Protection of Trehalose Against Dehydration for Model Peptide

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The interaction between carbohydrates and biomolecules, such as peptides and proteins, is thought to be functional for the protection against environmental stresses of these latter class of molecules. Among carbohydrates, the disaccharide trehalose is an excellent bioprotective agent, in particular regarding stress due to dehydration. To date there are three possible hypotheses that try to explain structural and dynamical mechanisms of the bioprotective mechanism (Figure 1). The first one is by substitution. Here, trehalose replaces the water molecules in the hydration shell of the protein, maintaining its functionality and structure [1,2]. The second one is by vitrification, where trehalose interacting with water solvent causes a glass-like transition of the system, stabilizing it [3,4]. The third one is by confinement. According to this latter hypothesis, the carbohydrate cages residual water molecules around the biomolecule to be protected, eliminating the stress due to further dehydration [5]. To clarify which of these hypotheses better describes the real situation, a series of neutron diffraction experiments with H/D isotopic substitution, combined with EPSR computer simulations, have been performed on aqueous solutions of trehalose and a model peptide (NMA). The results indicate that the addition of trehalose to peptide aqueous solution does not alter the peptide first hydration shell (Figure 2), with no hydrogen bonds between trehalose and NMA. Furthermore, trehalose creates a cage around the hydrated peptide (Figure 3) [6,7]. Therefore, these evidences provide support for the validity of the confinement hypothesis, without ruling out the vitrification scenario. Further studies at very low water content will be performed to investigate this issue in detail in order to reach a full comprehension of the bioprotective mechanism.

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Figure 1. Bio-protection hypotheses.

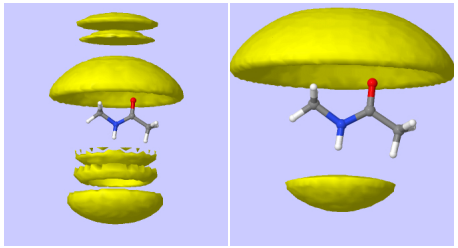

Figure 2. Hydration shell of NMA.

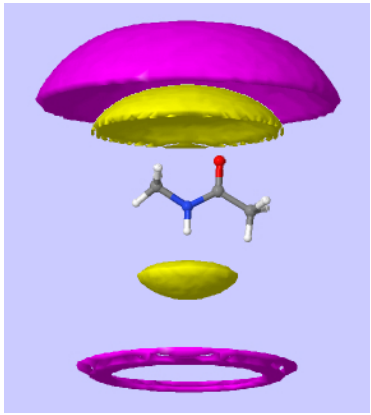

Figure 3. Hydration shell of NMA and around the trehalose cage.