Molecular footballs could revolutionize your next World Cup experience

June 22 2014

A new way to assemble individual molecules could revolutionize the creation of novel materials with numerous potential applications, including emerging technologies such as flexible TVs. The results of this ground-breaking research are published on 22 June in the prestigious journal *Nature Chemistry*.

This work focuses on the interactions between molecules and in particular on "amphiphilic" molecules, which contain two distinct parts to them. Household detergent is a good example of a product that relies on interacting amphiphilic molecules. Detergent molecules comprise two distinct parts: one that prefers to form bonds with water (hydrophilic) and the other that likes oily substances (hydrophobic). Detergents are used for cleaning because when they are added to dirty water, they orient and assemble around oily dirt, forming small clusters that allow grease and dirt to be more easily removed from the water.

The newly reported method takes the concept of amphiphilic assembly one step further, and applies it to a completely new set of hydrophobic molecules, intriguingly with no water-loving part to them. These new "hydrophobic amphiphiles" still have different 'parts', but the assembly process relies on more subtle interactions.

The research was carried out by an international team of researchers led by Dr Martin Hollamby (Keele University, UK) and Dr Takashi Nakanishi (National Institute for Materials Science, Japan). Together they showed used neutron scattering techniques at the Institut Laue-

Langevin (ILL) to investigate the arrangement of these clusters and showed that hydrophobic amphiphiles can still assemble into extended structures in much the same way as conventional amphiphiles.

One example is a molecule shaped like a football but with a long tail. The amphiphile has been tailor made from 'bucky balls' - football-shaped molecules made up of 60 carbon atoms (C60) which are chemically modified by attaching a much longer 'tail' made up of chains of carbon atoms, as found in a regular soap. The new detergents resemble "molecular tadpoles". When dissolved in solvents that interact with the tails, these molecules assemble to form a core of C60 spheres and a shell of carbon chains.

"Changing the chemistry of the chains can even lead to gels made of bundled C60 wires that have a measureable (photo)conductivity" explains Dr Martin Hollamby. "By adding pristine C60 in place of the solvent, we instead prepare a sheet-like material with totally different properties".

Small-angle neutron scattering data obtained on beamline D11 at the ILL was crucially used to prove the internal structure of these clusters.

"The light elements that makes up these 'molecular tadpoles' are easily located by neutrons" says Dr Isabelle Grillo, at the ILL. "Moreover, small angle neutron scattering which we use at the ILL allows to characterise the self-assembled systems from the nanometre scale to tenth of micrometres and is perfectly adapted to observe the coming together of the C60 footballs' into these beautiful core structures."

This flexibility is the remarkable thing about the new route towards self-organised structures. A great variety of different structures can be produced just by making small changes to the chemical structure and the additives (solvent or C¬60) used. This level of control over self-

assembly in complex molecules such as C60 is unprecedented.

One area that could be significantly impacted by this new discovery is the field of 'molecular electronics'. These carbon-based electronics could provide a cheaper alternative to traditional silicon technology and allow for flexible handheld devices for many functions, including smartphones and tablets for watching TV.

Furthermore, the new molecular electronic components could lead to improved properties (e.g. higher efficiency, lower power consumption) simply by optimizing how the molecules interact with each other. In 2018 during the next World Cup in Russia you could be using football-shaped molecules to actually watch the football.

More information: Directed assembly of optoelectronically active alkyl–p-conjugated molecules by adding n-alkanes or p-conjugated species, DOI: 10.1038/nchem.1977

Provided by Institut Laue-Langevin