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Optical transparency windows in near-infrared and short-wave infrared for skin, skull and brain: tissue optical properties and fluorescence bioimaging

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Fluorescence imaging is a perspective noninvasive optical technique to visualize emitting molecules and nanomaterials in biological objects. The limitation of this method is a depth of imaging due to a strong attenuation of light by the tissue, however, the use of near-infrared (NIR) irradiation allows for the visualization of objects under the tissue surface for millimeters. The tissue transparency windows within ˜700–1000 nm (NIR-I) and 1000–1350 nm (NIR-II) are conventional. Moreover, the lately explored short-wave IR (SWIR) optical transparency windows ranging ˜1550 to 1870 nm (SWIR or NIR-III, NIR-IIb) and ˜2100 to 2300 nm (SWIR-II) have more advantages due to much lower light scattering by turbid tissues. They are related to the attenuation coefficient and total attenuation length are determined for all windows and tissue types. The spectra indicate transmittance peaks in NIR, NIR-II and SWIR-II, with maximum tissue permeability for SWIR light. Thus, when comparing IR fluorescence imaging of quantum dots emitting at ˜1.0, 1.3 and 1.6 μm through the scalp skin, skull bone and brain, the SWIR fluorescence is detected the best. Moreover, it shows the utmost enhancement for the skull, which is a highly scattered medium. The benefits of the NIR-II and SWIR windows are shown for IR fluorescence imaging, the technique where the collimated transmission component is more important than the diffused one.

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