1. Abstract

We demonstrate a novel fiber optic probe with real-time, self-calibrating capability that can be used for diffuse reflectance spectroscopy (DRS) in tissue. The probe was tested in a number of synthetic liquid phantoms in different days over a relevant range of tissue optical properties. Absorption and reduced scattering coefficients are extracted with an average absolute error and standard deviation of 6.3±2.6% and 2.2±1.4%, respectively, with an inverse scalable Monte Carlo model.

2. Motivation

- UV-Visible DRS is sensitive to the absorption and scattering of biological molecules in tissue, thus can be used as a non-invasive tool to obtain quantitative physiological and morphological information of human tissue.
- Fiber optic probes are commonly used to deliver the illumination light to and collect the diffusely reflected light from the tissue for DRS measurements.
- For DRS to be used routinely in the clinic, calibration is required to compensate for:
  - wavelength-dependent instrument and probe response.
  - light intensity fluctuations (>25% during warm-up, >3% after 30 minutes, and 5-10% from day to day).
  - fiber bending losses during measurement (up to 10%).
- Current calibration techniques rely on measurements using power meters, reflectance standards, and/or tissue phantoms, typically after the clinical measurements are completed.
- Limitations associated with such calibration methods:
  - cannot correct for real-time lamp intensity fluctuations
  - require at least 30 minutes for lamp warm up, which is a significant problem in a clinical setting such as the OR.
  - require an additional 20-20 minutes before or after the clinical measurements for calibration.
- It is therefore desirable to create a fast, robust and systematic calibration approach that can be used for correcting tissue optical spectra obtained at different times and with different instruments and probes.

3. Experimental Setup

- The UV-VIS DRS system consists of a broadband Xe light source, a self-calibrating (SC) fiber optic probe, a spectrophotograph, a CCD camera, and a laptop computer.
- The probe has a built-in calibration channel that can be used to record the spectral response for each channel.
- The probe can be used in conjunction with the spectrophotograph to record the spectral response for each channel.
- Combined with a single reference, single-reference phantom measurement, the SC probe can be used to provide instrument-independent optical properties.

4. Correction for Lamp Warm-up

![Graph showing correction for lamp warm-up](image)

The variation in the illumination intensity is reduced from 6 dB to less than 0.25 dB.

5. Correction for Wavelength Dependence of SC Channel

![Graph showing correction for wavelength dependence of SC channel](image)

The required correction is obtained concurrently.

6. Clinical Data Calibration

![Graph showing clinical data calibration](image)

References


9. Conclusions

- We have demonstrated the feasibility of performing DRS using a compact self-calibrating fiber optic probe.
- The technique can effectively correct for instrument and probe responses, short- and long-term lamp fluctuations, and fiber bending loss.
- Most importantly, it removes the need of instrument warm-up and additional calibration measurements in the clinic, therefore saves 40-60 minutes of precious clinical time.
- We have also found that scattering is more sensitive to instrument fluctuations caused by the lamp or fiber bending.
- Combined with a single reference, single-reference phantom measurement, the self-calibrating probe can provide instrument-independent optical properties.

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