DNA Compactization in a Crowding Environment with Negatively Charged Protein

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We studied the conformational properties of DNA in a salt solution of the strongly charged protein bovine serum albumine (BSA). DNA is compacted when a suitable amount of BSA was added to the solution due to a crowding effect and strong electrostatic repulsion between DNA and BSA, both of which carry negative charges. However, it was found that DNA undergoes an unfolding transition with an increase in the salt concentration which observation contradicts the current understanding of polymer- and salt-induced condensation, ψ-condensation. We propose a theoretical model by taking into account of the competition between the translational entropy of ions and electrostatic interaction (results are shown in Figure). One can see that with an increase in the salt concentration, the point of the sharp coil-to-globule transition shifts to a higher protein concentration. This fact means that an increase in the low-molecular-weight salt could lead to the unfolding of DNA. This theoretical conclusion corresponds to the experimental data.

DNA swelling ratio α as function of the protein volume fraction $\phi_p$ for different salt concentrations $n_s=10^{-6}$ (a), $5 \times 10^{-6}$ (b), $10^{-5}$ (c). $\phi_i$ is critical protein concentration for inducing the folding transition into a compact state.

We would like to mention that the effect found and described here can be observed for any charged macromolecule in the presence of strongly charged species immersed in salt solution. The results obtained are compared with dates on DNA compactization called by another compacted agents.