(UG) Assessing indocyanine green as a chromophore for near-infrared spectroscopy tissue-mimicking phantoms

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Near-infrared spectroscopy (NIRS) is a non-invasive tool used to assess cerebral health by estimating tissue blood content and oxygenation from measurements of light absorption. To evaluate the accuracy of NIRS devices and algorithms, tissue-mimicking phantoms (TMPs) are used. TMPs typically consist of light-scattering media and light-absorbing dyes, such as Intralipid and indocyanine green (ICG), respectively, to mimic the optical properties of biological tissue. However, the dyes'absorption spectra can change based on their relative proportion with respect to the light-scattering media in the TMP, affecting the estimation accuracy of the TMP's optical properties. The study objective was to investigate ICG absorption properties in Intralipid-based TMPs at varying concentrations.

Four sets of TMPs were prepared with 0.8% Intralipid, and ICG concentration was increased from 0 µM to 0.2 µM in steps of 0.04 µM. An off-the-shelf spectrometer (QE Pro, Ocean Insight) was used to measure the diffusely reflected light from TMPs at each ICG concentration. Measurements were acquired by a spatially-resolved approach at source-detector distances ranging from 2.7 to 3.5 cm. The effective attenuation coefficient (μ_{eff}) was estimated at each ICG concentration and used to compute the scattering (μ_s') and absorption (μ_a) coefficients. ICG concentration was then estimated from μ_a and compared to expected values.

The estimated ICG concentrations in Intralipid increased with the addition of ICG. However, these concentrations were significantly different from expected values, as there was a linear scaling factor of 3.8, revealed by the plots'slope of recovered concentrations against expected values.

The current study shows that estimated ICG concentrations in Intralipid-based TMPs increase linearly with the amount of dye in solution. However, the slope of recovered concentrations versus expected values was 3.8 rather than unity, indicating an overestimation. This error could result from molar extinction coefficient changes of ICG in water as its concentration increases, due to its interaction with Intralipid, needing further investigation. Immediate future work will investigate the optical properties of other commonly used dyes, namely methylene blue and India ink, in Intralipid and the properties of these dyes in inorganic light scatterers like TiO_2 and glass microspheres.

Keyword-1

Near-infrared spectroscopy

Keyword-2

Tissue-mimicking phantoms

Keyword-3

Indocyanine green

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