Characterization of pH-controlled attraction / repulsion forces with functionalized substrates

Research framework

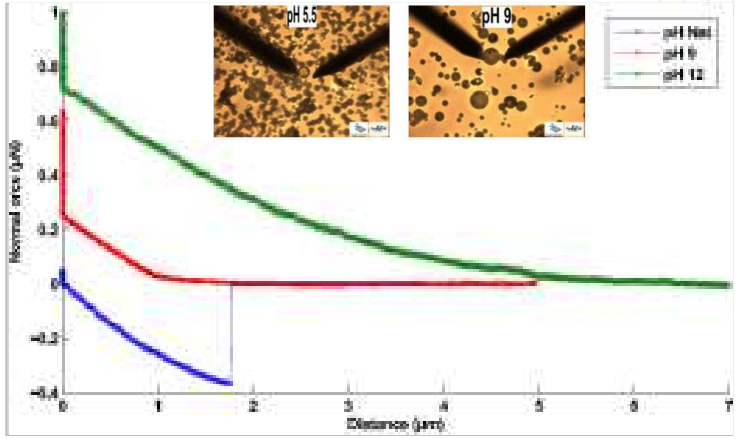
The adhesion that occurs between a micro-object and a micro-manipulation tool like the end-effectors of a micro-gripper is an important issue in micro-manipulation and micro-assembly. Adhesion forces cancellation or reduction in a controlled way is also a great challenge in micro-robotics. The adhesion force is directly linked to the surface chemical structure of both the object and the micro-tool and depends on their interaction. Based on the fact that electrostatic forces can generate a predominant effect on the micro-scale range when the micromanipulation occurs in a liquid medium, controlling the electrostatic forces should enable to control the attraction and repulsion behavior between surfaces during approach and retract stages.

Proposed approach

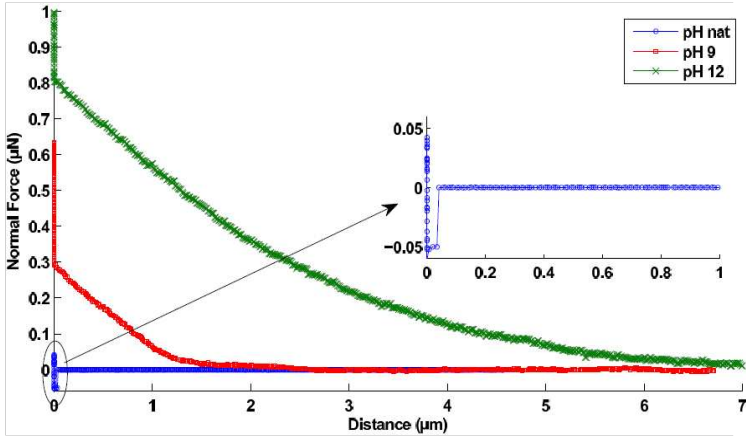
Electrochemical effects can be exploited in order to control electrostatic surface charge density via chemical equilibrium between the surface and the liquid medium. The principle used in this approach is based on the protonation of silica, which enables to switch from SiO_2 to SiO^- according to the pH. The combination of both effects enables to obtain a surface whose electrostatic charges switch from a positive value for low pH to a negative value for high pH which makes possible the control of the adhesion force with the pH. Surface functionalization of both object and gripper can be obtained by different methods (physisorption, grafting...).

The pull-off force measurements were performed with the NANOROL robotics platform specifically dedicated to micro-force measurements. They were done on a functionalized plane using a micro-cantilever whose end was equipped with a sphere that was functionalized or not.

Major article: Adhesion forces controlled by chemical self-assembly and pH. Application to robotic microhandling. Dejeu J., Gauthier M., Rougeot P., Boireau W. Applied Material & Interfaces, 2009, 1(9):1966-1977.



Force-distance curve for a APTES functionalized substrate during a retract stage and illustration of a corresponding situation during a micromanipulation task



Force-distance curve for a APTES functionalized substrate during an approach.

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