Aqueous Ionic Solutions Investigated by Time Resolved Delayed Luminescence

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Abstract

Many authors have suggested that liquid water could exists in two states, low-density (LDW) and high-density (HDW), a theory that was firstly used to explain the behaviour of water density in the range between -30° C, the super-cooled region, up to 70 C°. According to this view liquid water consists of rapidly inter-converting LDW clusters and HDW clusters and, while the molecular movements in liquid water require constant breaking and reorganization of individual hydrogen bonds on a picosecond time scale, at any instant the degree of hydrogen bonding is very high, more than 95%. This view has been further expanded and consolidated by the Chaplin's two states model of highly ordered icosahedral network that interconverts between a fully expanded low density form and a collapsed high density form.

Chaplin's model succeeded to explain many astonishing properties of water including the existence of a massive exclusion zone (EZ) whose existence has been recently demonstrated and which appears to involve millions of water layers and to be stable for days . In this frame recent spectroscopic measurements have been performed in order to compare the behaviour of the EZ adjacent to Nafion (hydrophilic) surface to that of saturated solution of inorganic salts in which water ordering is expected.

In fact the presence of ions stabilize localized water clusters in the bulk of the solution as they reduce the hydrogen bonding exchanges of the affected water molecules. According to the two-states model of water, there are two classes of solutes, that partition into HDW and LDW, respectively.

In the last few years several studies have demonstrated that the Delayed Luminescence (DL), the photo-induced ultra-weak emission of light which lasts from microseconds up to seconds after the switching off of the illumination source, is able to give structural information on several systems. DL, in facts, is connected to the formation and decay of collective electron states such as excitons or solitons and is then related to the structure of the whole system. For this reason DL should be potentially able to provide useful information on possible structures present in water.

In order to check this possibility the time resolved DL from diluted salt aqueous solutions has been measured. The DL signal from salt solutions is significantly relevant when a prevalence of LDW domains is foreseen. The decay time probability distribution function is characterized by a broad maximum in the microsecond range This suggests the existence of structures characterized by lifetimes in the same time scale. These results, never reported in Literature, appear important.