

## **Medical Applications of Fractionalization of Charge**

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Gene delivery requires inversion of DNA charge in order to facilitate its contact with negative cell membranes and penetration inside cytoplasm. Charge inversion of a DNA double helix by a positively charged flexible polyelectrolyte is widely used for this purpose. Effectiveness of charge delivery due to complexation is known to grow thousand times in cell cultures. Trials on cancer patients are in order.

We consider mechanism of charge inversion in terms of discrete charges of DNA when in the neutral state of the DNA-polyelectrolyte complex, all DNA charges are locally compensated by a polyelectrolyte charge. When an additional polyelectrolyte molecule is adsorbed by DNA, its charge gets fractionalized into monomer charges of defects (tails and arches) on the background of the perfectly neutralized DNA. These charges spread all over the DNA eliminating the self-energy of the polyelectrolyte molecule. This is the driving force of charge inversion. Fractionalization leads to a substantial positive charge of DNA-polyelectrolyte complex. It was observed in electrophoresis experiments.

We show that fractionalization driven charge inversion is also possible when polyelectrolyte is adsorbed on a surface with a two-dimensional lattice of opposite charges, for example, a charged solid membrane. This is the first classical example of fractionalization of charge beyond one dimension.