Photoaccoustic and Photothermal Infrared Spectroscopy of Skin: Options for Non-Invasive Glucose Measurement

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Mid-Infrared spectroscopy has proven to be highly specific for the spectroscopic analysis of body fluids, cells and tissues. With the advent of the quantum cascade laser (QCL) in the late nineties, powerful narrow-band single wavelength IR emitters, multi-wavelength sources, or, with an external cavity (EC), tunable EC-QCLs are now available. Their power reaches to hundreds of mW and their tunability can extend over several 100 cm^{-1}, sufficiently broad to scan the entire IR fingerprint region within some tens of msec. Probably their most pronounced advantage is their use in a pulsed mode, which makes them an ideal IR light source for photometric measurement of IR radiation absorbed in skin or tissues in combination with photoacoustic or photothermal detection.

The lecture presents our most recent developments in QCL applications for the measurement of skin parameters and body fluids *in vitro* and *in vivo* in comparison with FT-IR experiments. Photoacoustic detection methods with ultrasound resonance cells [1,2] and novel photothermal detection methods [3, 4] are described that are optimized for pulse frequencies and pulse energies of QCLs and that open the possibility for the depth-selective analysis of skin layers.

Probably the most attractive application is the use of QCLs and photoacoustic/photothermal detection for the non-invasive measurement of glucose in skin for diabetes patients. Glucose exhibits a highly specific molecular fingerprint in the MIR around 8-11 µm which can be easily used for the reagent-free quantitative analysis of glucose (and other substances) in blood or other body fluids. The lecture will describe the photoacoustic and photothermal detection principles, the depth-selective analysis of skin, the physiochemical background, the technical realization, and the validation of this method on diabetes patients. Further biomedical applications of MIR technology will be discussed.

References

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