Predictive rendering, a part of computer graphics, is based on the light transport equation and focuses on accurately predicting the appearance of objects and materials under various conditions. A variety of problems can be formulated as appearance prediction: from generating photorealistic images to enhancing color 3D printing. The accuracy relies on the materials' optical properties, which must either be estimated from first principles, or measured with expensive and sophisticated optical devices. Could we obtain these properties in an efficient and affordable way optimized for predictive rendering?

To answer the question, this thesis bridges the boundary between computer graphics and optics. We develop simpler and more affordable methods for measuring optical properties with a focus on color accuracy, thus making predictive rendering more accessible. We aim at two types of materials that are both ubiquitous but usually neglected because of their complex characteristics: *translucent materials* and *fluorescent materials*. For each, we present a separate measurement approach that only uses low-cost optical components, yet has a high spectral resolution for color-accurate applications.

Our first method is motivated by measuring translucent inks, which is required for accurate full-color 3D-printing algorithms. We develop an acquisition technique for the three unknown material parameters, namely, the absorption and scattering coefficients, and the phase function anisotropy factor. Only three point measurements with a spectrometer are required, as we found a three-dimensional appearance map, computed using Monte Carlo rendering, that allows the conversion between the three observables and the material parameters.

Our second method focuses on fluorescent materials. A Donaldson matrix is estimated for each material, which corresponds to a two-dimensional spectral characterization of the fluorescence and reflectance properties. Only a few measurements of the material's reflectance under a few illuminants are needed for the estimation with our algorithm. It is enabled by representing each Donaldson matrix with a multivariate Gaussian mixture model and bounded MESE (maximum entropy spectral estimate) and using gradient-descent optimization.