

Determination of absorption and scattering by Photon Density Wave spectroscopy: extremely high scattering

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The determination of the optical properties of dispersed media has been in the focus of research since decades. Whereas the absorption coefficient μ_a comprises information about the chemical constitution of the sample, the reduced scattering coefficient μ_s contains information of the substructure, i.e. the particle or droplet size for instance. To determine either of these properties the exact separation of scattering and absorption is required. However, this is a sophisticated problem and elaborate methods have been developed like measurements on fluence rates in combination with the added absorber method [1], measurements on the diffuse and collimated transmittance and reflectance [2] or Time-of-flight spectroscopy [3]. Yet, most of these methods are in need of calibration or time consuming inversion algorithms for data evaluation. On the contrary, Photon Density Wave (PDW) spectroscopy based on radiative transport theory is suitable for the independent determination of the absorption and reduced scattering coefficient in highly concentrated scattering and absorbing media [4]. Additionally, no calibration is required. The only information needed to determine both coefficients is the refractive index of the sample.

In previous studies it was shown, that both coefficients can be retrieved with high precision ($\approx 0.1\%$) and accuracy. Measurements were carried out on various materials like polymer dispersions, emulsions, milk, algae, cosmetics etc. in the wavelength range of 500-1000 nm. Due to the nano- or micrometer size of the particles/droplets and the moderate refractive index difference between particles and surrounding medium the reduced scattering coefficient of these samples lies in the range of $0.1\text{-}60\text{ mm}^{-1}$ (depending on particle volume fraction). Additionally, as most of these samples consist of high water content and no strong absorbers, the absorption coefficient lies in the range of $0.0001\text{-}0.05\text{ mm}^{-1}$. Hence the ratio between absorption and scattering ranges from $10\text{-}10^4$. In this study we will present PDW spectroscopy measurements on water dispersions of inorganic materials exhibiting high refractive indices. The absorption coefficient is found to be close to water ($\mu_a \approx 0.0001\text{-}0.05\text{ mm}^{-1}$). However, measured values of the reduced scattering coefficient exceed previously measured values by a factor of approx. ten. Hence, even in such highly scattering media both coefficients could be retrieved with high precision.

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