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Complexation of oppositely charged polyelectrolytes in gene delivery and biology

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Charge inversion of a DNA double helix by a positively charged flexible polymer (polyelectrolyte) is widely used to facilitate DNA contact with negative cell membranes for gene delivery. Motivated by this application in the first part of the talk I study the phase diagram a solution of long polyanions (PA) with a shorter polycations (PC) as a function the ratio of total charges of PC and PA in the solution, x, and the concentration of monovalent salt. Each PA attracts many PCs to form a complex. When $x = 1$, the complexes are neutral and condense in a macroscopic drop. When x is far away from 1, complexes are strongly charged and stable. PA are overcharged by PC at $x > 1$ and undercharged by PC at $x < 1$. As x approaches 1, PCs attached to PA disproportionate between complexes. Some complexes become neutral and condensed in a macroscopic drop while others become even stronger charged and stay free. The second part of the talk deals with biological example of PA -PC complexes namely self-assembly of vegetable viruses from long ss-RNA molecule paying role of scaffold and identical capsid proteins with long positive tails. I show that optimization Coulomb energy of the virus leads to the charge of RNA twice larger than the total charge of the capsid, in agreement with the experimental data. Then I discuss kinetics of the Coulomb complexation driven virus self-assembly. Capsid proteins stick to unassembled chain of ss RNA (which we call "antenna") and slide on it towards the assembly site. I show that at excess of capsid proteins such one-dimensional diffusion accelerates self-assembly more than ten times. On the other hand at excess of ss-RNA, antenna slows self-assembly down. Several experiments are proposed to verify the role of ss-RNA antenna in self-assembly.