Sydney Analytical

Chemical, biological and materials analysis

Sydney Analytical is the University's flagship facility for chemical, biological and materials analysis, supporting capability in vibrational spectroscopy, magnetic resonance, X-ray diffraction and scattering, protein production and characterisation, and drug discovery.

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Anti-viral research for COVID-19

Challenge

According to the World Health Organisation, by mid-2023 almost 770 million COVID-19 cases had been reported globally, causing close to 7 million deaths and post-viral health problems in an estimated 10-20% of infected individuals. Anti-virals that work effectively against the SARS-CoV-2 virus are needed to reduce the ongoing impact of the COVID-19 pandemic.

Research

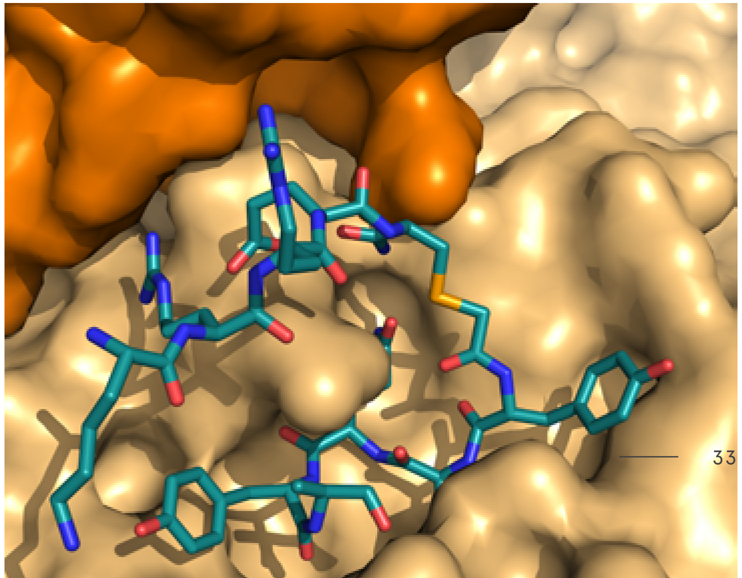
A team led by Professor Richard Payne (School of Chemistry, Faculty of Science), in collaboration with researchers from Sydney's School of Medical Sciences and School of Life and Environmental Sciences, Australian National University, Kirby Institute and University of California San Diego, sought to address this challenge by identifying novel inhibitors of the SARS-CoV-2 main protease, a key protein in the viral lifecycle that is required for productive infection. To achieve this, the researchers made use of Sydney Analytical's cyclic peptide display screening platform, the only university-based platform of its kind in the world, established by staff scientist Dr Toby Passioura.

Results

The team identified several molecules that potently inhibited the main protease target. They also showed that at least some of these molecules acted by binding to the active site of the viral protease. Perhaps most importantly, though, several of the identified molecules were able to prevent SARS-CoV-2 infection of cultured human cells, demonstrating their potential as starting points for the development of new drugs to treat COVID-19. The findings were published in the journal *Chemical Science*.

Funding sources include:

- Australian Research Council
- University of Sydney



Right: One of the novel molecules identified in the study.

Understanding cultural heritage through science

Challenge

In museum records, the materiality of collection items is often based on visual inspection alone. This can result in an incomplete understanding of an object's history and significance. When the University's Chau Chak Wing Museum was preparing for its *Chinese Toggles: Culture in Miniature* exhibition, it built on a long-running collaboration with Sydney Analytical to enhance knowledge about the exhibits and better communicate their cultural heritage value.

Research

Technical experts from Sydney Analytical, led by Vibrational Spectroscopy facility manager Dr Elizabeth Carter, undertook scientific analysis of early modern Chinese belt toggles to determine their materials of origin. This work used the capabilities of Sydney Analytical's Vibrational Spectroscopy arm and its state-of-the-art near-infrared and Raman spectroscopy equipment. The analysis largely covered objects on loan from Sydney's Powerhouse Museum, which includes one of the world's largest collections of Chinese ornamental belt toggles.

Results were combined with close visual and multivariate data analysis to shed light on ivory and jade toggles. Curators from both the Powerhouse and Chau Chak Wing Museum then worked with the Sydney Analytical scientists to confirm or revise records in preparation for the exhibition.

Results

The analysis led to the revision of a number of collection records. For example, an object once thought to be elephant ivory was confirmed to be mammoth ivory, offering evidence that mammoth ivory extracted from Siberian ice circulated as raw material in the 19th century. Further, an ivory toggle was found to have been dyed green to pass for more expensive jade. This multidisciplinary study demonstrates the value of harnessing science to further cultural heritage research.

The scientific characterisation of materials enabled nuanced identification, empowering the institutions to interpret and exhibit the works to the public with confidence. Sydney Analytical's characterisation work will be included in a forthcoming book from Power Publications on Chinese toggles, and featured in collaborative programming with Chau Chak Wing Museum for National Science Week.

Left: Scientists from Sydney Analytical characterised early modern belt toggles from the Powerhouse Museum collection for the Chau Chak Wing Museum's exhibition, *Chinese Toggles: Culture in Miniature*.

The future of data storage

Challenge
Humanity's ever-increasing output of digital information demands denser methods of information storage. The next frontier in this quest involves reducing data cell size to the molecular scale, and increasing the dimensionality of storage devices from 2D to 3D. Crystal lattices hold potential for data storage, but their high degree of ordering means their storage capacities are inherently low. Disorder is required to increase potential for data storage.

Research
Professor Cameron Kepert (School of Chemistry, Faculty of Science) is an expert in the design of metal-organic frameworks, which are ordered arrays of metal-containing clusters interconnected by organic molecular linkers. Professor Andrew Goodwin (University of Oxford) is an expert in the theory and characterisation of disordered materials. Ongoing collaboration between their research groups saw the development of a new metal-organic framework material incorporating disorder.

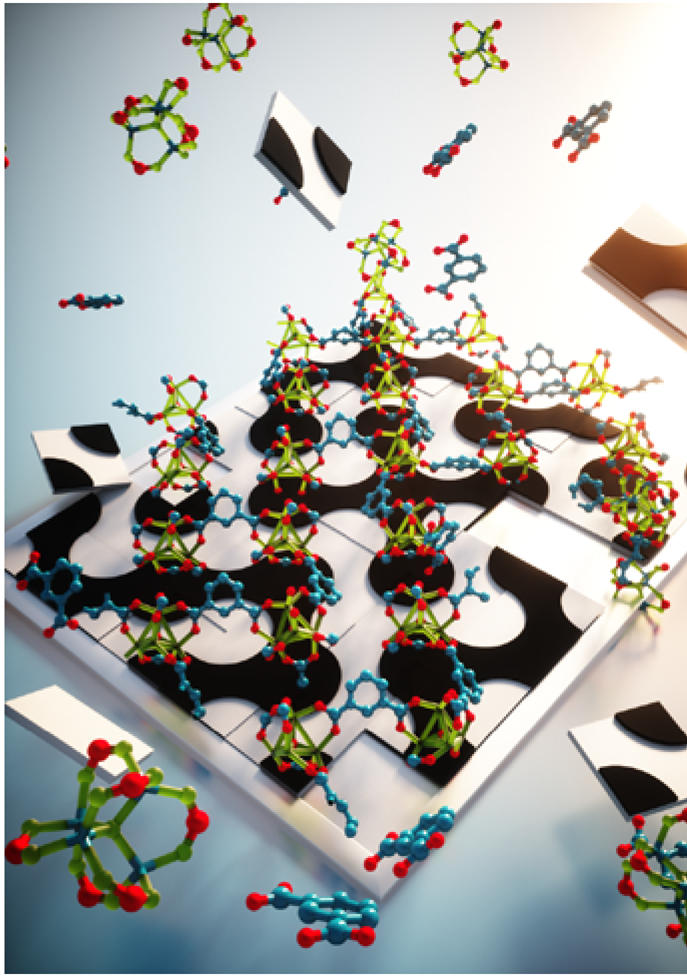
The material was first synthesised by Dr Lisa Cameron, Professor Kepert's former student, and Professor Goodwin's student Emily Meekel travelled to Sydney to study it. With the assistance of Sydney Analytical staff including diffraction specialist Dr Sam Duyker, she used the facility's single-crystal and powder X-ray diffraction capabilities to investigate the material's structure.

International collaborators also contributed to the work. The material was named TRUMOF-1 because the 3D tiling of its sub-units is analogous to a 2D tiling set discovered by French monk Sébastien Truchet in 1704 which underpins the encoding principles of barcodes and QR codes.

Results
Detailed analysis revealed that TRUMOF-1 contains clusters that are uniformly coordinated by six linkers, but asymmetric linkers used in its construction connect the clusters in a disordered fashion that never repeats, generating a labyrinthine network bearing "complex order". The porous nature of the material may also give rise to other emergent properties due to its periodic/aperiodic structure. The discovery was recently published in *Science* and offers a glimpse at what 3D-encoded data on the molecular scale might look like.

Funding sources include:

- Australian Research Council
- European Research Council
- The Royal Society



Right: A visualisation of the parallels between the structure of TRUMOF-1, revealed using capabilities at Sydney Analytical, and a Truchet tile set.