABB

While all fiber optic probes reduce S/N Ratio when coupled to FTIR-spectrometers - due to an evident troubles of efficient coupling, – their spectra quality is almost the same as for a common ATR-accessories used for FTIR with DTGS detectors:

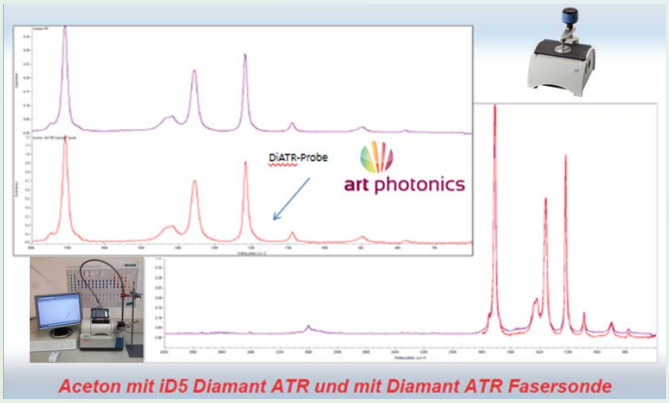


Fig. 2. Example of Acetone spectra measured with iS5 FTIR from Thermo equipped with standard ATR-accessories and 1,5m long PIR-fiber ATR-Probe

At the 1st stage fiber coupled FTIR-spectrometers should be used for intensive studies of tissue or bioliquid in a broad spectral range to detect specific changes related to the disease, but these changes are already known for the set of few wavelengths (signal & reference) – then small and low cost fiber sensors can be developed for specific diagnostics.

Fig.3. Fabry-Perot Spectral Engine from VTT vs iS5

ATR-Probes

ATR-Absorption Spectroscopy with detachable PIR-fiber loops enable molecular analysis of liquids and tissue in-vivo, in real-time, including endoscopic applications, in two parts of Mid IR-range (due to use of CIR- or PIR-fibers): 6500-1700cm-1 and 3600-600cm-1.

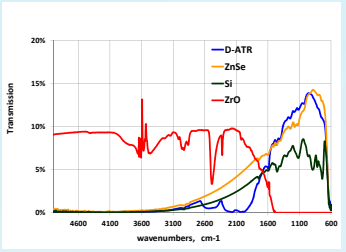


Fig. 4. Transmission spectra of different ATR-probes of 1,5m length and design of detachable single & multi-loop ATR-tips.

ATR-probes with detachable tips based on PIR-Loops (or other ATR-tips – like Silicon or Diamond-cone) enables to sterilize them and to use for diagnostics in-vivo (which is also needed for disposable PIR-loops).

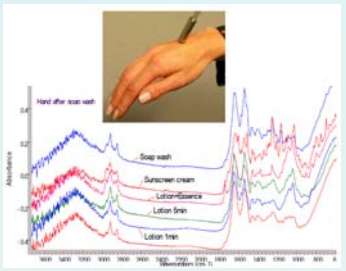


Fig. 5 Examples of ATR-absorption spectra for a hand skin.

Sterilization is needed for all biomedical applications in-vivo and it was tested for detachable PIR-Loop ATR-tips. Spectral overlay of bovine cartilage after sterilization does not show any significant changes in the Amide I & II peak heights

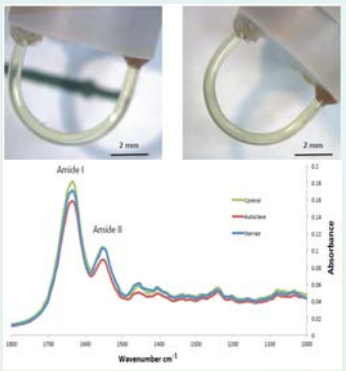
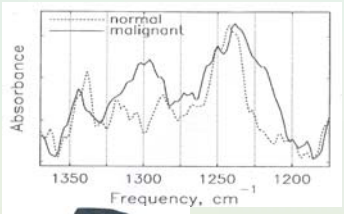


Fig. 6. Photos of PIR-loops glued in detachable PEEK-caps & Absorption spectra of bovine cartilage after PIR-Loops sterilization

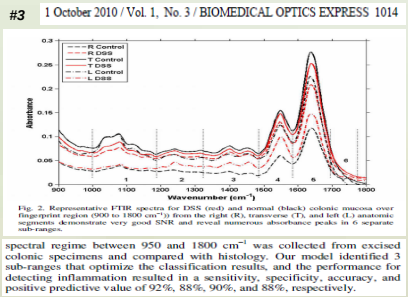
FTIR-spectroscopy with ATR-Fiber Probes in biomedical applications

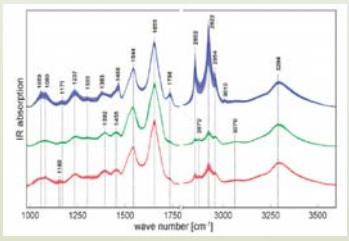
Pioneering applications of FTIR-fiber spectroscopy were started long time ago to detect malignant tissue during cancer operation (*#1*) and now much more trials are done in-vivo (*#2*) & in-vitro (*#3*) – see *data presented from 3 articles at Fig. 7* **to show great potential of FTIR-spectroscopy for molecular tissue diagnostics.**



#1. Proc. SPIE v.2328, pp.76-81, (1994)

#3





#3. Spectra of normal Blue), necrotic (green) and carcinoma (red) brain tissue.
N.Bergner et al., *Analyst,* 2013, 138, 3983