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Simulation method linking dense microalgal culture spectral properties on the [400-750 nm] range to the physiology of the cells

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The mass production of autotrophic microalgae has largely increased over the last decade, as it is seen as a promising source of biomass for crucial applications such as energy production [1], source of highly valuable molecules. Optimizing the monitoring of the mass cultivation process is a challenging issue [2] as this requires high frequency biochemical and physical characterization of the microalgal cells throughout the cultivation process. However, the current techniques used for biomass algal monitoring such as optical density or pigment fluorescence suffer from a lack of specificity as such measurements include particles other than algae or are dependent on the highly variable physiological status of the microalgae3.

Using visible (VIS) and near infrared (NIR) spectroscopy has the potential to characterize the status of dense microalgal cultures since such measurements are fast, can be performed with minimum or no sample preparation. The critical point in applying spectroscopic methods to dense algal cultures relies in the multiple scattering effects due to high cell density (106− 109cell/mL).

The present study addresses the issue of modeling the optical properties of dense algal samples where multi-scattering occurs, with an optical thickness much higher than 0.3, and reaching up to 16. Our work aims at providing a simulation method that can be used to interpret the spectral optical properties of a dense algal culture (i.e. spectral total transmittance), and to provide information on the biochemical and physical characteristics of the algal cells during their growth. For this purpose, an modeling method based on the solution of Kerker of the extended Mie theory [4] coupled with the numerical resolution of the radiative transport theory [5] was implemented. The algal cells are thus modeled as multilayered spheres of different organic materials and dissolved photopigments [6]. The method aims at simulating in the forward running the total transmittance spectra of bulk algal media over the [400-750nm] spectral range, from parameters describing the constitutive algal cell chemical composition and mean size. In the inverse running, the physical and pigment characteristics of the cells were retrieved from the total transmittance spectra measured on the dense culture aliquots of two cultivated microalgae, the quasi-spherical small flagellate Isochrysis galbana and the elongated diatom Phaeodactylum tricornutum, at different growth phases.

The first results give strong support for the development of a promising tool providing rapid and accurate estimations of biomass and physiological status of a dense microalgal culture based on only light transmittance properties.

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