Repulsive Force for Micro- and Nano-Non-Contact Manipulation

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Debye length

$$\kappa = \sqrt{\frac{\varepsilon k_B T}{\sum_i q_i^2 C_i^0}} \qquad \text{(SI-1)}$$

Where ε is the dielectric constant of the medium ($F.m^{-1}$), k_B the Boltzmann constant, T the temperature (K), q_i the ion charge, C_i the ion concentration ($ion.m^{-3}$)

Sphere-plan case modeling

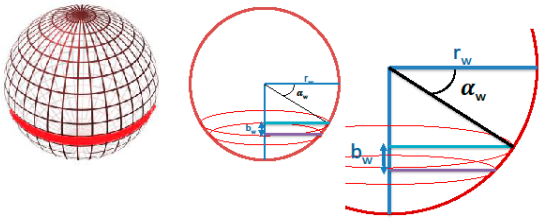

Figure S1: Band by band modeling of the sphere.

The elementary surface of the sphere dS_w is given by equation (SI-2):

$$dS_w = 2\pi . r_w . b_w \qquad \text{(SI-2)}$$

where w is the number of bands, b_w is the thickness of the band and r_w is the radius of the considered disk to the height of the band w:

$$r_w = r\cos(\alpha_w) \qquad \text{(SI-3)}$$

with α_w is the angle of the band w.

The orthogonal distance between the charge of the sphere and the substrate is defined by:

$$h_w = z + b_w.(w-1) + \frac{b_w}{2} \qquad \text{(SI-4)}$$

where z is the distance between the bottom of the sphere and the substrate.

Triple Electrical layer

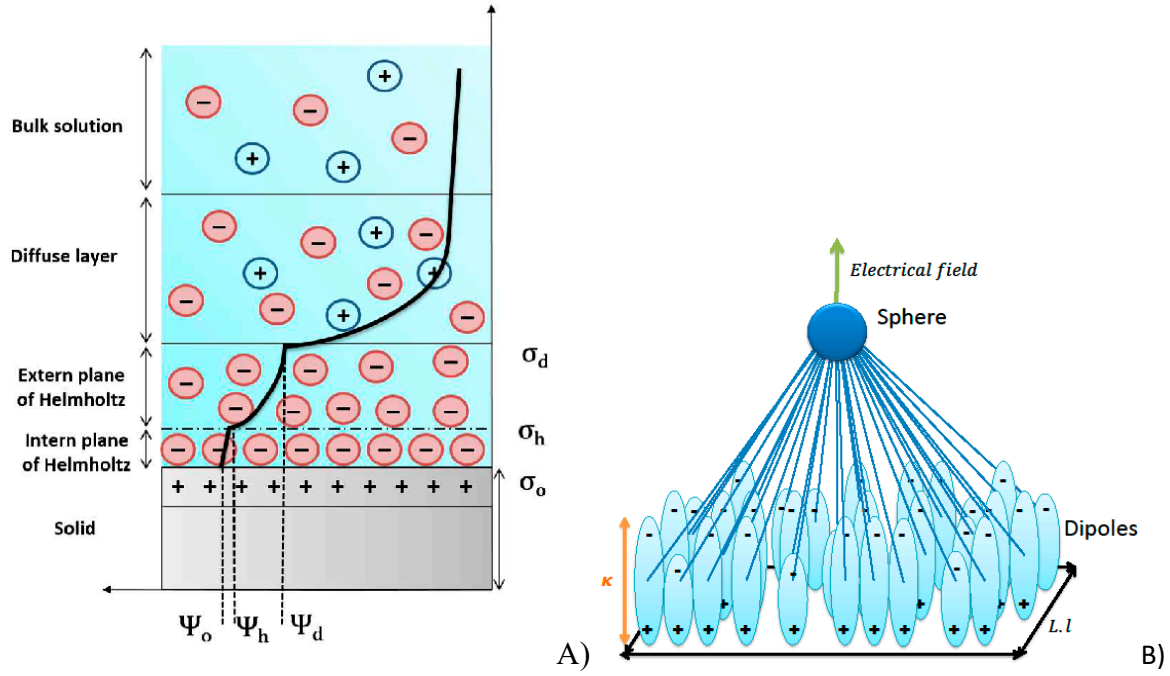

Figure S2: A) Ions distributions according to the triple electrical layer model; B) General modeling of interaction between charged micro-object and surface for this theory

Double Electrical layer

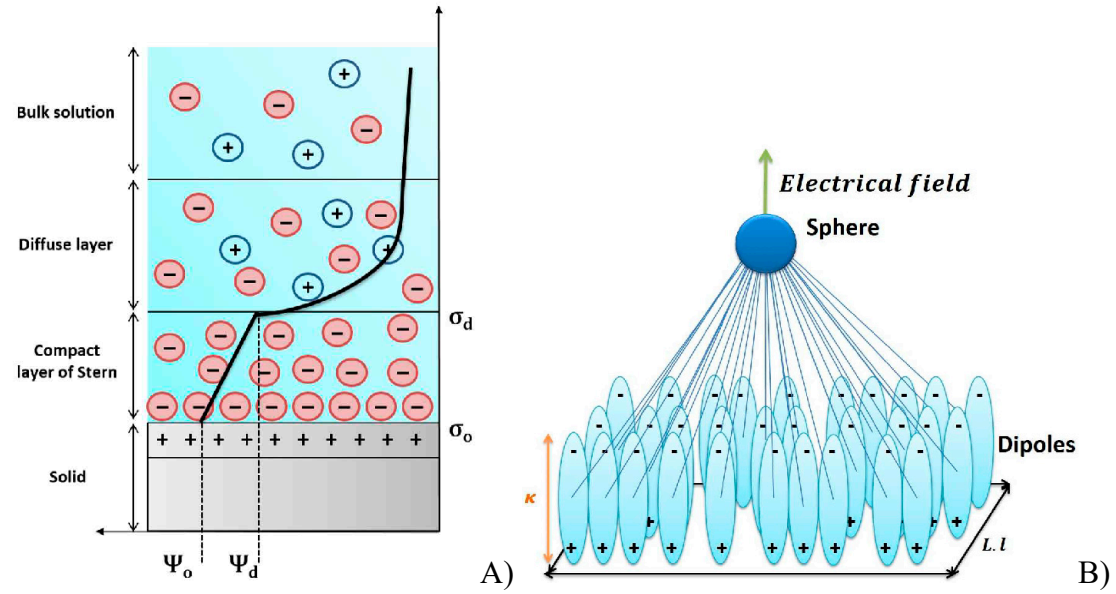

Figure S3: A) Ions distributions according to the double electrical layer model; B) General modeling of interaction between charged micro-object and surface for this theory

Influence of the band number on the sphere

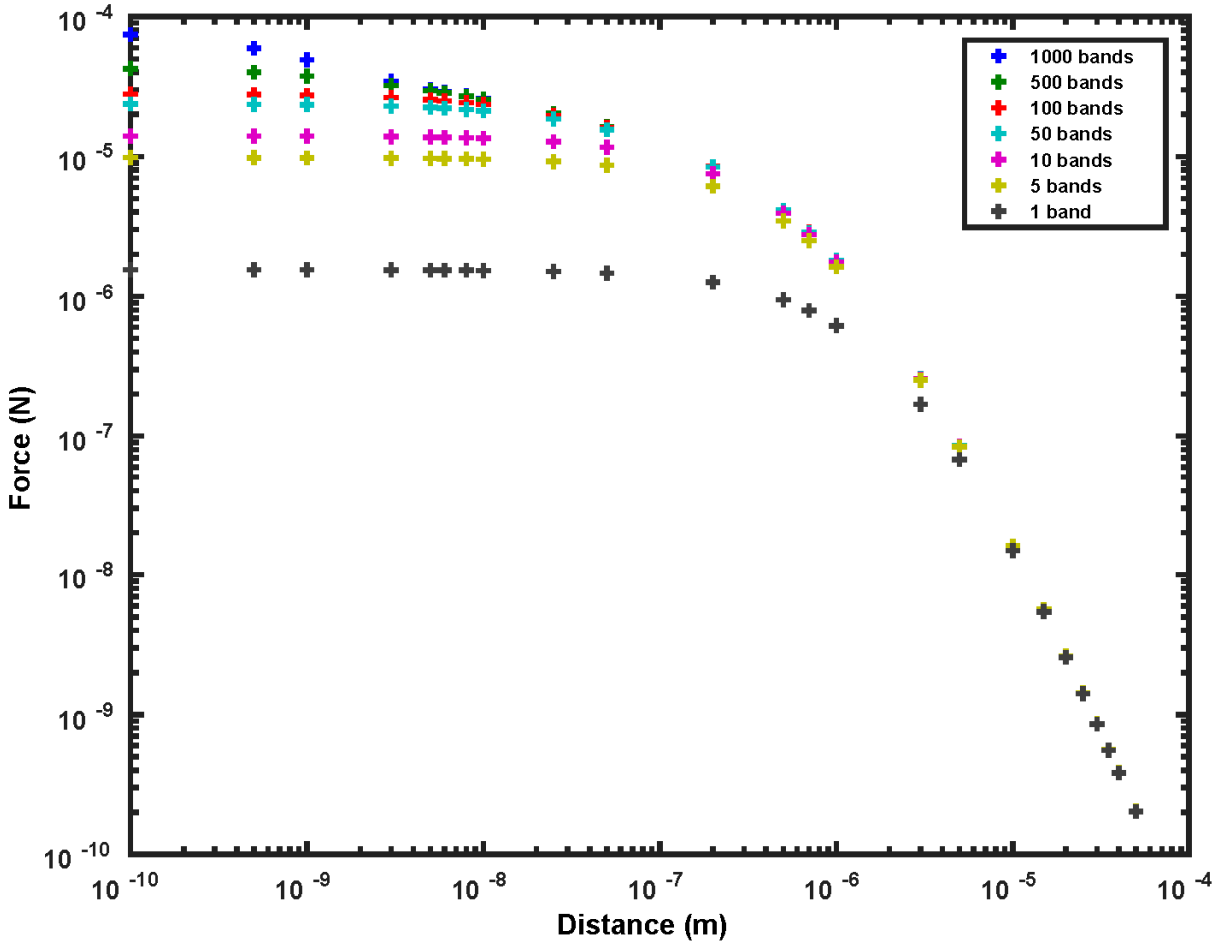

Figure S4: Modeling of the impact of the sphere band number on the force for a borosilicate sphere with a 10µm of diameter.

Modelling of the repulsive forces and distance between APTES film on surface and on borosilicate sphere glued on the tip extremity

The both surface charge were taken to 0.02 charge/nm² measured by zetasizer.

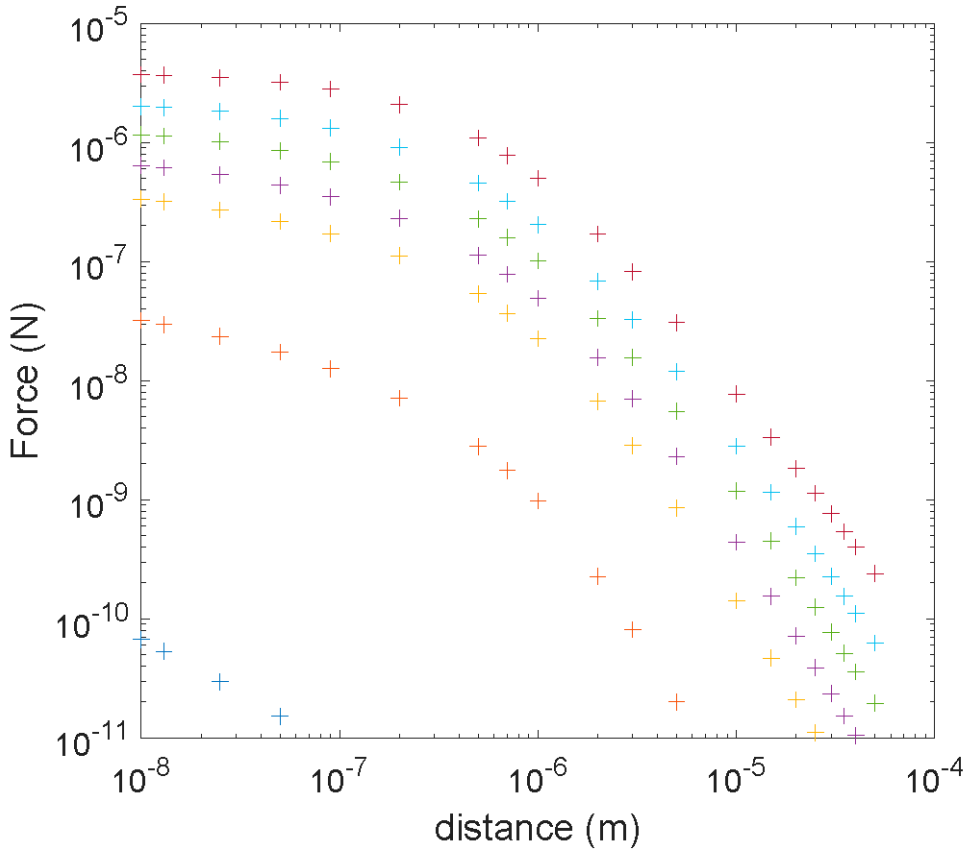

Figure S5: Modelling of the repulsive forces and distance between APTES film on surface and on different diameter size of borosilicate sphere glued on the tip extremity

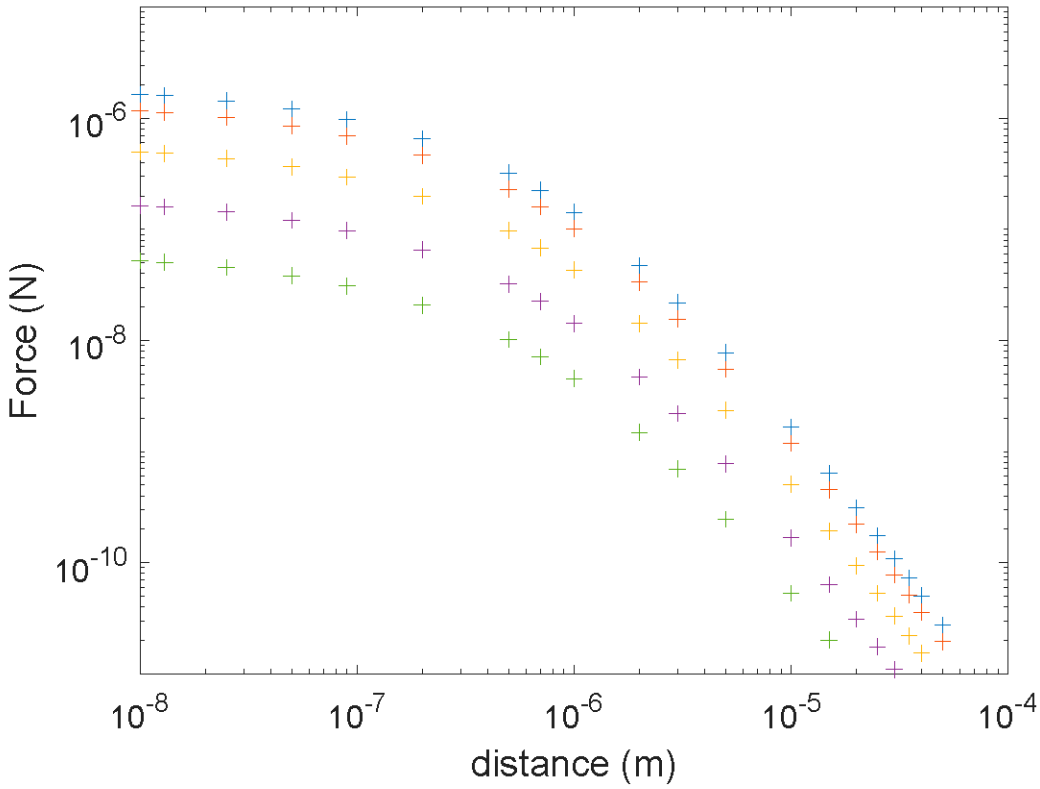

Figure S6: Modelling of the repulsive forces and distance between APTES film on surface and on 10µm borosilicate sphere glued on the tip extremity for different ionic strength.

Polypyrrole film

- **Electrodeposition localization**

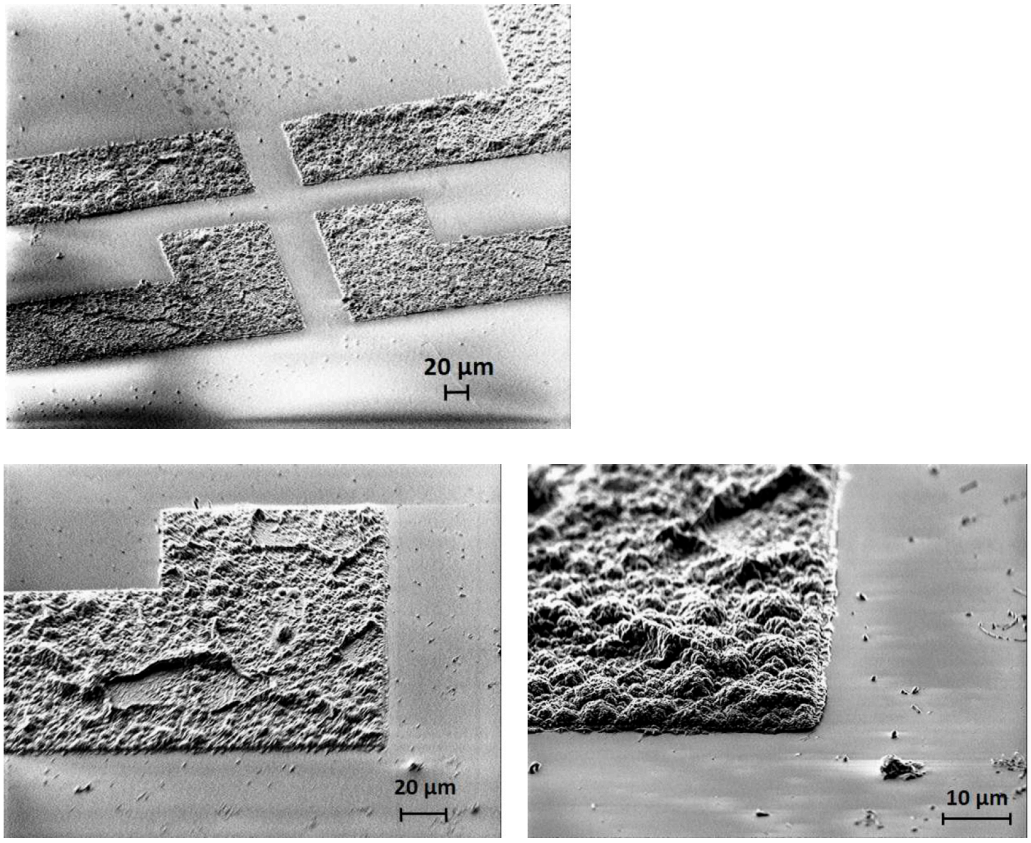

Figure S7: SEM images of the electrodeposition localization of polypyrrole with $LiClO_4$ on a gold electrode

We observe the right localization of the deposit on the conductive polymer whose morphology (cabbages flower) is a characteristic of the polypyrrole deposited with $LiClO_4$.

- **Current density**

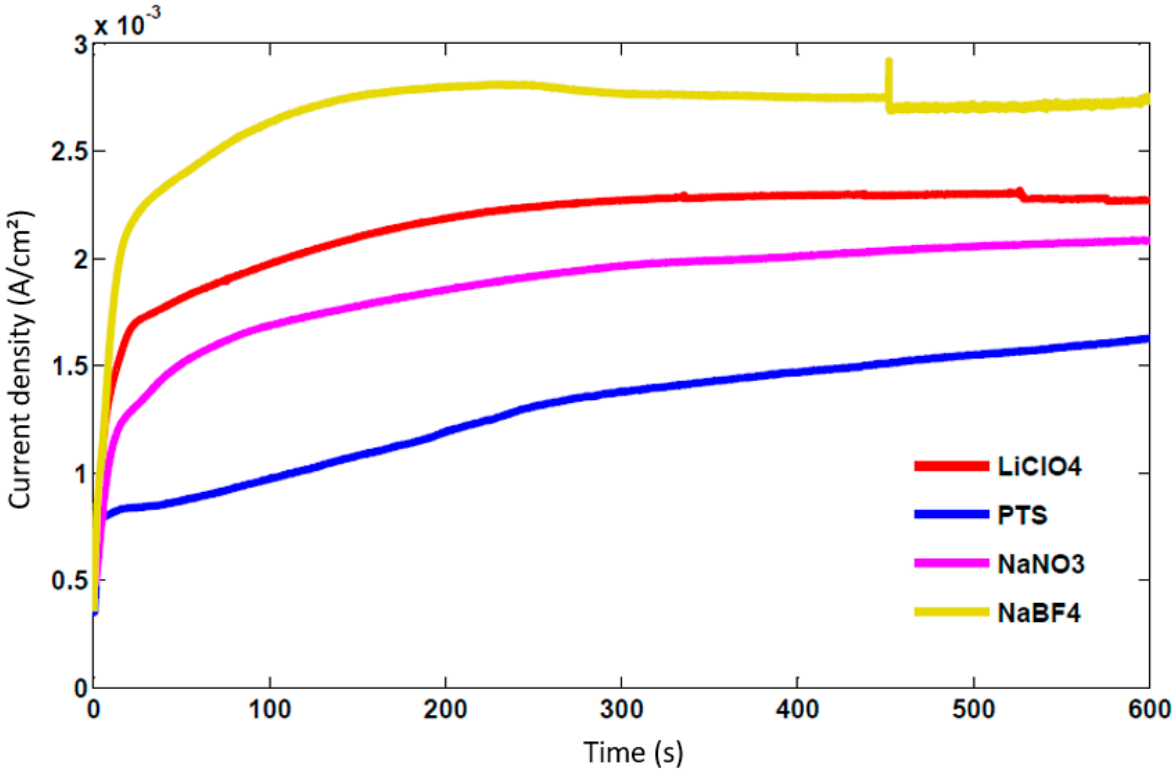

Figure S8: Evolution of charge density with time for different supporting salts.

- **SEM pictures**

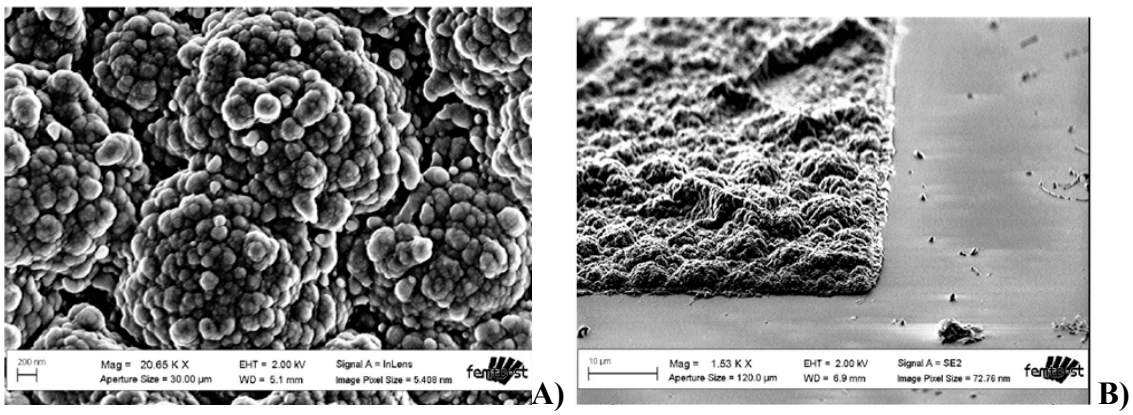

Figure S9: SEM image of the PPy/$LiClO_4$ film

- **Morphology**

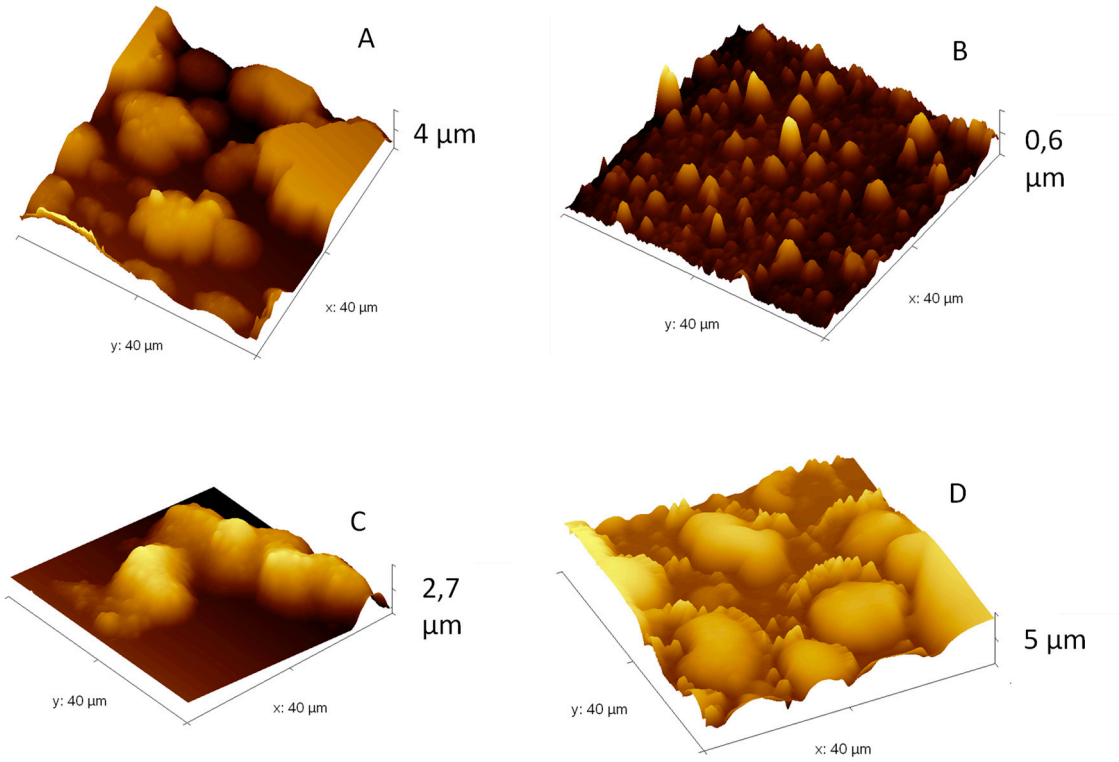

Figure S10: Polypyrrole film morphology versus the counter-ion used: A) ClO_4^-, B) PTS, C) NO_3^- and D) BF_4^-.

- **Repulsive force**

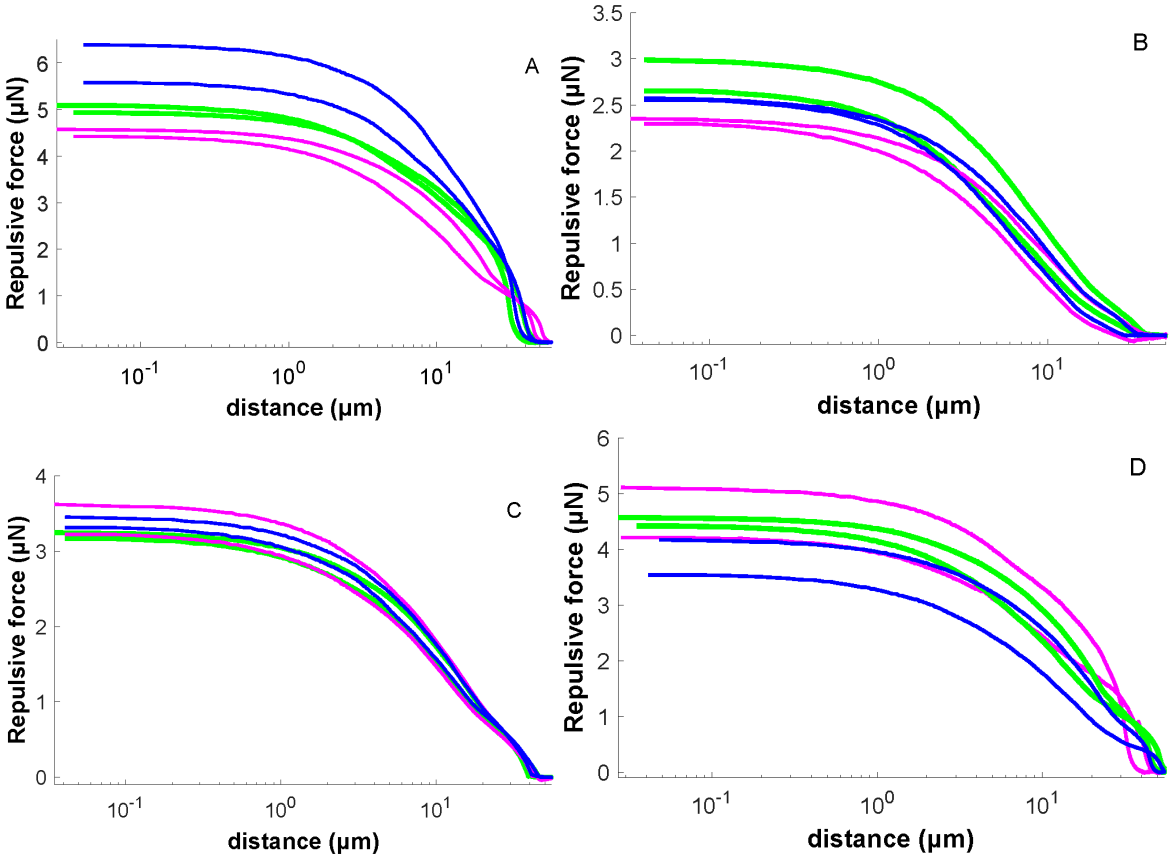

Figure S11: Repulsive force measured at pH 2 at three different points on the polypyrrole film electrodeposited with: A) ClO_4^-, B) PTS, C) NO_3^- and D) BF_4^-.

Electrophoresis simulation

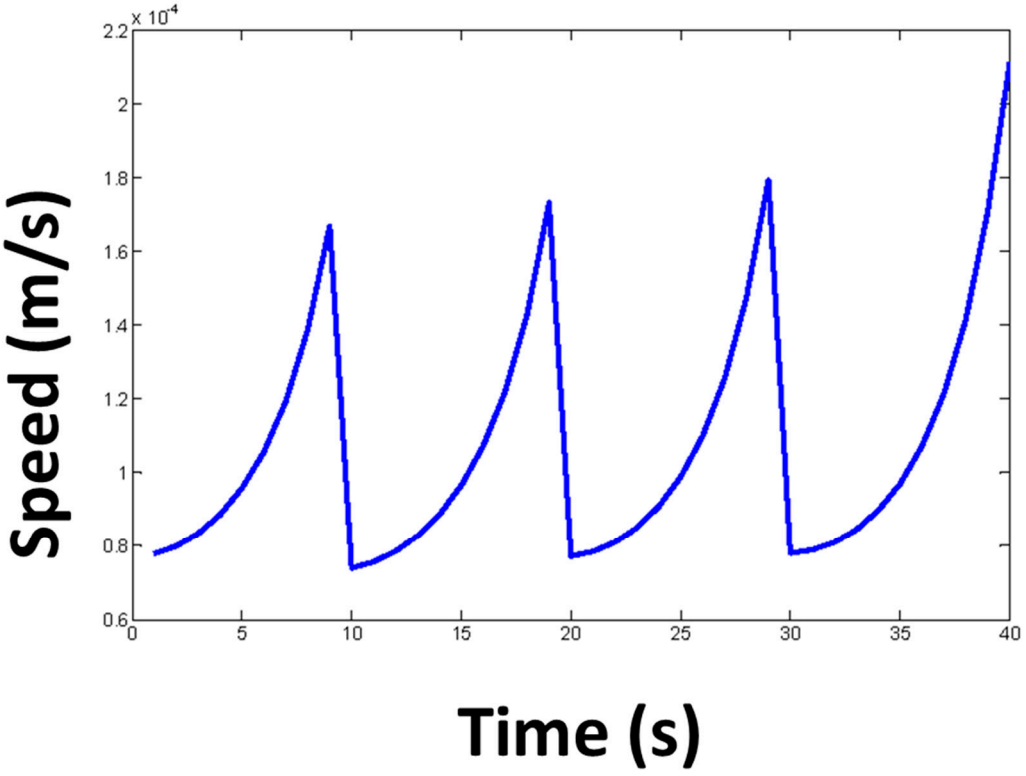

Figure S12: Electrophoresis simulation of functionalized microsphere

Micro-object rotation

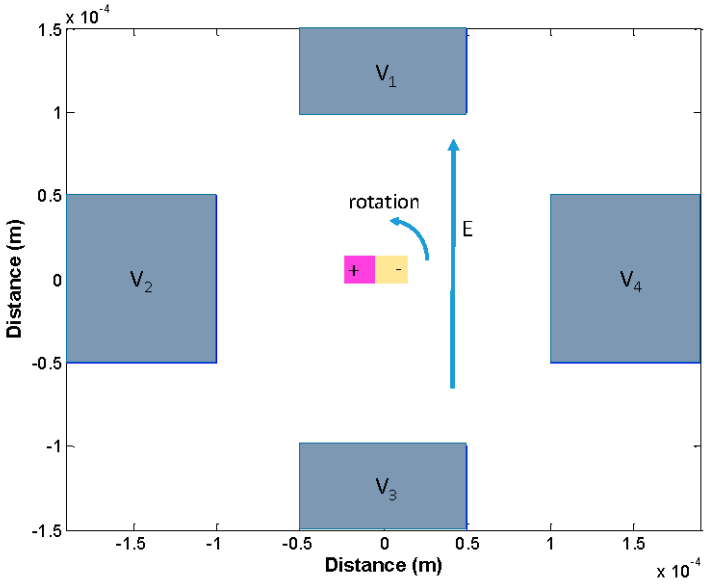

Figure S13: Rotation simulation of a micro-object functionalized by two molecules of opposite charge.