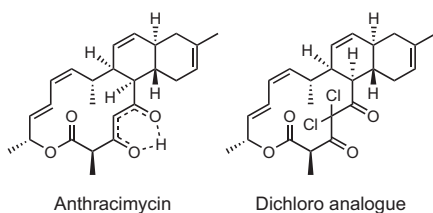


NATURAL PRODUCTS

Anti-anthrax agents

Angew. Chem. Int. Ed. **52**, 7822–7824 (2013)



Few diseases carry the sinister connotations of anthrax. It is a deadly infection that predominantly affects herbivores, although it has also been used for bioterrorism and adapted for biowarfare. Anthrax is caused by *Bacillus anthracis*, and, like other bacterial diseases, it is normally treated with antibiotics; however, because the infection does not always respond to treatment — and because the infection needs to be completely eradicated — the course of antibiotics may need to be taken for up to six months, or as a continuous intravenous supply. This dangerous combination of a potentially lethal

infection and its resistance to treatment means that new antibiotics are needed to target this bacterium.

In an effort to discover new antimicrobial scaffolds, a team led by William Fenical at the University of California at San Diego, USA, isolated metabolites from a marine organism (a species of *Streptomyces*) and tested them for antibacterial activity. One metabolite showed potent activity against the Gram-positive *Bacillus anthracis* and methicillin-resistant *Staphylococcus aureus*; although it had only very limited activity against Gram-negative bacteria such as *Escherichia coli*. A series of NMR spectroscopy, mass spectrometry and X-ray crystallography analyses enabled the team to characterize the structure and stereochemistry of this new antimicrobial compound — which they termed anthracimycin. The compound has an unusual triple-ring system formed from 14, 6 and 6 atoms, respectively, as well as an enolized β -diketone.

Although the tricyclic ring system found in anthracimycin is rare, it is not unprecedented. A related metabolite called chlorotonil features the same tricyclic ring

system — along with a dichloro group on the 14-membered ring. Fenical and the team decided to incorporate this dichloro moiety into anthracimycin to see what effect this would have on the antimicrobial activity. Interestingly, the dichloro analogue was approximately half as potent against *Bacillus anthracis*, however, it exhibited greater activity against some strains of Gram-negative bacteria — which the team believe is linked to easier penetration through the cell wall. RJ

REACTIVE INTERMEDIATES

Non-classical crystals

Science **341**, 62–64 (2013)

When either enantiomer of *exo*-2-norbornyl bromide reacts with a nucleophile, a racemic mixture of products results. Explaining the stereochemical outcome of this reaction has been at the heart of a long-running debate about the structure of the cationic reaction intermediate — and whether it is a so-called non-classical carbocation. Now, in what seems to be the final (and definitive) argument in this famous case, a team of

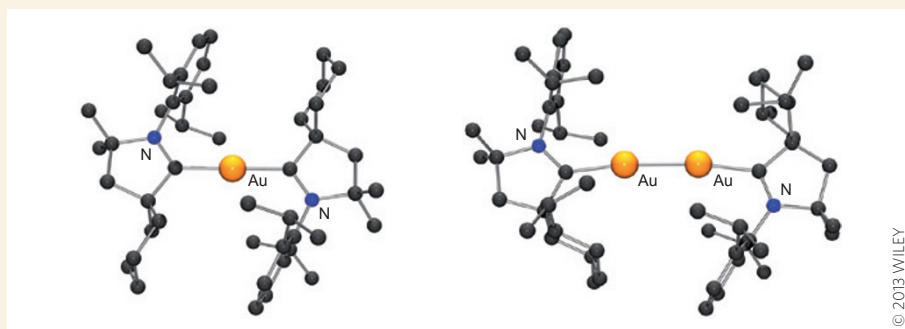
TRANSITION METAL COMPLEXES

24-carat chemistry

Angew. Chem. Int. Ed. <http://dx.doi.org/10.1002/anie.201304820> (2013)

From the City of Gold to the Golden Fleece, from the Californian gold rush to the earliest 'al'chemists, gold has captured our imagination like few other elements have. Unlike most elements, gold is typically found in nature in its pure elemental form. In complexes, its common oxidation states are $-I$, $+I$ and $+III$, with the odd rare compound featuring gold $+II$, $+IV$ and $+V$. Apart from the elemental form, however, the zero oxidation state of gold has generally remained elusive to chemists. There have been some examples of mixed gold(I)/gold(0) complexes and mixed-metal clusters where an oxidation state of zero was assigned to gold. But simple mononuclear (L_nAu), binuclear ($LAu-AuL$) and polynuclear [$(LAu)_n$] neutral complexes, with atoms of gold coordinated end-on by ligands, have not been isolated.

A team from the USA and Germany, led by Guy Bertrand at the University of California, San Diego, have now managed to isolate metal–ligand complexes — containing either one or two gold atoms — in which the formal oxidation state of the metal atoms is zero. Each complex features



two cyclic (alkyl)(amino)carbene (CAAC) ligands, forming a linear $L-Au-L$ structure in the case of the mononuclear complex and slightly bent $L-Au-Au-L$ dinuclear compound. CAACs are good π -electron acceptors, which helps them to stabilize the electron-rich gold(0) centres; the carbene ligands are capable of forming strong bonds with the gold atoms. The green (mononuclear) and brown (dinuclear) complexes are stable for days at room temperature in solution and in the solid state, and the team were able to determine their structures (pictured) using X-ray crystallography.

Phosphines are currently used as ligands to stabilize gold clusters of various sizes, and these have found a wide range of applications as organic photovoltaics and therapeutic agents and in catalysis. However, gold particles stabilized by phosphines have all been positively charged. Thus, the ability of these CAAC ligands to stabilize gold in the formal zero oxidation state could open the door to the synthesis of neutral, differently sized gold clusters. These tiny 'nuggets' of neutral gold could provide a wealth of future opportunities in catalysis and other applications. RD