Effect of osmolytes and Hofmeister salts on protein adsorption

Florian Evers, 1,* Juny Koo, 2 Christian Reichhart, 2 Anne K. Hüsecken, 1 Roland Steitz, 3
Thomas Gutberlet, 4 Metin Tolan, 1 and Claus Czeslik 2

1 Fakultät Physik/DELTA, Technische Universität Dortmund, D-44221 Dortmund, Germany
2 Fakultät Chemie, Technische Universität Dortmund, D-44221 Dortmund, Germany
3 Helmholtz-Zentrum Berlin, D-14109 Berlin, Germany
4 FZ Jülich, JCNS at FRMII, D-85747 Garching, Germany
*e-mail: florian.evers@tu-dortmund.de

In a biological cell, proteins perform their functions in a highly complex environment comprising crowding and confinement effects as well as interactions with interfaces, cosolvents, and other biomolecules. Cosolvents can stabilize or destabilize the native folded structure of proteins in solution. Here, we present recent studies on how ionic and non-ionic cosolvents affect the interfacial affinity and structure of proteins at hydrophilic and hydrophobic surfaces [1,2]. We studied the adsorption of bovine ribonuclease A (RNase A) at the silica-water, the polystyrene-water, and the air-water interface as model systems that were analyzed applying optical reflectometry as well as neutron and X-ray scattering techniques. The degree of protein adsorption and the density profile of the adsorbed protein films were determined in the absence and the presence of cosolvents. It has been found that both the protein stabilizing glycerol and the destabilizing urea cause a distinct reduction in the interfacial affinity of RNase A, which may represent a rather unexpected result. At the hydrophobic polystyrene surface, it has been found that both the kosmotropic salts, (NH₄)₂SO₄ and Na₂SO₄, and the chaotropic salts, NaSCN and Ca(SCN)₂, significantly reduce the amount of adsorbed protein, while maximum adsorption is observed in the presence of NaCl.

Fig. 1. Suggested mechanisms for the effect of kosmotropic and chaotropic ions on protein adsorption.

These findings were explained by the suggestion that proteins become preferentially hydrated in the presence of kosmotropic cosolvents thus disfavoring conformational changes of the protein, whereas chaotropic cosolvents are accumulated at the protein surface thus weakening hydrophobic protein-substrate interactions. Thus, there seem to be general mechanisms how protein stabilizing and destabilizing cosolvents influence the process of protein adsorption.