

Study of polyelectrolyte adsorbent theory on a repulsive charged surface

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Abstract. Applying scaling theory of polyelectrolyte adsorption, and according to ratio of the dielectric constant between the medium and the substrate, and taking into account strong interaction between polyelectrolytes of multivalency adsorption, we proposed a scaling theory of the approximation method on a repulsive charged surface. It is divided into two kind phase diagrams that one is qualitatively different. This shows when the surface charge density is low (or the bulk counterion density is high), the surface and the bulk counterion density are almost the same. Once the surface charge density is high enough, counterions condense on the surface. In this regime, polyelectrolytes of lower valency form a correlated many-chain state. As their valency is high enough, the state turns out to be single-chain because of stronger repulsion between neighboring chains.

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Key words: dielectric constant, polyelectrolyte, charged of surface, adsorbent theory

1 Introduction

Over the past decade, lots of researches have been done on polyelectrolytes on induced surfaces both theoretically and experimentally [1]. By applying Van der Waals Force based on Lifshitz quantum electrodynamics established the general theory, Chen and Li researched on the attractive potential between same dielectric molecules in the vacuum,

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hoping to get their (including atoms) equivalent interaction potential [2]. Through analysis of the dielectric constant on a material surface for granular film, Ge and Zheng calculated the dielectric constant of granular film, based on the relative dielectric constant of the substrate material and the distance between polar molecules. In their paper, they also found out that the interaction between molecules and the material surface plays the solo role when the molecular size is close to the molecular critical size; while the local-field interaction plays the major role when the two values differ largely [3]. Recently, Grosberg's research on the physics of strong interaction of water at room temperature leading to the discovery of abnormal charge inversion of charged macromolecules has aroused great attention [4]. Theories on polyelectrolyte absorption on induced surfaces focus on analyses of multilayer forms of the charge inversion on surfaces. They fall into two categories involving combinations of multi-chain polyelectrolyte absorption on two different charged surfaces. One is the self-consistent field theory (SCFT), also known as Edwards's equation and Poisson-Boltzmann equation [5-7]. The former describes the conformation fluctuation of polyelectrolytes within the ground state limit [8]; while the latter is concerned with the local electrostatic potential at the mean-field level [9]. The other is scaling theory, which predicts that polyelectrolytes on induced surfaces will go through the transformation from the compressed state to the invisible metamorphosis state before desorption [10-11]. When conformational changes are ignored, the scaling of absorbing layer of surface charge density is different from that of SCFT.

The single-stranded absorption on high dielectric substrate which repels surface charge is protruding; indicating polyelectrolytes can overcome slight surface repelling with the Coulomb attraction and be absorbed by the substrate. This paper tends to further study the strong correlation between multi-valent dielectrics absorption, so as to establish an approximate scaling theory on surface repelling charge. Poisson-Boltzmann equation can be applied to explain the absorption of monovalent ions with opposite charge, because mean-field theory is still valid for their general behavior.

2 Theoretical models and results

Polymer dielectric chain will be related to polymerization number N , charged monomers fraction f , bond length a , if it is in the solution whose dielectric constant is ϵ . In the solution which bases the high dielectric chain ϵ' , its base's surface charge density is σ . In low ionic strength, Debye screening length is much larger than the adsorbed layer thickness. When the charge level is slightly repulsive, simple polymerization dielectric is still adsorbed. In other words, when the surface charge density does not exceed the critical value, polymer dielectric will release the potential barrier formed by repulsive surface, the outcome of the encounter of the image charge [12].

When the multivalent polymerization is adsorbed on the electric exclusion surface, forming a two-dimensional surface (2D) Wigner liquid [13-16], the Poisson Boltzmann theory will fails due to the strong interaction between polymer dielectric.