Development of a glass-based imaging phantom to model the optical properties of human tissue

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Reliable fabrication of stable, reproducible optical calibration standards is critical to the assessment of optical imaging systems. In biomedical applications, these are referred to as 'imaging phantoms'. Imaging phantoms underlie the reliable use of medical imaging modalities such as diffuse optical tomography, Raman imaging, and optical coherence tomography. This requires the development of imaging phantoms that mimic the optical scattering and absorption of human tissue. Several approaches have been described in the literature, typically introducing scattering and absorbing agents into either water or a solid matrix (e.g., polymer, agar). However, many of these approaches suffer problems in achieving optical homogeneity or lack long-term stability.

In this research, we propose a novel glass-based imaging phantom that achieves both optical homogeneity and long-term stability. The imaging phantom comprises crystalline glass, doped with nickel ions to control the absorption of the material. Nickel ions were chosen as they mimic the absorption spectrum of hemoglobin around 420nm and 540nm. The glass then undergoes a process of controlled heating at 750°C and 800°C to introduce crystalline structures which provide optical scattering. By controlling the concentration of nickel ion doping and the temperature of the heat treatment, we are able to independently control absorption and scattering. Using this approach, we have fabricated a series of imaging phantoms to mimic both low and high scattering tissue with low and high levels of absorption.

The imaging phantoms were characterized through separate measurements of absorption and scattering, and also the combined optical attenuation from both of these mechanisms. Figure 1 shows the optical attenuation of several phantoms measured with UV-VIS. In conclusion, these phantoms provide an important tool to support the reliable development of optical imaging for a range of diagnostic clinical applications.

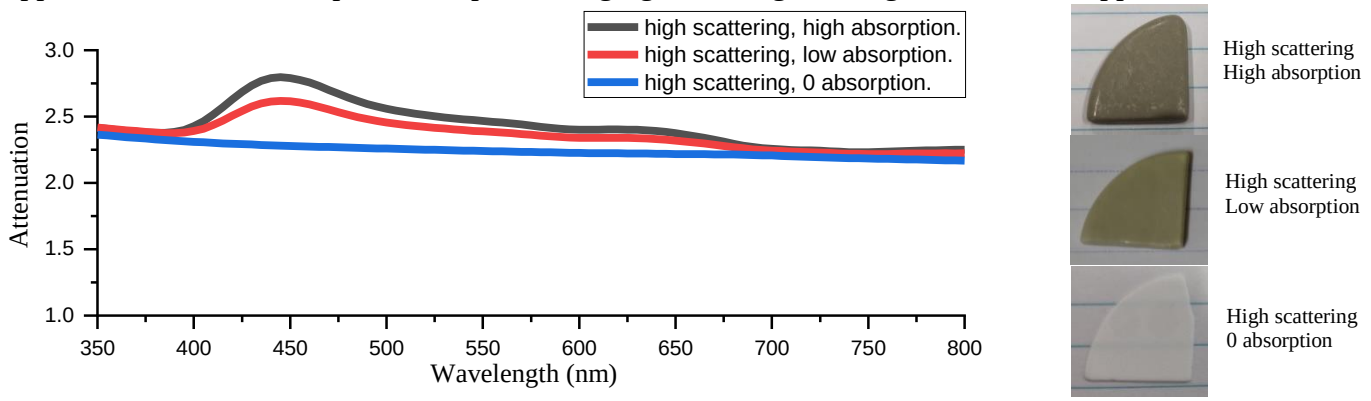

Figure 1 The optical attenuation of high scattering phantoms measured using UV-VIS.