METAL ORGANIC FRAMEWORKS

AN ENTIRE RUGBY TURF IN A TEASPOON: THE TINY CRYSTAL GAME-CHANGERS IN COMBATTING CLIMATE CHANGE.

Can nano-crystals clean up water, gas and air?

2018. CO_2 emissions rose. The IPCC issued warnings. World leaders gathered. And here in NZ, a group of MacDiarmid Institute scientists made significant headway on MOFs, or Metal-Organic Frameworks, tiny crystals that could be key to mitigating our changing climate.

MacDiarmid Institute Principal Investigator and Massey University Professor Shane Telfer says MOFs can be tailored to match the size and shape of target 'guest' molecules. One super topical and very welcome 'guest' is CO_2.

"MOFs are already being used for carbon dioxide capture from power plants and we're now looking to use them to sieve out the CO_2 that is already present in the atmosphere. While these materials don't break down the CO_2, they prevent it from being released into the atmosphere. Therefore, they can mitigate climate change."

And this year, Professor Telfer's PhD student Omid Taheri had a major breakthrough. He had been looking for MOFs that could separate oxygen and nitrogen in the air "…a sort of nanoscale air purification system," he says. Mr Taheri was making lots of new MOFs, and screening them on the group's MacDiarmid Institute-funded gas adsorption analyser. On one sample, his data pointed to something unexpected. "It didn't work for oxygen-nitrogen, but it was really good at separating ethane and ethylene," says Mr Taheri. "I was so surprised!" After that realisation, Professor Telfer says they, "…got on a bit of a roll," and started testing this group of MOFs – which are all chemically quite closely-related to one another – for other gas mixtures. Another surprise awaited – one of their new molecular sponges proved to be very efficient at absorbing carbon dioxide.

> "Shane is known internationally for delivering a lot of output from a team that is small by international standards. He has discovered a family of porous materials that are elegant in their simplicity and have all the functions embedded inside them with simple processes"
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> ASSOCIATE PROFESSOR MATTHEW HILL, CHEMICAL ENGINEERING MONASH UNIVERSITY AND PRINCIPAL RESEARCH SCIENTIST, COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION (CSIRO) AUSTRALIA.

"Carbon capture is one of the biggest challenges in gas separation," says Associate Investigator and MacDiarmid Institute alumnus Dr Matthew Cowan, a Chemical and Process Engineering lecturer at the University of Canterbury. Having spent three years in the United States working on carbon capture for coal-fired power plants, this is an area that Dr Cowan knows well. "Industry and governments are looking for low-cost options that let them make a difference. New technologies like Shane's can provide those options."

Professor Telfer admits that they're not yet at the stage of competing with existing carbon capture technologies, but says that they're certainly on the right track, "We've done a lot of the fundamental research and testing under idealised conditions, and it looks really wonderful," he says. "But the next stage is key – to answer specific industrially-relevant questions, and convert our provisional patent to a full patent. After that we'll switch our focus to packaging our MOFs into something that actually can be implemented in the field."

To support this, the MacDiarmid Institute has provided funding that will allow Mr Taheri to take a few months away from his PhD research, and specifically focus on the commercialisation questions that will be so vital to their patent. Professor Telfer and Mr Taheri have also engaged an intellectual property lawyer, and are talking to representatives from industry about the project.

All the while, their other MOF-related research continues,

as they have an even bigger prize in mind – sucking carbon dioxide directly out of the air. "Longer-term, this is something we want to explore," says Professor Telfer. "It's a far more challenging prospect, because the concentrations of CO_2 are relatively low, but MOFs certainly have the potential to do it. And if they can, it would be a total game-changer."

ANOTHER ROLE FOR MOFS

Quite apart from their potential role in sequestering CO_2 from the air, MOFs could lower industrial energy use, on a global scale. Gas separation is a process most of us give little thought to, yet it's a vast global business. Everything from water desalination companies, to gas separation industries to the pharmaceutical industry invest millions in separating mixtures as efficiently as possible. But existing techniques are incredibly energy-intensive,

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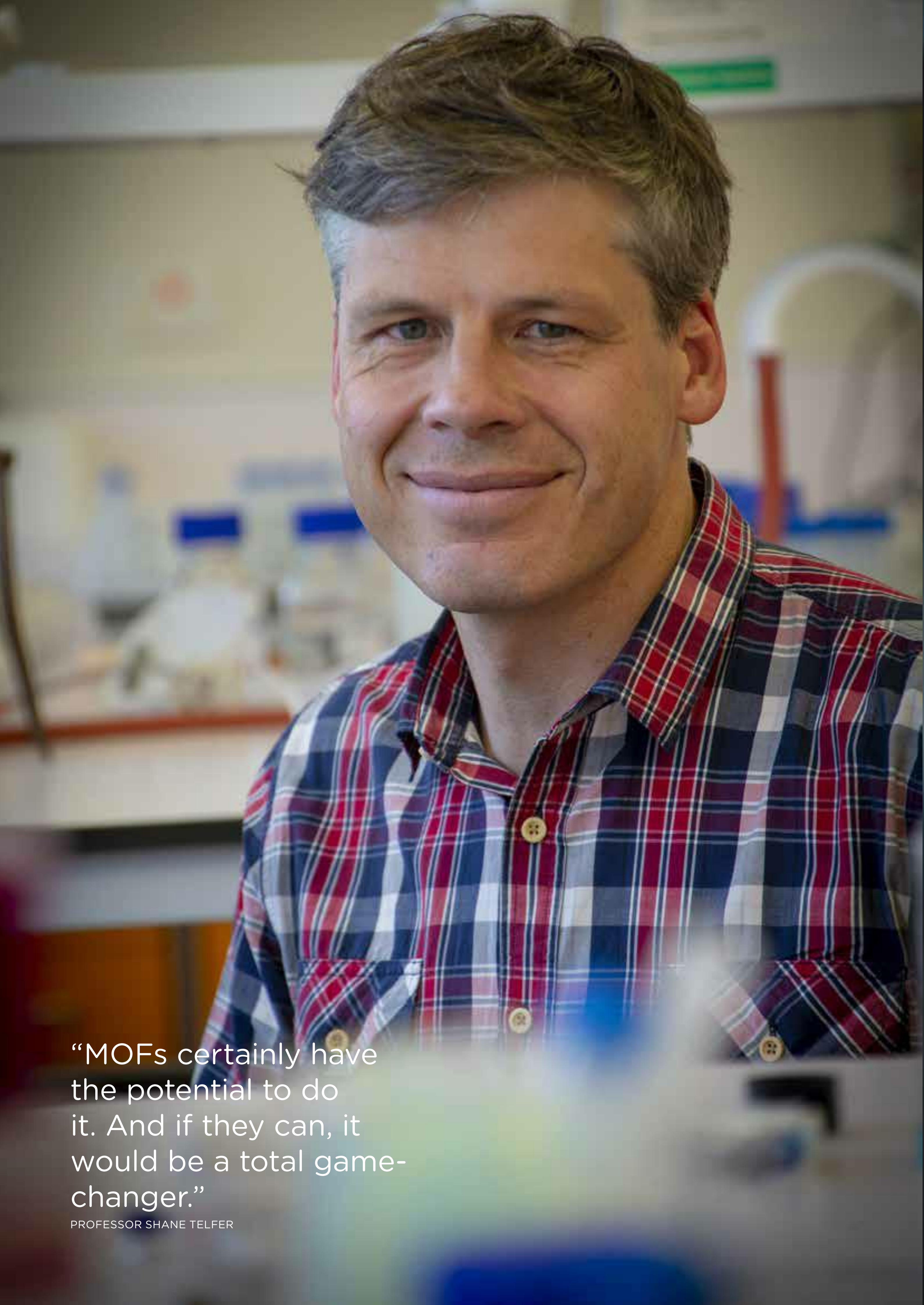
and account for 10–15% of the world's total energy use. Reducing that energy footprint is a huge priority for research groups across the globe, and in recent years, alternative separation materials have been finding their way out of the lab, and into widespread use in industry.

"The major challenge with separating gases like these is that they have very similar physical properties," says Professor Telfer. "But because we can engineer MOFs so precisely, and define exactly what pore size we want, we can make them highly selective. In other words, they can pick out specific molecules with minimal energy input."

And one of Professor Telfer's collaborators at CSIRO, Associate Professor Matthew Hill, says that there are ever increasing strains on global resources, and that processes need to become more and more efficient, whether they be cleaning water, making medicine, or nutrients for crops.

"Porous materials are the path to achieving all of this as soon as possible. Shane has discovered a family of porous materials that are elegant in their simplicity and have all the functions embedded inside them with simple processes. It is very encouraging to have new materials like Shane's that can help to save energy."



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PROFESSOR SHANE TELFER