



CALIFORNIA STATE SCIENCE FAIR 2016 PROJECT SUMMARY

Name(s) Labanya Mukhopadhyay	Project Number 36663
Project Title A Study of Micro-robotic Motions with Helical Flagella in Low Reynolds Number Liquids	
Objectives/Goals In fluid mechanics, a unit less ratio known as Reynolds number quantifies the relative importance of viscous forces over inertial forces. My hypothesis is that the speed of the micro-robots through high viscous liquids at room temperature will decrease with increasing viscosity. Also the helical flagella which has larger length will generate more thrust on the liquid, move faster and have more stable motions through the liquids. Speed through a given liquid medium will increase with larger flagella diameter for a given length and pitch of the flagella. Abstract Methods/Materials The micro-robot was made using the dc motor from the electronic flosser, two coin batteries, and push button latching switch. The viscosity of three liquids, corn oil, motor oil and car washing detergent, were first measured based on Stokes' law and compared against the known values. Then the speed of the robot was recorded through these mediums. Results The viscosity value measured for corn oil, motor oil and car detergent are 300, 600 and 7000 centipoise respectively, which is close to expected values. The experiments showed that speed of the robot decreased with increasing viscosity of the medium. Also the micro-robots with larger flagella length moved slower with decreasing speed. Velocity also decreased with larger helical flagella diameter for a given liquid, length and pitch of the flagella. The calculated Reynolds number for corn oil, motor oil, and car detergent are 3.5, 0.33, and 0.006 respectively. Conclusions/Discussion The experimental data about the speed of the robot for different parameters of the flagella partially contrasted my hypothesis. I found out the reason for the anomaly is due to greater drag force and load on the motor due to increasing length and diameter of flagella. The Reynolds number for all three test liquids are much less than 2000, which confirms to laminar flow. The measured value of the Gray and Hancock coefficients also matched Resistive Force Theory(RFT), the ratio of the normal and tangential force coefficients being under 2. The study has numerous applications in real world. These micro-robots in nano-scale could be propelled through arteries and veins for targeted drug delivery, minimally invasive surgical procedures, removal of arterial blockage and many more. These micro-bots can also be useful in detecting and repairing cracks and other internal damages in the oil pipelines.	
Summary Statement A novel approach to the design of swimming micro-robots with helical flagella and studying the effects of flagella characteristics on its propulsion through different low Reynolds number liquids.	
Help Received Received help from my dad in soldering the electronic circuits for making the micro-robot, and for taking pictures during the experiments.	