Infrared spectroscopic analysis of human interstitial fluid in vitro and in vivo using FT-IR spectroscopy and pulsed quantum cascade lasers (QCL)

M. Pleitez[1], H. von Lilienfeld-Toal[2], T. Lieblein[1], and W. Mäntele[1]

[1]Institut für Biophysik, Goethe-Universität, Frankfurt am Main, D-60438 Frankfurt, Germany
[2]Elté Sensoric GmbH, Gelnhausen, Germany

Middle infrared photoacoustic spectroscopy (MID-PAS) is a highly sensitive spectroscopic technique suitable to study the absorption properties of opaque samples, like human tissue. With this technique it is possible to reach the *stratum spinosum*, in the shallow human epidermis, were glucose can be found as one of the most important components of interstitial fluid (ISF). By combining the high power density offered by external cavity pulsed quantum cascade lasers (EC-QCLs) and the highly sensitive and specific absorption properties of glucose in the middle infrared region, the development of a reliable non-invasive glucose measurement technique becomes possible [1].

To make use of the advantages offered by pulsed MID-PAS regarding the non-invasive monitoring of glucose as described above, it is necessary to study how the most important components of ISF, relevant in the MID-IR region, might interfere in the determination of glucose. We carried out this task by analysing the absorption properties of real and simulated ISF samples with the well-known and already established ATR-FTIR spectroscopy technique in the spectral region between 850 and 1800 cm^{-1}. The simulated samples were prepared by mixing different concentrations of albumin, glucose and sodium lactate within the physiological range. The real interstitial fluid sample was extracted from healthy volunteers after producing a small blister on the skin. The absorbance of glucose in interstitial fluid *in vivo* was probed in healthy volunteers using a setup with a pulsed tunable EC-QCL and photoacoustic detection [2]. A variation of blood glucose between approx. 80 mg/dl and 250 mg/dl in the volunteers was obtained using the standard oral glucose tolerance test (OGT).

The comparison of ISF from the volunteers with model ISF samples indicates that the only substances of significant concentration detected by mid-infrared spectroscopy are albumin, glucose and lactate. Due to their spectral properties, and for selected wavelengths, albumin and lactate can be neglected for the calculation of glucose on the basis of IR spectroscopy data. This results were corroborated by our *in vivo* measurements in which the contribution of albumin and sodium lactate were neglected to establish a correlation between blood glucose concentration and glucose concentration in ISF; a correlation factor of about 0.8 was found in this experiments, but the variations are mainly due to the surrounding noise and sample holding system instead of spectral interference of albumin or sodium lactate.

References

[1] H. von Lilienfeld-Toal, M. Weidenmüller, A. Xhelaj, W. Mäntele, *Vib. Spectrosc.* 38, 209–215 (2005).

[2] M. Pleitez, H. von Lilienfeld-Toal, T. Lieblein, W. Mäntele, *Spec. Acta A–Mol. Biomol. Spec.* (accepted)