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Solvents break the ice!

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Add sand to a jar of water and the level will rise. But adding sugar does not raise the level as much, as the sugar dissolves. S.Ananthanarayanan takes a peek into what actually happens!

In the first case the level rises because sand particles ‘edge out’ the water molecules, which then occupy new space. But in the second case, the sugar molecules do not quite ‘edge out the water, but end up ‘sharing’ the space between the water molecules.

Hence, if we add 10ml of sand to water standing at the 100mlmark in a jar, then the liquid will rise to the 110 ml mark. But if it were 10 ml of sugar that we added, the volume does not rise by the whole 10 ml.

Solvents break the ice!

The water, in fact, ‘weakens’ the forces that keep the molecules of sugar as crystals and gets the molecules to ‘loosen up’ and ‘mix around’. And the structures of the water and sugar molecules are such that there is ‘interlocking’, with the sugar finding place within ‘gaps’ inside the water molecules.

This is how the sugar dissolves without adding as much volume as it occupied to start with, and the solution is just a wee bit bulkier than the water was at first. But the whole weight of the sugar is there in the solution, and the solution is certainly ‘denser’!

Vintners and milkmen

That a solution gets ‘denser’ is useful to find out how much of the solute there is. A ‘hydrometer’ is an instrument that sinks deeper in ‘lighter’ liquids, and its narrow neck can be marked to directly read off the density of the liquid. This is how they tell how much sugar there is in grape juice, to know how good it is to make wine. And when it is used to tell how much fat there is in milk, then the instrument is called a ‘lactometer’. (In the first case it’s a ‘vinometer’)

This change of density of a solution is important for sailors when cargo ships move from seawater to river water. Seawater, which is salt, is nearly a third heavier than river-water and a ship that floats high in seawater and sinks deeper in fresh water.

Its good the sea is salt!

Salt, in fact, does some strange things when it dissolves. For one, it does not just become salt molecules, from the ‘bound’ salt crystal. It also ‘ionises’. This means the sodium and chlorine atoms do not stay together, but they float apart, as positively and negatively charged sodium and chlorine ‘ions’. The water molecule itself is a negative oxygen atom, linked to two positive hydrogen atoms, and not ‘symmetrically’, but bent, like a clip. This creates a surrounding charge field that helps the sodium and chlorine atoms to drift around.

In fact, these drifting ions also causes the ‘clip’ shaped’ water molecule to fold up a bit, and the volume of a solution of salt, in fact, is ‘less’ than the original solvent! This fact leads us to another marvel - just think, if the sea were less salt, the oceans would occupy more space, and most landmasses would be submerged!