Measuring directionality of molecule structures in biological samples

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Abstract Molecule structures in biological samples often show birefringence, that alters the polarization properties of transmitting light. The presented hardware extension makes it possible for a general transmission laser scanning microscope to measure the polarization properties of transmitting light. By controlling the incident light polarization, the directionality of the molecule structure of the sample can be determined.

Introduction

Highly organized molecular macroaggregates are found in many hierarchically organized biological systems: DNA-condensates, cell walls, cytoskeletons, stacked membranes, membrane domains, protein aggregates etc. However, our understanding concerning their self-assembly, molecular organization, structural dynamics and physiological functions is still rudimentary. Polarization birefringence measurement techniques provide important and unique information on this type of complex systems. In most cases, however, the measurements are difficult, or sometimes virtually impossible, to perform and/or interpret on macroscopic samples, and in their native environments. Hence it would be important to determine the microscopic parameters, and map the spatial distribution of these parameters of the anisotropic architecture.

In this paper, we describe an extension to transmission laser-scanning microscopes that makes it possible to measure optical birefringence in biological samples.

Materials and Methods

Due to the ongoing preparation of patenting the measurement principle and device architecture, we cannot share the technical details of the project until our preferential right to the invention is assured by submitting the patenting request to the national bureau of intellectual properties.

Results

A sample measurement data is shown on Figure 1. In Fig. 1A the transmission image of a sample cell obtained in regular laser-scanning transmission operation mode is shown. In Fig. 1B the image of the same sample cell obtained using our polarimetric extension is shown. The yellow edge of the cell on the upper-left and lower-right parts of the cell wall shows that the cell wall contains highly organized molecular structures. Further measurement data are shown in Fig.2.

Discussion

In parts of cells, where elongated molecules are constrained in tight volumes, often the molecules are organized. Such structures can be found in e.g. microvilli of insect eyes or cell walls. Cell wall directionality can be found in Figure 2B, where the directionality encoded with a yellow-blue false-colour palette changes gradually along the perimeter of the cell.

A B

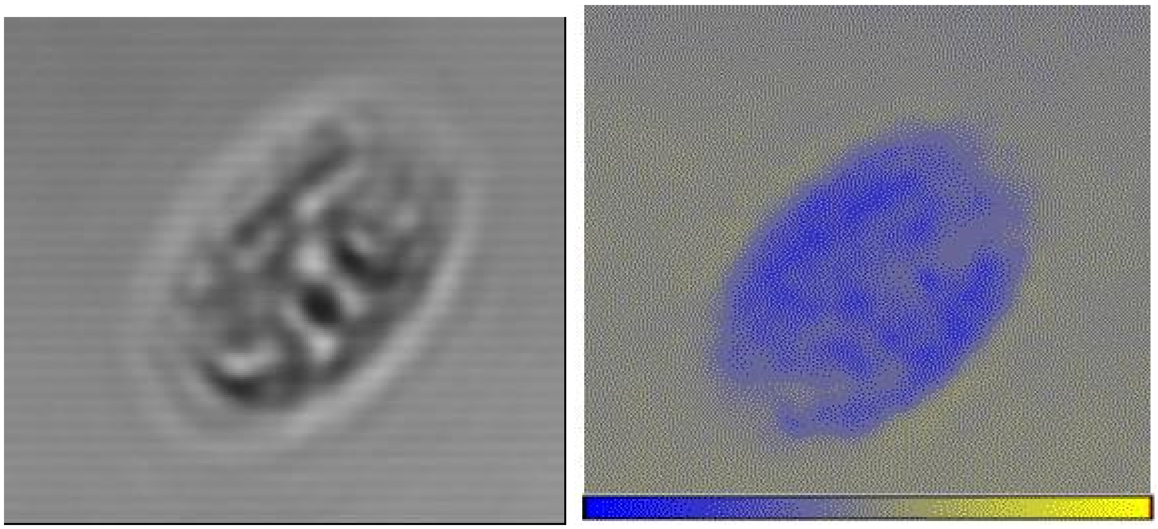
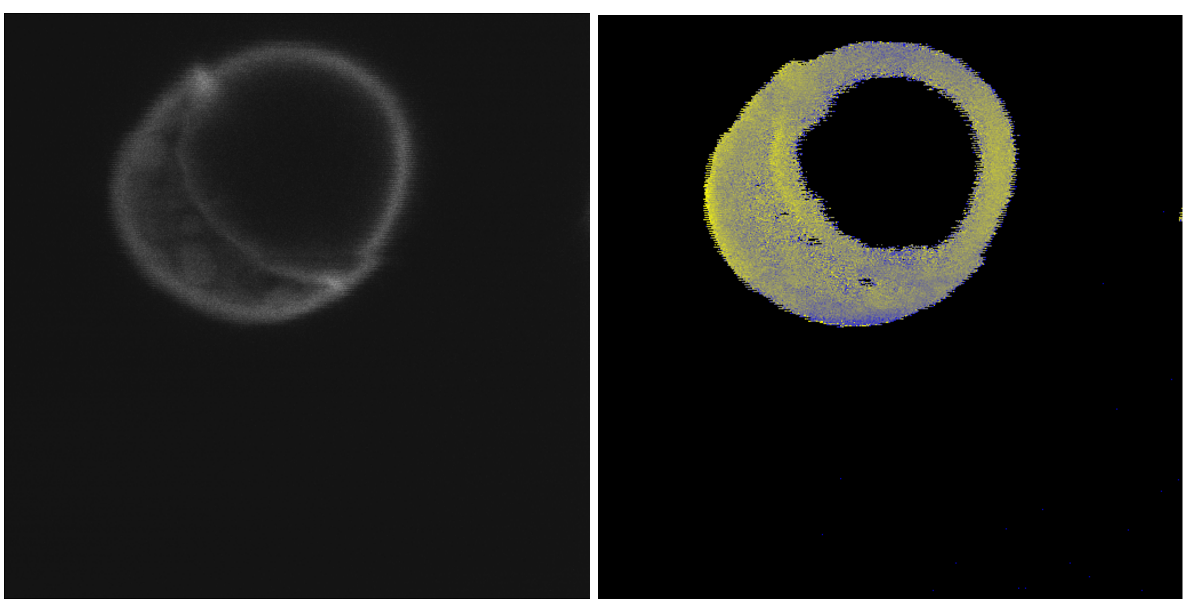


Figure 1. A sample measurement with a transmission laser-scanning microscope. **A:** The transmission image of the sample cell obtained in regular laser-scanning transmission operation mode. **B:** The image of the same sample cell obtained using our polarimetric extension. The color codes the direction of birefringence. The yellow edge of the cell on the upper-left and lower-right parts of the cell wall shows that the cell wall contains highly organized molecular structures. This measurement method obtains the directionality of the molecule structures.



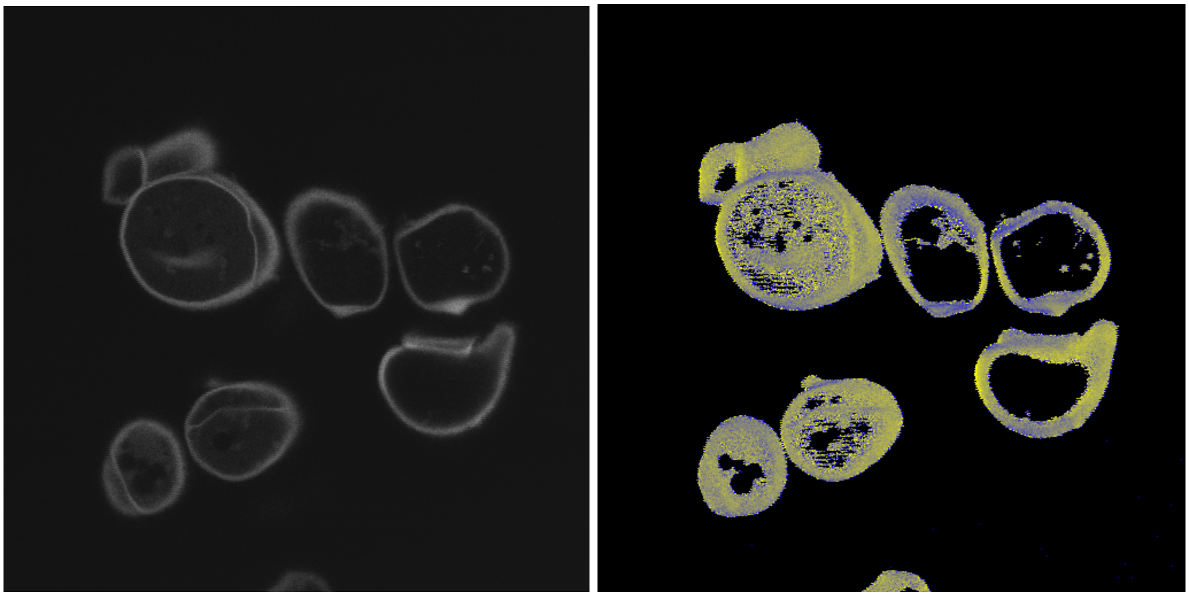


Figure 2. Two other examples of normal transmission laser-scanning microscopy images of cells with their pairs obtained by our polarimetric extension.