Fiber coupled FTIR-spectroscopy for biomedical diagnostics

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Within the last decade vibrational spectroscopy methods are growing fast in life science as they enable molecular analysis of tissue, bio-liquids and even exhalation in real time - in-vivo and in-citu, - need no sample preparation and require no injection of specific fluorescent markers. Complimentary methods of Mid-IR absorption and Raman scattering spectroscopy can be used not only for open surface analysis for a screening or intra-operative diagnostics. All advantages of these methods can be also used in the synergy with fiber optic probes designed for endoscopic applications. As fiber optics is available now from UV to Mid IR-range it enables to design probes with different spectral methods combination – to provide diagnostics with better sensitivity, specificity, accuracy and high positive predictive value.

In difference with PhotoDynamic Diagnostics requiring injection of various photosensitizers Raman & IR-Absorption spectroscopy methods are not invasive and can be relatively fast developed for pragmatic use in medicine as clinical approval for them needs no long time consuming procedures in contrast with this demand for any new PDD pharma-agents. Short review of biomedical diagnostics realized with fiber coupled FTIR-spectrometers will be provided in comparison with an alternative spectroscopy methods.

The latest development in Mid IR-fiber optics expands spectral range of bio-spectroscopy from UV-vis-Near IR-range towards Mid IR - up to 18µm (20.000 to 550cm^{-1}). Up to now the most of fiber spectroscopy systems were configured for biomedical diagnostics using reflection, fluorescence, absorption/ transmission and Raman-spectroscopy methods realized with Silica fiber probes. In result these system were limited to silica glass transmission range from 180nm to 2.4µm. Nowadays IR-glass fibres, Polycrystalline PIR-fibres and Hollow Waveguides can cover the longer wavelength Mid IR-range - up to 18µm, - including “finger-print” spectral region where the most of molecular vibrations possess by specific absorption bands. These fundamental vibration bands in Mid IR are 100-1000 times more intensive and more narrow compared to their 2nd & 3rd harmonics at a shorter wavelengths <2µm.
So informative method of Mid IR-absorption spectroscopy is compared to the complimentary Raman spectroscopy – which provides information on molecular vibrations as well, but due to non-elastic scattering effect. As tissue absorption is quite low for a main laser wavelengths used for Raman scattering (in Near IR) – NIR-laser beam penetrates in tissue much deeper compared to Mid IR-range. In result the total scattering signal collects from a relatively large tissue volume all spectral features specific for a different tissue parts in this volume – and they are different in molecular composition. This overlap of different spectra makes the task of tissues differentiation quite complicated, especially when the collected signal intensity is million times weaker compared to laser beam intensity. Tissue absorption spectroscopy with ATR-probes (with sensitive tips based on Attenuated Total Reflection) is based on signal analysis from a very thin layer of tissue connected to ATR-tip (few µm depth). As so thin layer is almost homogenous - the more precise molecular analysis for it can be done with Mid IR-absorption spectroscopy compared to the Raman or Fluorescent diagnostics. While this feature looks positive – it could not fulfil the dream of doctor to see through the tissue as deep as possible and to find malignant cells deep enough with good accuracy.

Discussion of these and another pro & contra factors could not help to select a winner from two alternative vibrational spectroscopy methods, but improves our understanding of their potential in complimentary use for screening and diagnostics of cancer and other diseases.