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Translational and rotational diffusion of semiflexible DNA polymers and rod-like *fd* virus particles on weakly charged freestanding cationic lipid membranes

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Diffusion and conformational dynamics of single semiflexible and flexible macromolecules and colloids adhereing to freestanding lipid membranes is a challenging problem both from the experimental and theoretical standpoint. Using cationic supergiant unilamellar vesicles [1] as an experimental platform for mimicking freestanding lipid membrane in combination with single-molecule fluorescence video microscopy, we have previously discovered that local interaction of single DNA molecules with moderately and strongly charged freestanding lipid membranes can lead to interesting unexpected effects [2]. In the present contribution, using the same experimental technique, we investigate the diffusion behavior of semiflexible DNA polymers and much more rigid negatively charged colloidal particles, *fd* viruses [3], upon their electrostatic binding to weakly charged freestanding cationic lipid membranes. The wide range of contour lengths of DNA macromolecules (5–48.5 kbp) and *fd* virus particles (0.88–9.7 μm), allowed us to observe the crossover from the stiff-rod to semiflexible (*fd* virus) and from semiflexible to flexible (DNA) behavior which is accompanied by a crossover in the diffusion behavior of membrane-attached particles – from the 2D membrane-controlled to 3D bulk fluid-controlled diffusion dynamics. We compare the obtained experimental results on translational and rotational diffusion of DNA and *fd* virus particles with the predictions of hydrodynamics-based theories of membrane diffusion [4–8] and determine their ranges of applicability.

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