INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Programme of Study	:	Ph.D.

Thesis Title: Development and Fabrication of Cost Effective Gold – Polypyrrole Actuator for Underwater Application.

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SHORT ABSTRACT

Polypyrrole based active actuator exhibits unique combination of properties such as low actuation voltage, high strain and stress, large bending displacement, low weight and high flexibility, biocompatibility and manufacturability in micro scale. Tri-layer strip actuator with self-contained electrolyte storage generating bidirectional bending motion in non-electrolyte fluid medium makes it suitable for bio-inspired robotics system. While few Polypyrrole based underwater robotic systems have been developed, their underwater dynamics is not fully characterized. Further, high fabrication cost and low life cycle limits their practical applications. In order to develop a real time underwater system based on Polypyrrole actuator, this thesis focuses on fabricating a cost effective PPy actuator and systematically characterizes and models the underwater bending and hydrodynamic performances of the Polypyrrole actuator and then applies these results to develop a bio-inspired swimming robotic system. The low cost Polypyrrole actuator is fabricated by using layer by layer electrochemical polymerization and deposition technique from the aqueous solution of NaDBS at room temperature. The underwater bending characterization is carried out in quiescent water under both AC and DC voltage for estimating the time, voltage amplitude and frequency dependent bending displacement, force and operational life cycle of the actuator. The frequency response of bending experiment is carried out to identify the bending frequency, speed and vibration responses of the actuator. Following this, the hydrodynamic performances such as thrust, speed, power and efficiency were evaluated for the PPy actuator operating in quasi static and dynamic condition. To validate the experimental results and study the performances for a wide range of applications, a comprehensive hydrodynamic bending model is developed in transfer function form which is a function of electrical, chemical, mechanical and working parameters including material and geometrical properties of the actuator. Then the linear and nonlinear responses of the actuator are studied by both experimentally and numerically to show the feasibility of the actuator for underwater operation. To demonstrate the real time application, a PPy actuator based a tadpole like undulatory robot has been developed and estimate the swimming speed and effectiveness from real time swimming experiment. The tadpole robot shows efficient swimming with excellent maneuvering capabilities, hence this system can be further used for various underwater applications like scanning, surveillance, exploring and environmental control.