Stabilization of layered nanomaterials by polyelectrolytes

Marko Pavlovic[1*], Paul Rouster[1], Li Li[2], Zi Gu[2], Endre Horvath[3], Laszlo Forro[3], Istvan Szilagyi[1]

[1]*Department of Inorganic and Analytical Chemistry, University of Geneva, Geneva, Switzerland*
[2]*Australian Institute for Bioengineering and Nanotechnology, University of Queensland, Brisbane, Australia*
[3]*Laboratory of Physics of Complex Matter, EPFL, Lausanne, Switzerland*

**marko.pavlovic@unige.ch*

Inorganic nanoparticles have been widely used as efficient gene and drug delivery agents. Among them, layered double hydroxides (LDHs) and titanates are popular nanocarriers due to their ionic exchange properties which allow intercalation of negatively charged bioactive compounds. The colloidal stability of the carriers is a critical issue, since aggregation of the particles can prevent the successful delivery of the target molecules. Therefore, we have studied the effect of adsorption of biocompatible polyelectrolytes, such as heparin (see structure in Figure 1) and PAMAM dendrimers on charging and aggregation of LDHs [1] and titanate nanowires (TiONWs) [2].

We found that polyelectrolytes strongly adsorb on particle surfaces of opposite charge leading to charge neutralization and subsequent charge reversal at appropriate doses. Light scattering experiments revealed that the particle stability is largely sensitive to the polyelectrolyte dose and the ionic strength. Unstable samples were observed near the charge neutralization point, however, the dispersions were highly stable when the particles were completely coated with polyelectrolytes, e.g., TiONW with PAMAM dendrimer or LDH with heparin. Figure 1 shows the latter example when the effect of the ionic strength on charging and aggregation of bare and heparin-coated LDHs were investigated. The coating resulted in negatively charged particles and an enormous stabilization effect reflected in a significant shift towards higher ionic strengths in the critical coagulation concentration (CCC) values.

In conclusion, bare LDH and TiONW particles were unstable at low salt levels, while polyelectrolyte-coating gave rise to highly stable dispersions, which are potential candidates as carriers in delivery processes even at high electrolyte concentrations where the bare particles would rapidly aggregate. These results allow designing efficient delivery systems where aggregation of nanocarriers can be tuned with biocompatible macromolecules.

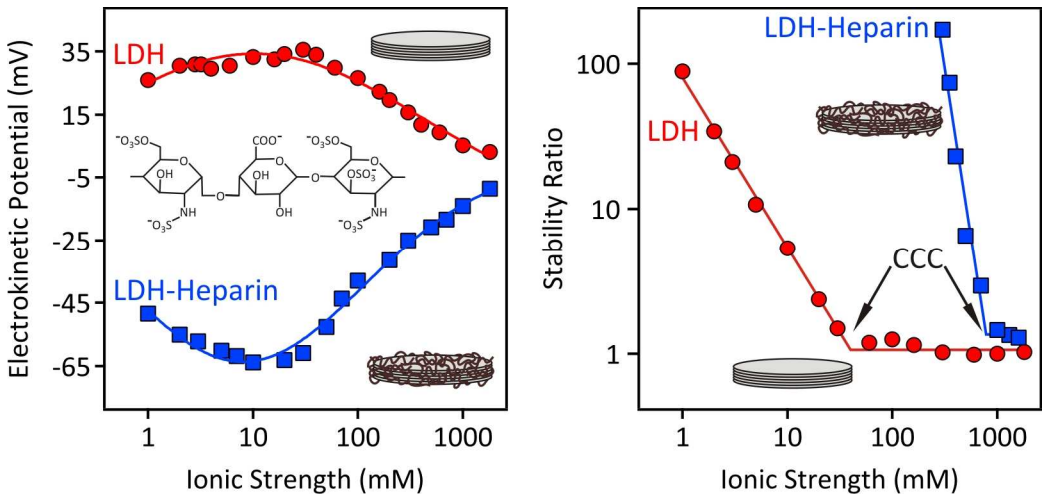

Figure 1. Electrokinetic potential (left) and stability ratio (right) of bare (circles) and heparin-coated (squares) LDH nanoparticles as a function of the ionic strength. Stability ratios close to one indicate rapid particle aggregation, while higher values refer to more stable samples.

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[2] M. Pavlovic, M. Adok-Sipiczki, E. Horvath, T. Szabo, L. Forro and I. Szilagyi, *J. Phys. Chem. C*, 2015, **119**, 24919.