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Fabrication and multimodal imaging of hybrid lyotropic liquid crystal structures such as myelin with the use of nanoparticles.

A plethora of naturally occurring lyotropic liquid crystals (LLC) holds significant biological importance, including their presence in cell membranes, myelin, condensed phases of DNA, and collagen. These systems, composed of biomolecules and water, play a vital role in numerous processes within living organisms. Consequently, a comprehensive study of their formation, stability, and, crucially, the integrity of liquid crystalline phases becomes necessary. The existing probes for LLCs exhibit limitations, prompting the exploration of more effective markers.

This project primarily focuses on phospholipid-based research, addressing issues related to cognitive decline associated with myelin loss in conditions like multiple sclerosis (MS). Traditional neuroimaging methods, such as magnetic resonance imaging (MRI), magnetization transfer rate (MTR), diffusion tensor imaging (DTI), and positron emission tomography (PET), have been employed to quantify myelin and link it to cognitive impairment. However, these techniques are costly and only offer a comprehensive picture when significant myelin integrity loss is already apparent. This study aims to explore different myelin imaging modalities, including one- and multiphoton imaging, as potential predictors of cognitive dysfunction.

Furthermore, the inherent ability of phospholipids to self-assemble in LLC phases presents an opportunity for the controlled organization of nanomaterials. Leveraging experience in constructing hybrid liquid crystalline materials based on DNA, the project seeks to organize nanoparticles (NPs) within various phospholipid structures, such as tubes and coiled figures and fabrication of new hybrid material. Carbon nanodots are introduced to facilitate precise imaging of these structures due to their small size and exceptional luminescent properties. The study also plans to utilize metal NPs, both plasmonic and magnetic, for characterizing and manipulating the LLC.

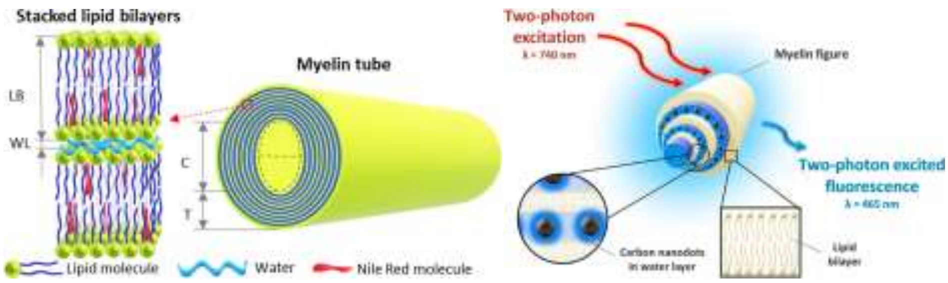

Fig.1**.** *(left) Scheme of the myelin tube inner self-organization (LB* - phospholipid bilayers, WL - water layer, C – water core, T – thickness of the tube) *and (right) the placement within the water layer of the hydrophilic carbon nanodots* [1,2].

The investigation extends to the synthesis and use of carbon nanodots with chiral properties, exploring their influence on the self-assembly of coiled structures in myelin tubes. Plasmonic NPs, characterized by the plasmonic effect, are considered for generating heat upon irradiation, potentially useful for local heating effects and bioimaging in myelin studies. Magnetic NPs, such as ultrasmall superparamagnetic iron oxide nanoparticles (uSPIOs), are introduced for their potential role in manipulating myelin figures through the application of a magnetic field. This approach represents a novel manipulation of LLC doped with uSPIOs, aiming to uncover new insights into myelin structure and function.

References:

1. Benkowska-Biernacka, D.; Smalyukh, I. I.; Matczyszyn, K., Morphology of Lyotropic Myelin Figures Stained with a Fluorescent Dye. *The Journal of Physical Chemistry B* **2020,** *124* (52), 11974-11979.
2 .Benkowska-Biernacka, D.; Mucha, S. G.; Firlej, L.; Formalik, F.; Bantignies, J.-L.; Anglaret, E.; Samoć, M.; Matczyszyn, K., Strongly Emitting Folic Acid-Derived Carbon Nanodots for One- and Two-Photon Imaging of Lyotropic Myelin Figures. *ACS Applied Materials & Interfaces* **2023**.