MODELING NATURAL HABITATS WITH LIQUID CRYSTALS: MOTILE BACTERIA IN ANISOTROPIC ENVIRONMENT

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Liquid crystals (LC) are compounds that retain the properties of a liquid, such as fluidity, and those of a crystal: highly ordered orientation of constituents underlies the ability of a LC to exhibit variations in physical properties along different molecular axes (anisotropy). The orientation of anisotropic medium imposes constraints on moving objects placed inside it. Among examples of such are motile bacteria that naturally occur in habitats with physical characteristics similar to LC. Soil, solid tissues of plant and animal organisms represent the environments with local anisotropy. Colonization of such environments, a process that largely depends on bacterial motility, until recently has been studied without taking into account the physical characteristics and the structural organization of the medium. Yet the anisotropy of natural biotopes can affect both the dynamics of bacteria movement and intercellular signaling, exerting an effect on the differentiation of cells and their response to exogenous stressors, including antibiotic substances.

In our study we have used disodium cromoglycate (DSCG), a biocompatible lyotropic chromonic LC that exhibits phase transitions from isotropic to anisotropic state as a function of both temperature and concentration. As a motile object, a bacterial strain *Proteus vulgaris* Hauser 1885 UKM B-905 was chosen. It is a pleomorphic peritrichous bacteria with multiple flagella located on its surface, responsible for its motility. The bacterium inhabits the intestinal tract of humans and animals, but as an opportunistic pathogen can cause urinary tract infections. In case of *P. vulgaris*, the colonization of the surfaces is performed by specialized differentiated cells 'swarmers'– elongated multinucleoid hyper flagellated structures, with a type of motility called 'swarming'. The latter are reported to be virulent forms with enhanced production of hemolysins and proteases.

We have developed and adjusted a system that allows for combining a LC and active motile bacteria: a set of nutrient media for bacteria cultivation and LC preparation was tested, the growth parameters in batch culture calculated, morphology of cells studied using transmission electron microscopy. Observation (using polarization microscopy) of bacterial behavior was performed in microchambers with oriented LC of various concentrations and temperature, in different solvent media, and within various time intervals. After being transferred to a different medium, majority of bacterial cells differentiated into large swarmer cells reaching 10μm. In an isotropic phase (under 10wt% of LC) their movement was chaotic, while in anisotropic phase bacterial behavior was drastically different: they moved parallel to the orientation of LC director. The movement was nonpolar, that is, approximately the same number of bacteria moving to the right and to the left.

The orientation order of LC reveals new facets of the dynamics of the bacterial movement up to providing a tool to control individual trajectories of bacteria. Studying behavioral patterns of bacteria in an anisotropic environment as an approximation of biological *in vitro* experiment to such *in vivo* opens the prospect of extending existing ideas about the interaction of macro- and microorganisms, as well as improvement in the technology of antimicrobial agent development.