Surface charge and lipid phase domains regulate adsorption of polymer coated nanoparticles on lipid model membranes

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The interplay between NanoParticles (NPs), or more in general nanomaterials, and cell membranes is the basis of their possible usage for therapeutics [1]. Being the cell membrane the first place in which this interaction takes place, it's interesting to have a better understanding of the mechanisms of interactions at this level. A study on NPs and their capability of induce biological responses showed that rod-shaped semiconductor nanoparticles (NanoRods, NRs) can lead to tentacle-writhing behavior on a cnidaria *Hydra Vulgaris* in vivo [2]. Starting from this observation, in our group we are currently investigating how NPs of different shape, size, composition and superficial charge interact with neural networks and, in particular, how NPs surface charge is influencing electric activity of neurons [3]. With the aim to model the mechanism at the molecular scale, we studied here the interaction between semiconductor NRs and model membranes. NRs were in-house synthetized and on purpose functionalized with an amphiphilic polymer to tune their charge between -25 mV and +10 mV. The interaction with lipid mixtures of different complexity was tested, starting from mono-component membranes to multi-component, with and without the presence of lipid phase domains. In particular, NRs adsorption to Supported Lipid Bilayers (SLBs) was monitored by QCM-D technique; the interaction with lipid monolayers was measured with Langmuir isotherms. Preliminary results showed that tuning mutual electrical properties of the system regulates the adsorption of NRs on the membranes, where a threshold value in the difference between the zeta potential (ZP) of the NRs and the model membrane have to be reached in order to induce adsorption (fig. 1), and that structural properties of the membrane itself (i.e. the presence of saturated lipids or rigid phase-domains) have a role in the regulation of NRs adsorption (fig. 2). In particular high NRs binding affinity was measured in liquid disordered (Ld) phases (POPC/POPS mixtures); the presence of DMPC, lipid with saturated alkyl chains, greatly reduces NRs binding and even more in the presence of DMPC liquid ordered (Lo) phases at T=20°C.

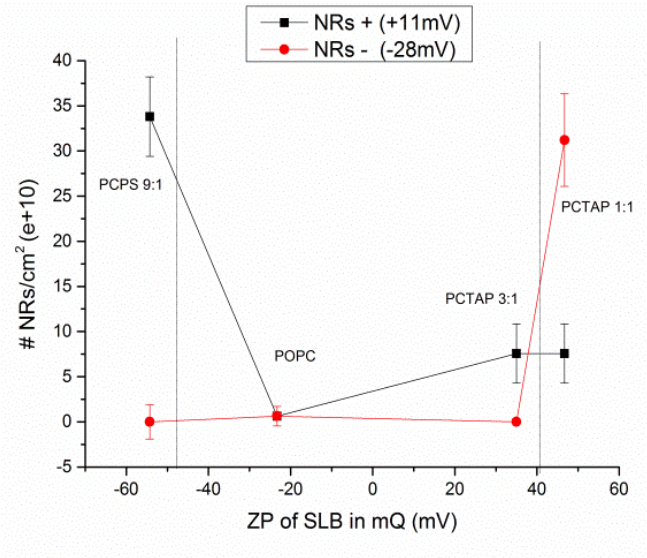

Fig.1. Number of NRs adsorbed per cm^2 on SLBs vs. SLB's zeta potential (in mV). Every ZP was measured from vesicles solutions in milliQ water. The graph indicates that the interaction between lipids in the SLB and NRs depends on electrostatic forces, and in particular on the difference between the ZP of SLB and NR.

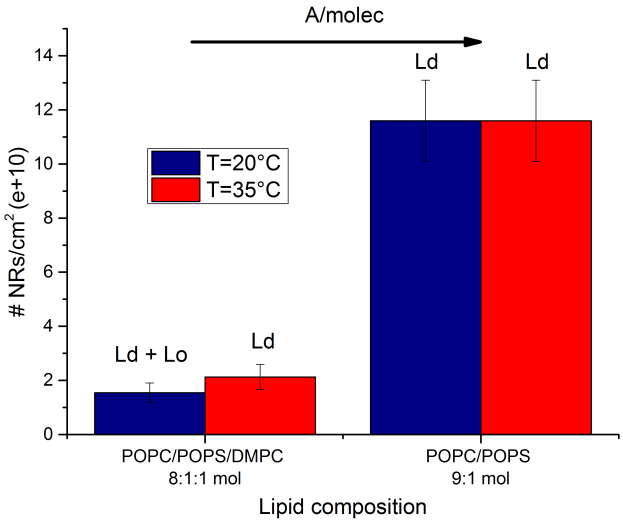

Fig.2. Number of positive charged NRs (ZP = +11mV) adsorbed per cm^2 on negative charged SLB (ZP = -58mV) composed by POPC/POPS 9:1 mol and POPC/POPS/DMPC 8:1:1 mol. It is useful to remind that the presence of DMPC itself and Lo phases reduces the average area per molecule occupied by the lipids in the SLB.

1. Parveen, S. et al, (2012) *Nanoparticles: a boon to drug delivery, therapeutics, diagnostics and imaging.* Nanomedicine: Nanotechnology, Biology and Medicine. **8**(2): p. 147-166.
2. Malvindi, M.A. et al, (2008). *Rod-shaped nanocrystal elicit neuronal activity in vivo*. Small, 4: 1747-1755.
3. S.Dante et al, ACS Nano (2017), DOI:10.121/acsnano.7b00397