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Joining up nanocircuits

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A team of scientists based in the UK and Germany have covalently bonded strings of porphyrin molecules on a gold surface - a step forward in the quest to develop nano-electronics.[1]

Other researchers have linked more than two molecules on surfaces as supramolecular structures before, but the patterns were held together only by non-covalent methods, such as hydrogen bonding and van der Waals interactions.

Non-covalent links are reversible and relatively fragile, says Stefan Hecht, chair of organic chemistry and functional materials at Humboldt University in Berlin and a member of the team. But covalent bonds are more stable and can transport electrical charge.

The team uses porphyrins, flat square-shaped molecules with four phenyl arms, one extending from each edge. The molecules are synthesized so that some or all the arms have a bromine atom at the end. The bromine atoms are removed by heating the molecules, leaving behind carbon radicals that combine through covalent carbon-carbon bonds, linking the porphyrin molecules.

Two methods were used to activate the molecular building blocks. The first involves depositing intact molecules onto the gold surface and then heating. In the second method, the molecules were activated in the evaporator and deposited on the surface, which is at room temperature. In both cases, the activated building blocks are covalently connected directly on the surface upon thermal diffusion.

Hecht says the inspiration for the research project came from earlier work by physicists constructing covalent bonds between two molecules using a scanning tunnelling microscope (STM).[2]

'Our idea was to take bigger molecules and extend this to something much more sophisticated,' he said. The success of the experiments is a first step toward eventual assembly of stable nano-architectures that could be used for molecular electronics and sensing devices, Hecht added.

Neil Champness, chair of chemical nanoscience at the University of Nottingham, called the team's success 'a very significant breakthrough'.

'They have an incredible level of accuracy to determine the relative positions of the molecules they are linking,' said Champness. 'I know a variety of groups trying to do what has been done.'

Although the team used porphyrins and a gold surface, Champness suspects that the technique eventually could be used with other sorts of molecules and surfaces.

Potential applications for molecular electronics would include wires, transistors, capacitors, and magnetic storage, he said.

Champness believes the first devices could be available in as little as 10 years and may eventually lead to the development of tiny computers. 'That is the Star Trek view of the world,' he admitted. 'We are a long, long way from that and [this] paper is a step in that direction.'

Ned Stafford

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References

1 L Grill *et al, Nature Nanotech.*, 2007, DOI: 10.1038/nnano.2007.346
2 S-W Hla *et al, Phys. Rev. Lett.*, 2000, **85**, 2777 (DOI: 10.1103/PhysRevLett.85.2777)

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