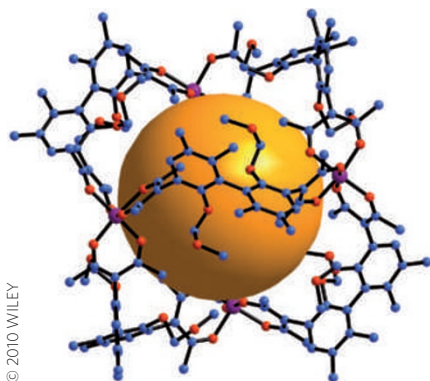


CHIRAL CAGES

Hand-picked guests

Angew. Chem. Int. Ed. **49**, 4121–4124 (2010)



Molecular cages with nanosized cavities have attracted much interest in recent years, in part because of the unusual chemistry that can be studied within their confines. Rigid and directional ligands linked to unsaturated metal atoms lead to the creation of high-symmetry cage-like structures. Incorporating chiral groups into these systems means they can be used for enantioselective processes, but there is still difficulty in making large chiral cages that are optically pure.

Now, Yong Cui and colleagues from Shanghai Jiao Tong University have used 1,1-biphenyl derivatives to make homochiral tetrahedral cages that can enantioselectively separate racemic alcohols. Each biphenyl ligand coordinates to two of the metals — iron

or gallium — to create the cages. Single-crystal X-ray diffraction revealed the chiral and porous nature of the compounds, with internal volumes around 1,800 Å³ and an aperture 7 Å across. These apertures allow guest molecules to enter the interior of the cage, where there are inwardly directed functional groups.

A racemic mixture of the chiral alcohol 2-butanol was co-crystallized with the *S*-form of the iron-based compound and only *S*-2-butanol was absorbed. Analysing the subsequently desorbed alcohol showed it to be the *S*-form in 98.8% enantiomeric excess. Similar behaviour but the opposite preference was shown by the *R*-form of the iron compound. Thermogravimetric analysis of the inclusion complexes showed that three alcohol molecules were absorbed in each tetrahedral cage. Although the handedness of the ligand in the host compound determined its enantioselectivity, control experiments showed that the ligands alone could not resolve enantiomers of the alcohol.

ENZYME MECHANISMS

Environmental issues

J. Am. Chem. Soc. **132**, 6955–6963 (2010)

Structural similarity and related substrate promiscuity are tell-tale signs of evolutionary links between enzymes. The enzymes alkaline phosphatase and nucleotide pyrophosphatase/phosphodiesterase (NPP) share such links. Their active sites share many similarities but alkaline phosphatase primarily catalyses phosphate monoester hydrolysis and

shows secondary activity for the hydrolysis of diesters, whereas NPP, although also catalysing both processes, does so with the opposite activity. Detailed understanding of their mechanisms of action could help understand their evolutionary changes since they deviated from a common ancestor.

Now, a team of chemists from Spain led by Iñaki Tuñón and Vincent Moliner have carried out a theoretical study on the reaction mechanisms of phosphodiester hydrolysis, either catalysed by NPP or uncatalysed in aqueous solution, to understand environmental effects. Such reactions can occur through mechanisms that range from an S_N1-like dissociative reaction (where the leaving group detaches before nucleophilic attack) to an associative reaction (where no bond breaking occurs as the nucleophile–phosphorus bond forms).

The team investigated the energetics and transition-state structures of both the catalysed and uncatalysed reactions using hybrid quantum mechanics/molecular mechanics methods. By examining the lengths of the bonds in the transition states between both the nucleophile and phosphorus and the leaving group and phosphorus, they found that the catalysed reaction proceeds through a dissociative mechanism, whereas the uncatalysed reaction proceeds through an associative one. The electrostatics of the NPP active site stabilize dissociative transition-state structures, causing the observed mechanistic differences and leading to the suggestion that the related enzymes of this family may have evolved to stabilize substrates in this way.

ARTIFICIAL PHOTOSYNTHESIS

All together now

Nature Nanotech. **5**, 340–344 (2010)

Converting light into usable chemical energy is the driving force for life on Earth. Bacteria, algae and plants evolved with the ability to efficiently photosynthesize millions of years ago, and scientists are playing catch-up. Now, they have taken a leaf out of nature's book and are trying to mimic the precise nanoscale organization of natural photosynthetic systems by optimizing the distance between functional components. To do this, Angela Belcher and colleagues from the Massachusetts Institute of Technology and Harvard University have used a genetically engineered 'M13' virus as a template that can organize important photosensitizer and catalyst molecules together on its surface.

This spatial organization arises from the virus's highly ordered protein coat, which has exposed amine groups that Belcher's team used to chemically graft carboxyl-bearing photosensitive zinc porphyrin molecules.

INTERFACIAL WATER

Disruptive influences

J. Phys. Chem. Lett. **1**, 1487–1491 (2010)

The ubiquity of liquid water has resulted in a great effort to understand its complex and dynamic hydrogen-bonded structure. Focus has recently shifted to study how this intermolecular network is altered by solvated ions and interfaces, because they play a direct role in many important aqueous biochemical processes. Now, Akira Yamakata and Masatoshi Osawa from Hokkaido University, Japan, have investigated the extent to which the structure of interfacial water at a hydrophobic surface changes when different cations are present.

They used a model hydrophobic surface of carbon monoxide molecules adsorbed on a platinum electrode and exposed it to perchlorate solutions containing different cations. The cations were drawn towards the negatively charged platinum surface and the resulting interfacial water structure was scrutinized using infrared spectroscopy. They specifically examined infrared bands associated with 'free' OH bonds: those that do not form part of the water network but point towards the hydrophobic surface. At low electrode potentials the observed behaviour of hydrophilic cations (Na⁺, Mg²⁺, Zn²⁺, Me₄N⁺) was different from that of the hydrophobic cations (Et₄N⁺, Pr₄N⁺).

The hydrophilic cations caused a decrease in the number of free OH bonds (in comparison with a solution with no cations) suggesting that they replace water molecules at the interface, disrupting the interfacial structure. The hydrophobic cations, however, did not cause the same disruption. Yamakata and Osawa explain that water molecules in the primary hydration shell of a hydrophilic cation form directional hydrogen bonds that can interact strongly with a second hydration shell and consequently affect local water structure. The equivalent interactions for hydrophobic cations are too weak to have this effect.

They then created core-shell nanowires by affixing a shell of iridium oxide — a water oxidation catalyst — to the virus's protein coat via a binding peptide. The team engineered a library of M13 viruses bearing random octameric peptides, and examined their affinities for binding indium oxide to determine which was most effective.

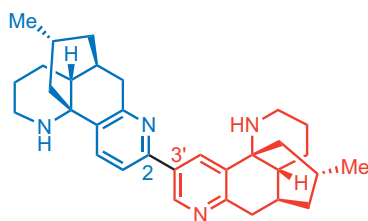
The co-localized IrO₂-porphyrin nanowires oxidized water into molecular oxygen and protons far more efficiently than the control materials tested in which the same components were not spatially organized.

TOTAL SYNTHESIS

Pseudosymmetry solved

J. Am. Chem. Soc. **132**, 5926–5927 (2010)

J. Am. Chem. Soc. **132**, 5924–5925 (2010)



Complanadine A is an alkaloid natural product isolated from the club moss *Lycopodium complanatum*, which may be useful in the treatment of diseases of the central nervous system. As with many natural products, its synthesis is important to provide sufficient quantities of material for biological testing. Two recently developed total syntheses of (+)-complanadine A highlight different approaches to this interesting and complex structure.

Although it is immediately evident that complanadine A is a dimeric structure, its synthesis is difficult because the molecule is only pseudosymmetric — the dimer is formed by a bond between the 2-position of one pyridine ring and the 3'-position of the second. Daniel Fischer and Richmond Sarpong from the University of California, Berkeley, nevertheless aimed to prepare the molecule by formation of this bipyridyl (C2–C3') bond. They rapidly prepared a key pyridyl triflate intermediate ready for a cross-coupling reaction. The same pyridyl triflate was reduced to the pyridine and, using an iridium-catalysed C–H functionalization, the second cross-coupling partner — a boronic ester — was produced. A Suzuki-type cross-coupling and deprotection then gave the natural product.

At the same time, Dionicio Siegel and co-workers, from the University of Texas at Austin, prepared the same target by a sequence of two cobalt-catalysed [2+2+2]-cycloaddition reactions to form

each of the pyridine rings. They were unable to find conditions under which the two cycloadditions would occur in one pot, but succeeded in a stepwise formation of one pyridine ring followed by the other. In the process, however, they observed that the addition of a phosphine ligand to the reaction mixture resulted in an interesting switch between the undesired symmetrical product — linked by a bond between the 2 and 2' positions of the pyridines — and the desired asymmetric natural product.

GLOBAL WARMING

A molecular affair

Proc. Natl. Acad. Sci. USA **107**, 9049–9054 (2010)

Since carbon dioxide was identified as a greenhouse gas, methane, nitrous oxide and a variety of halogenated compounds have also been recognized for their contribution to global warming. Partha Bera and co-workers at Purdue University and NASA's Ames Research Center now show how the global warming potential of molecules can be assessed to enable the design of compounds that are less harmful to the environment.

Previously, the researchers had investigated the molecular characteristics that contribute most to the greenhouse effect (*J. Phys. Chem. A* **113**, 12694–12699; 2009), and found that although the concentration and stability of molecules in the atmosphere certainly influences their global warming potential, it is their radiative efficiency — their ability to absorb infrared radiation — that is the main factor. In particular, the presence of fluoride atoms introduces very polar X–F bonds with stretching modes in the atmospheric infrared window, which leads to a large absorption, and thus a large radiative efficiency. Now, Bera and colleagues have investigated various types of perfluorinated compounds, including ethers, thioethers, olefins and alkyl chains, and found large differences in their infrared absorptions in the atmospheric window.

Ethers showed a particularly large infrared intensity, due to the very polar C–O bonds that absorb in the atmospheric infrared window. Molecules with long carbon chains showed a relatively small infrared intensity per bond, but a large absorption overall. Finally, simply spreading fluorine atoms throughout a compound, rather than attaching several to the same carbon, can halve the radiative efficiency of some compounds.

The definitive versions of these Research Highlights first appeared on the *Nature Chemistry* website, along with other articles that will not appear in print. If citing these articles, please refer to the web version.

blogroll

Our favourite things

What we all like about chemistry, one Heck of a named reaction and a coffee surprise.

When Chemjobber wrote a blogpost titled My Favorite Things about Chemistry (<http://go.nature.com/CoPZaN>), he probably didn't realize that the meme would infect so many people. Less than a week later, we had a good idea of the chemical blogosphere's favourite things. They included working chromatography columns, the smell of favourite solvents (THF, ethyl acetate, ether...), the thermite reaction and molecular models. Lots of people like crystals — big crystals, pentacene crystals, pretty crystal structures. So many people got involved that we can't mention them all here, but Azmanam has compiled a list at the end of his blog post (<http://go.nature.com/YWGIZa>).

Carmen Drahl wrote a great piece for C&EN (**88**, 31–33; 2010) about how named reactions get their names, addressing the controversy that sometimes surrounds the problem. One example discussed was the Mizoroki–Heck reaction (a carbon–carbon bond formation using a Pd catalyst). In a blog post (<http://go.nature.com/iklede>) on CENTral Science's Newsletters, she revealed the difficulties she'd had in tracking down Richard Heck. He retired to the Philippines in 1989, but eventually — with some help from Heck's former colleagues and Tagalog speaker in the C&EN offices — Drahl got through. Unfortunately, Tsutomu Mizoroki died fairly soon after his work on the reaction, in 1980, and even finding a photo of him proved difficult. With more former colleagues and a chemical historian on the case, a photo came through in the end.

And finally: a pinch of salt for your coffee, sir? That's the titular question posed by Martin Lersch on his Khymos molecular gastronomy blog (<http://go.nature.com/XKbJPI>). Lersch, with a PhD in organometallic chemistry, asks the question because in some parts of the world this is fairly common practice. He explains that sodium ions interfere with the mechanism for tasting bitter flavours, so adding salt can make some bitter things sweeter.