Optical transmission spectra for analysis of bloodcomponents and -gases

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Application Note

Introduction

Knowledge about the amount of certain substances in blood is of fundamental importance in life sciences. Either in homecare applications or clinical emergency cases measurements have to be performed by comfortable, robust and reliable devices. Laboratory systems such as HPLC or GC/MS have very high performance and sensitivity, yet a transfer to portable, noninvasive and continuous techniques is not easily done.

Determination of functional changes of the molecule hemoglobin (e.g. oxygen saturation) and other endo- and exogenous components (e.g. hemoglobin derivates, drugs) by pure optical means has already been established or is of high relevance in current research worldwide. The basis for all optical approaches is the knowledge about the optical characteristics of the target analyte and its environment, i.e. human tissue and blood.

Experimental Setup

To analyze these characteristics a fiber coupled setup was built to determine the optical transmission of various substances in the VIS and NIR. The setup core consists of an Andor Shamrock SR-303i-B imaging spectrograph with dual output ports and two cameras connected (silicon CCD detector DU420-BR-DD and iDus InGaAs photodiode array DU490A-2.2, both TE cooled). The spectrograph is equipped with three diffraction gratings, blazed for 300 nm and 800 nm with 150 lines/mm each and 1700 nm with 75 lines/mm, which can be changed comfortably by the Andor Solis control and data acquisition software.

For illumination purpose a 150 W Xenon arc lamp and a 50 W halogen lamp are available. To reject higher diffraction orders, which would adulterate the measurements, various optical highpass filters can be used. The light is guided to a large core quartz fiber by a fiber focusing assembly. A custom built cuvette changer holds the reference and the sample cuvettes, made from special optical glass with path lengths from 1 mm to 10 mm. The cuvette changer is connected to the fibers by focusing/collimating optics to achieve high light yield. For wavelength calibration three Pen-Ray lamps can be used (Kr, Ar, Ne).

The complete setup practically covers the broad wavelength range from 300 nm to 2000 nm still having a sub-nanometer resolution. This makes it a very versatile instrument for a large number of diverse experiments.

Results

Figure 1 shows the transmission spectrum of propofol, a hypnotic agent widely used in total intra-venous anesthesia (TIVA). Until today propofol concentrations can only be measured discontinuously by time consuming and expensive laboratory methods, such as HPLC. To investigate the possibility to determine propofol spectrophotometrically and directly at the patient in a continuous manner, the optical characteristics have to be known in detail to identify possible target absorption wavelengths.

The graph shows the spectra of propofol and two chemically similar substances (phenol and 1,3-diisopropylbenzene) in the NIR from 1000 nm to 2000 nm. By comparison of the spectra the absorption peaks can be assigned to the molecules' functional groups (hydroxyl, methyl, aromatic).

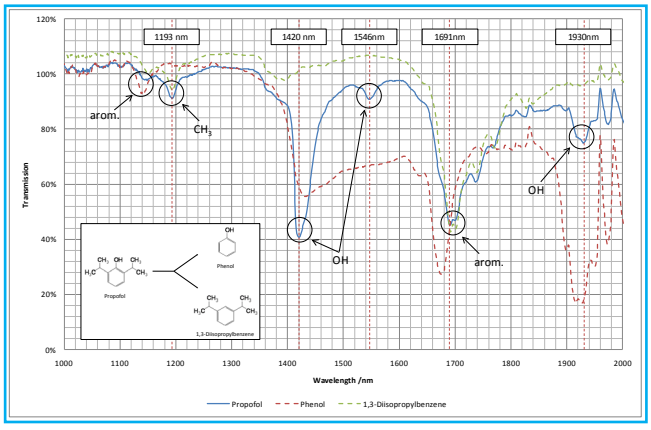

Figure 1 – Optical transmission spectra of propofol, phenol and 1,3-diisopropylbenzene between 1000 nm and 2000 nm, all referenced to air. By comparison of the absorption bands of the chemically similar substances, the bands can be assigned to the functional hydroxyl, methyl and aromatic groups.

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Reference

B. Weber, B. Nestler, L. Dibbelt, H. Gehring: **Optical Transmission of Propofol in The Wavelength Range of 1000 nm to 2000 nm**, *44. Jahrestagung der Deutschen Gesellschaft für Biomedizinische Technik im VDE – BMT 2010,* 2010, Rostock

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