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Spectroscopic Demonstration of Protective Effects of Trehalose in Proteins Aqueous Solutions Against Electromagnetic Fields

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ABSTRACT

Abbreviations: EMFs: Electromagnetic Fields; FTIR: Fourier Transform Infrared; HB: Hemoglobin; BSA: Bovine Serum Albumin; LYS: Lysozyme; MB: Myoglobin; SMF: Static Magnetic Field

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In this brief review paper the protective effectiveness of trehalose against magnetic fields was shown. FTIR spectroscopy was used to study this protective effectiveness and, to this aim, typical proteins in water solutions in absence and in presence of trehalose were used. Trehalose is a disaccharide such as sucrose, having the same chemical formula $C_{12}H_{22}O_{11}$ and the same number of hydroxyl groups. Trehalose has the peculiarity to protect some organisms in extreme life conditions because it can stabilize organic systems and it has been already used to protect organic systems from several stress agents. Several hypotheses were proposed to explain such protective effectiveness. For instance, (Crowe, et al. [1]) assumed that trehalose-water interactions occur because trehalose can be adapted to the tetrahedral coordination of pure water (the so called "water replacement hypothesis") and (Donnamaria, et al. [2]) confirmed this hypothesis.

These mechanisms can explain bioprotective effectiveness of trehalose against several stress agents that was observed up to now and in particular against man-made electromagnetic fields (EMFs).The importance of this study is due to several experimental observations of harmful effects of EMFs on biological systems that were reported in literature. In order to show the effects of exposure to EMFs and the protective effectiveness of trehalose against EMFs, Fourier Transform Infrared (FTIR) spectroscopy was used by the authors, because this technique represents a valuable tool for analyzing proteins structure in water solutions in absence or in presence of bioprotectors [3-5]. Hemoglobin (Hb), bovine serum albumin (Bsa), lysozyme (Lys) and myoglobin (Mb) diluted in water solution at the concentrations of 50-

150 mg/ml were already used to test the effects of EMFs on simple organic systems [6-9]. Further studies have been carried out to investigate the response of some bioprotectors to this stress agent, so that other proteins samples in aqueous solutions were prepared at the same concentrations adding trehalose at the concentration of 50 mg/ml.

A static magnetic field (SMF) at 200 mT and a 50 Hz frequency EMF at 1-2 mT were created by an experimental setup which consisted of a couple of Helmholtz coils, with pole pieces of round parallel polar faces, to produce a uniform magnetic field at the center of the coils distance where proteins sample were located. Exposures of 3 h were carried out for each type of sample. More details regarding sample preparation and this experimental setup can be found in [10-12]. Exposure of Hb in water solution to a SMF at 200 mT induced a decreasing in intensity of the Amide A vibration band and of CH_3 symmetric and asymmetric stretching vibrations, but the addition of trehalose in Hb aqueous solution reduced significantly these effects [12]. Exposure of Bsa to 50 Hz EMF at 1 mT produced a loss of C=O and C—N stretching vibrations and of NH bending linkages, but these changes were not observed in the secondary structure of this protein after the addition of trehalose. Furthermore, 3 h exposure of Hb and Bsa in separated water solutions to 50 Hz EMF at 1 mT induced also a heavy effect on their secondary structure, represented by an increase in intensity of the β-sheet feature as to the α-helix component in the Amide I region of these proteins, whereas no significant alteration was observed exposing analogue samples in trehalose aqueous solution [10,11].

This result can have relevant application in medicine, because previous studies showed that proteins denaturation represented by the transition from α-helix to β-sheet feature in proteins secondary structure represents a relevant sign of proteins aggregation that can lead to the neurotoxicity and neurodegenerative disorders. Indeed, the primary sign of neurological diseases such as Alzheirmer, Parkinson and Huntington is proteins aggregation [13-16]. Finally, more relevant sign of denaturation was observed after exposure to microwaves of Hb, Lys and Mb in bidistilled water solution, but this effect did not occur in samples in trehalose aqueous solution [17-21].

This protective effect of trehalose that was highlighted by means of FTIR spectroscopy can be explained assuming that a compensatory mechanism occurs under exposure to EMFs or SMFs. Typical proteins in aqueous solution were used in those simulation studies in order to represent the environment in a cell in which ions, proteins and other macromolecules are embedded. The partial mobility of proteins in such environment can allow EMFs to induce their orientation and denaturation, that can be detected by FTIR spectroscopy by measuring changes in intensity or frequency of their vibration bands. In contrast, the addition of trehalose produces a sort of tetrahedral coordination of pure water, inducing a reduction of proteins mobility that occurs under exposure to EMFs, stabilizing their secondary structure and producing a shielding action against EMFs.

In the light of these results we can conclude that trehalose stands out as a good bioprotector against harmful effects of EMFs.

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