ADSORPTION OF PROTEIN AND BIONANOPARTICLES: MECHANISMS AND APPLICATIONS

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ABSTRACT: In biotechnology and biomedical engineering the adsorption properties of biological materials such as proteins, viruses, virus like particles are of utmost interest. Virus, virus like particles, protein superstructures, and nanoparticles made of biological material are often termed bionanoparticles. Understanding of the adsorption mechanism helps to design surfaces for separation of proteins or bionanoparticles either by chromatography on porous beads, by membrane chromatography with functionalized membranes, or monoliths. Understanding of adsorption mechanism also helps to develop strategies to prevent undesired protein binding to surfaces. The initial binding of biological material on surfaces may lead to progressive fouling, which is not desired for a lot of biomedical devices, especially those which are implanted for a long period. The adsorption of proteins on surfaces can be driven by the surface tension in the liquid and the hydrophobicity of the surface. With increasing salt concentration of kosmotropic salts the adsorption is promoted. This has been described by the solvophobic theory. In such a case the adsorption itself is an entropic driven process. Simultaneously to the adsorption the protein can undergo a conformational change, which again is a highly entropic process. The surface acts as a kind of catalyst for the unfolding. Depending on the nature of the surface the unfolding can be reversible after desorption. The kinetics of unfolding is a rather slow process compared to heat or chemical denaturation of proteins. The adsorption can be also driven by electrostatic interaction, especially at low salt concentration. Also for electrostatic interaction the adsorption is an entropic process for proteins and bionanoparticles. All proteins and bionanoparticles carry charge groups, which bind to the surface. With increasing size of molecule the interaction strength increases in electrostatic interaction. Thus a lot of bionanoparticles also bind in presence of a relatively high salt concentration; often above 200 mM NaCl. This is explained by the high number of charges on bionanoparticles. Theoretical consideration will be discussed how the binding capacity increases in porous chromatography media and in monoliths with increaseing molecular mass. The effect of diffusional hindrance will be explained. Examples will be given for separation of proteins with ion exchangers and the effect of salt on binding. Design rules for scale up will be provided and an overview of current media will be presented. Then examples will be discussed for purification of bionanoparticles with monoliths. Strategies will be shown how to prevent fouling or unspecific adsorption of bionanoparticles in charged media. Trends for separation of bionanoparticles will be discussed and an outlook will be given.

KEYWORDS: pore diffusion, adsorption, protein, virus, virus like particles, dynamic binding capacity, equilibrium binding capacity, selectivity