Dynamics of a probe pushed by Physarum polycephalum under electrotaxis

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One of the main considerations on the operation of Lab-on-Chip (LOC) devices are the source of energy to drive micrometer-sized actuators. Proposals for source of force generation includes the use of electromagnetic mechanism, high pressure gases, optical forces among others. Currently, there is also rapid development in the area of biologically inspired driving mechanisms for actuator devices. Already, active baths composed of E. coli were used to drive micrometer sized gears. Furthermore, bacterial bath composed of E. coli was shown to drive passive colloidal beads thereby allowing such beads to undergo super-diffusion. On the other hand, it is also possible to utilize the tactic response of biological organisms to drive micro actuators. This latter approach gives an important benefit of control, i.e. by changing the external stimuli one can change the force exerted by the biological organism. One possibility is the use of the slime mold, Physarum polycephalum (P. polycephalum). P. polycephalum has already been used as active component for a biological transistor, proposed biological computer among others. In this study, we performed experiments to measure the movement of a probe, 0.9 mm in diameter, along a 1 mm diameter channel being after being pushed by a plasmodium of P. polycephalum under electrotaxis. Fresh samples of plasmodium of P. polycephalum were exposed to DC electric field with strengths from 0.48 V/mm to 6.25 V/mm. The movement of the starved plasmodia were observed for several hours where the mean node position was found to move towards the cathode signifying a negative electrotactic response. Three dynamical modes of the probe were also observed: pure translation, translation + swinging and translation + rotation. All three dynamical modes of the probe were observed for the electric field strengths that were used. Furthermore, using single particle tracking and for the case of pure translation, it is apparent that the trajectory contains periodic component which is reminiscent of shuttle streaming. Our work opens up the possibility of using P. polycephalum to exert force on interfaces under electrotaxis.