The search for extra-terrestrial life is often restricted to the 'Goldilocks Zone,' that is, to planetary objects with environments that support liquid water. This is because of the importance of water to life as we know it on Earth, however, using terrestrial limitations to search for extra-terrestrial life is short-sighted. Through evolution, life as we know it has come to rely on water, but is it possible for all the conditions for life to originate in a water-free environment?

Compartmentalisation is one of the features of prebiotic environments believed to be essential to the origin of life. Compartment create sequestered units that can undergo natural selection and evolution, and concentration of substrates. One of the simplest prebiotic compartiments are vesiicles which share a similar membrane structure to modern day cells, and can self assemble from simple lipids (Figure 1). In this research compartmentalisation is used as a model for the possibility of life.

In the search for a non-aqueous environment that supports spontaneous self-assembly we must consider the relevant properties of water and then find other solvents that also possess these essential features. Hydrophobic interactions, mediated by the extended three-dimensional hydrogen-network of water, are the main driver for the self-assembly of lipids in water, so we focused on polar solvents that would similarly repel the non-polar tails of the lipids.

Obvious molecular hydrogen-bonding alternatives to water, such as glycerol and ethylene glycol, are liquid over temperatures similar to water. To explore the possibility of a drastically expanded Goldilocks Zone, we seek more exotic solvents with extreme melting points and very broad liquid stability ranges, including molten salts or ionic liquids.

Surfactants are known to self-assemble into micelles in ionic liquids, making them ideal prospects for this investigation. In addition, ionic liquids can be specifically tuned for certain properties, and many exhibit extensive hydrogen bond networks akin to those in water.

Deep eutectic solvents (DES) are mixtures similar to ionic liquids that are also expected to repel hydrophobic lipid tails in the same manner as water.

These liquids could thus comprise a completely unexplored and truly alien prebiotic environment.

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**Why Is Water So Special?**

**Lipid Vesicle Formation in Ionic Liquids and Deep Eutectic Solvents**

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The formation of vesicles by lipids in ionic liquids has been shown to occur in a diverse range of ILs and DESs. This is possible in extreme, non-aqueous environments and therefore the search for extra-terrestrial life should not be bound by terrestrial limitations and preconceptions. It highlights the fact that water is not as unique to fundamental processes as previously thought and therefore should not be the sole priority in the search for extra-terrestrial life.

The answer to the question ‘Why is water so special?’ appears to be, ‘It’s not.’

**Conclusions and Prospects**

The formation of vesicles by lipids in ionic liquids has been shown to occur in a diverse range of ILs and DESs. This is possible in extreme, non-aqueous environments and therefore the search for extra-terrestrial life should not be bound by terrestrial limitations and preconceptions. It highlights the fact that water is not as unique to fundamental processes as previously thought and therefore should not be the sole priority in the search for extra-terrestrial life.

The answer to the question ‘Why is water so special?’ appears to be, ‘It’s not.’

**References**

2. Callaghan, N.S.W. 2308 Australia
4. Callaghan, N.S.W. 2308 Australia
7. Callaghan, N.S.W. 2308 Australia
8. DMEAF, which cannot form H-bond networks, also supported vesicles with all lipids examined. This suggests that hydrogen bonding is not a requirement of vesicle self-assembly and that electrostatic interactions are far more important, raising the prospect of prebiotic compartmentalisation in molten salts at extreme temperatures.