

Marketing Material Creation

CCUS Innovation 2.0

Key Knowledge Deliverable 6.4

Key Knowledge Deliverable Cover Sheet

This Key Knowledge Deliverable (KKD) has been produced by Promethean Particles Ltd. as part of the Department for Energy Security and Net Zero £1bn Net Zero Innovation Portfolio (NZIP) - CCUS Innovation 2.0 programme. The document is reflective of the status of the project at the time of writing. The material presented could have been subject to change as the project matured. These documents should not be considered a full representation of the final project.

Description of project

The project will involve the design and fabrication of a prototype carbon capture unit that utilises Metal Organic Frameworks (MOFs) as the novel solid sorbent, which will be installed onto Drax's CCUS Incubation Site. The installed unit will be operated to demonstrate the effective separation of CO₂ from Drax's industrial flue gas stream, with the sorbent adsorbing and desorbing over several cycles to demonstrate a capture capacity of 0.5-1tCO₂/day. The use of this high-performance sorbent category will enable more energy-efficient CO₂ capture – through reduced regeneration energy penalty – while overcoming several undesirable aspects of solvent-based CO₂ scrubbing, such as zero waste production, zero aerosol emissions and a smaller site footprint. The demonstration of such a prototype unit, which utilises novel sorbent materials that are currently held back due to misconceived lack of scale and cost viability, is expected to significantly de-risk the innovation and - in turn - pave the way for adoption in a range of point source carbon-emitting processes and industries. A Lifecycle Assessment (LCA) and Technoeconomic Analysis (TEA) will also be conducted within this project, based on the data collected from test trials at Drax, and compared to alternative sorbent technologies where corresponding data is known or publicly available. This will validate the innovation of the novel solid sorbents and allow a strong business case to be built, for commercialisation and exploitation beyond the project timeframe.

Description of KKD D6.4 – Marketing Material Creation

Creation of a Project Logo, development of brochures and/or videos to highlight the key objectives, scope, activity and benefits of the MONET project, which can be used to raise awareness with technology adopters and end-users.

Executive Summary

Within WP6, Task 6.2 (Dissemination Activities) aims to promote the scope, aims and achievements of the MONET project. While the technical work packages (WPs 1-4) focus on developing the technology, WP6 targets the communication of project activities to external stakeholders, thereby increasing their likelihood of successful exploitation and commercialisation beyond the project duration.

Deliverable Description (from Project Execution Plan)

As part of the work in T6.2, this deliverable report D6.4 contains a summary of the marketing materials created to showcase Metal-Organic Framework (MOF)-based carbon capture. These materials include technical content, such as white papers and technical presentations; and design assets, such as infographics and images. These all serve to engage audiences, build credibility, and drive interest in MONET. This report summarises the materials that Promethean has published into the public domain through its own channels, and the external publication opportunities that have followed from this – namely magazine articles.

KKDs to be released in full:

D6.4 - Marketing Material Creation

D6.5 - Conference Presentations and Trade-Show Exhibitions

KKDs to be released after redaction:

D3.2 - Control and Safety System Manufacturing

D3.4 - Build of Capture Rig

D4.1 - Installation of Capture Rig at Drax

D4.3 - Rig Operation and Decommissioning

D5.1 - CAPEX Technoeconomic Analysis (TEA)

D5.2 - OPEX TEA

D5.3 - Life Cycle Analysis (LCA)

D6.6 - Stakeholder Analysis



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Introduction

Within the MONET project, the Technology Readiness Level (TRL) of MOF-based carbon capture and storage (CCS) will be progressed beyond its current status of TRL5. Aside from the technical development of the technology itself, the success of the project is reliant on the effective communication of project aims to external stakeholders, and the dissemination of project results. Such external stakeholders can include system integrators (engineering companies); carbon emitters or technology end-users (e.g. in power generation, manufacturers of cement, steel or chemicals); regulatory bodies (HSE, Environment Agency); trade or technology associations (UKCCSRC, CCSA) or potential technology investors (venture capital firms, corporate venture groups).

Communication and dissemination of the MONET project to these various groups is necessary to give the technology the best chance of commercialisation and deployment after project completion. It is also important to note that the background and interests of each group is likely to vary, so the message to be delivered to each stakeholder may require consideration and tailoring.

Marketing Materials

Through Promethean's creative design agency, AMPM Inc., a range of images were created to showcase MOF-based CCS, with the aim of visually engaging audiences.

Figure 1 shows an infographic that showcases how MOF-based CCS could work for a point-source emission process, which was created by AMPM with Promethean's direction. The aim of this infographic is to visually explain to audiences – whether they have a technical background or not – how MOF-based CCS technology could be integrated into a CO₂ emitting process. The key features of the image include the implementation of MOFs as a solid sorbent, in pellet-form to pack contactor beds; and Promethean's role as the manufacturer of the MOF (and not as the provider of the CCS system).

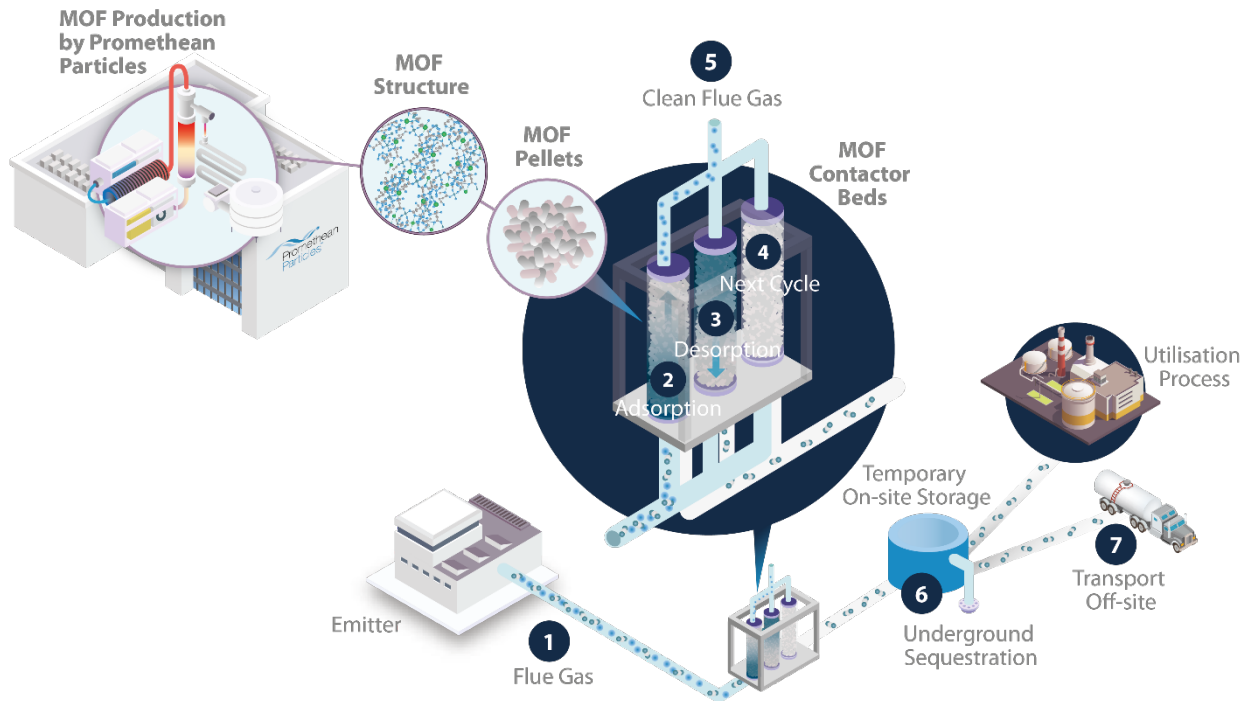


Figure 1. Infographic created to depict simply how a MOF-based CCS system could work. Step 1: Flue gas continually flows into the MOF-based CCS system; 2: CO₂-rich flue gas enters a column of MOF pellets which capture the CO₂; 3: Once saturated, a column goes into a regeneration/desorption mode; 4: After desorption, the column is ready for the next cycle; 5: “Clean” flue gas stripped of CO₂ is released into the atmosphere; 6: Stripped CO₂ is sent to temporary on-site compression and storage; 7: CO₂ can then be transported off-site, further used, or sequestered.

This infographic has been used in a range of contexts and media forms. The first of these was in a technical white paper written by the Promethean team, titled “Beyond CO₂ Uptake – Determining the Industrial Viability of MOFs for CCS Applications”, shown in Figure 2. This piece was published on Promethean’s website in April 2023, and can be accessed [here](#).

This white paper discussed the different technical, economic and governance factors that would impact the likelihood of a MOF composition being upscaled in production to meet industrial demand for CCS.

There is significant focus, from groups looking to develop MOF-based CCS, on the absolute CO₂ uptake capacity of different MOFs, with the perception that the higher this is the better. The white paper challenged these perceptions and discussed other performance factors, such as a MOF’s selectivity for CO₂ and its chemical and mechanical stability. Commercial factors were also discussed, such as the ability for the upstream supply chain (of the raw materials required for MOF production) to scale with the large volumes of MOFs that will be needed to address the vast, global CCS requirements.



Figure 2. The Promethean team wrote and published a White Paper in April 2023, discussing the industrial viability of MOFs as sorbents for CCS.

To accompany the release of this white paper, members of the Promethean team held an hour-long, live webinar session in May 2023 - a screen shot of the online event is shown in Figure 3. Here, the key messages from the white paper were delivered as an oral presentation by Promethean's Product Market Manager, Dr Selina Ambrose, and included the infographic from Figure 1. Towards the end of the session, the audience were given the opportunity to ask questions of the Promethean team and have them answered live.

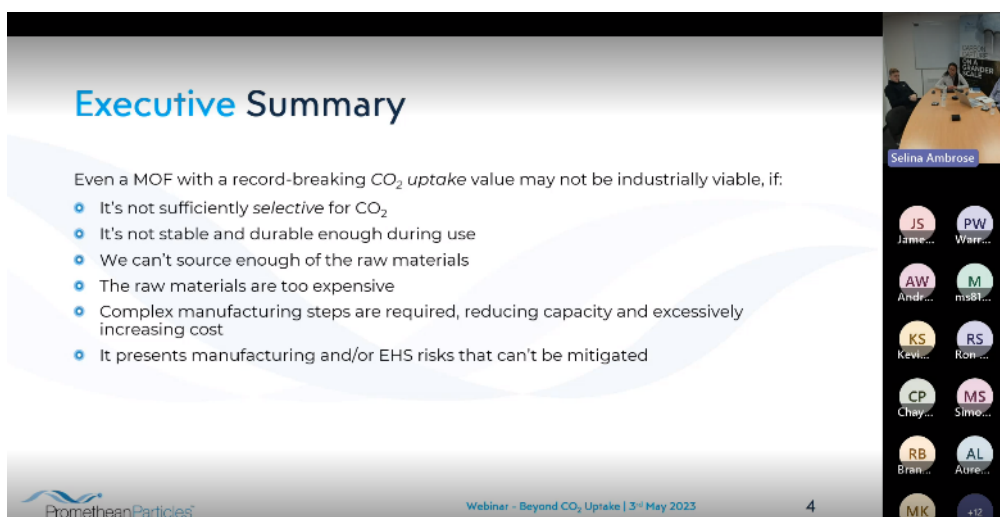


Figure 3. To accompany the release of the White Paper, the Promethean team hosted a live webinar in May 2023 discussing the contents of the article.

The infographic has also been used for in-person oral presentations. Figure 4 is a photo showing Promethean's CEO, James Stephenson, delivering a talk at the Innovation Zero conference in London Olympia, with the infographic in view. Held in May 2023, the conference

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also had an exhibition area where Promethean had hired a booth; this allowed for follow-up conversations, between the audience and Promethean staff, after James' talk.



Figure 4. Promethean's Chief Executive Officer presenting MOF-based CCS at the Innovation Zero event in London, which took place in May 2023.

Aside from the infographic, another example image created by AMPM Inc. is shown in Figure 5, and depicts a post-combustion flue stack that, at its base, morphs into a tree trunk within in a green and natural environment.

Unlike the infographic, this image was intentionally crafted with a less technical slant, and was created to resonate with a very broad range of audiences. The summation of Promethean's work in cleantech and decarbonisation needed to be conveyed, but the image should stoke interest and act as a stimulant for further questions, rather than telling a detailed story.

This image has been used on the front page of Promethean Particles' website, and earned a Silver Addy Award in 2023 from the American Advertising Federation.

Beyond the company website, the image has also been used on a display stand at tradeshow and exhibitions, including the Innovation Zero event in May 2023 and at The Advanced Materials Show, held at the NEC in Birmingham, UK on the 28th and 29th June 2023. Figure 6 shows Promethean's booth at the latter event, with the image from Figure 5 used on the display stand within the booth.

As well as having an exhibition space at The Advanced Materials Show, Promethean had a speaking slot during the Conference session of the event, where the company's Product Market Manager presented the concept of MOF-based CCS, and Promethean's activities in the development and cost-effective manufacture of MOFs at industrial-scale. Both the image in Figure 5 and the infographic from Figure 1 were used in the slide deck presented.



SILVER ADDY

Nanomaterials Reimagined Website

PROMETHEAN PARTICLES

Figure 5. The image created by AMPM for Promethean Particles, which has been used to highlight the company's work in cleantech, and the Silver Addy award won for Promethean's website which showcases this image.



Figure 6. Promethean Particles' exhibition booth at The Advanced Materials Show, held in June 2023 in Birmingham, UK. The graphic described in Figure 5 can be seen on the display stand on the left side.



Figure 6. Left: The digital banner announcing Promethean Particles' Product Market Manager, Dr Selina Ambrose, as a speaker at the conference session of The Advanced Materials Show; Right: Selina delivering her presentation on stage, where the graphic shown in Figure 5 can be seen on the title slide.

Promethean has also used the graphic in Figure 5 to form a full page advert, which was published in Decarbonisation Technology magazine – as shown in Figure 8. In this case, the image was accompanied by a brief description MOF-based CCS and Promethean's work in this space.

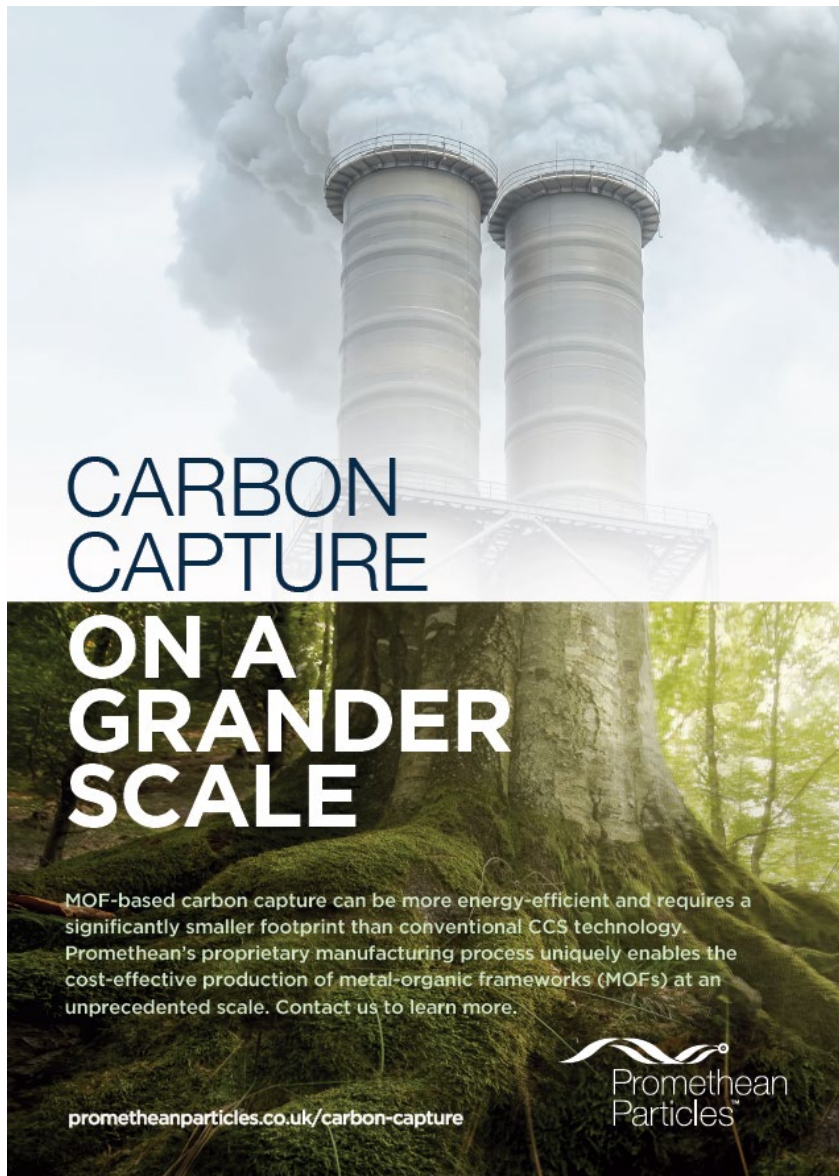


Figure 8. Graphic used in the creation of an advert promoting MOF-based Carbon Capture, which was published in Decarbonisation Technology magazine.

External Publications

Following the various marketing activity described in Section 2, Promethean received interest from journalists of trade magazines, each looking to include articles about the company and its technology in their publications.

The first of these was Decarbonisation Technology, a publication which principally targets audiences with a technical background and publishes its magazines quarterly in digital format. In this case, the journalist had an opportunity for the Promethean team to publish an 'op-ed' article in the August 2023 Issue of its magazine. The nature of the article allowed the Promethean team to express their views on the technological landscape directly, rather than via the perspective of the journalist. Topics discussed in the article included the limitations of current leading CCS technology, how these limitations could be overcome with MOF-based

processes, and the work Promethean is doing to facilitate the large scale implementation of MOF-based CCS.

The first page of this article is shown in Figure 9, while the full piece can be accessed at the magazine's website ([here](#)).

The second publication to feature an article on Promethean Particles was Nano Magazine, which covers a range of topics and applications relating to nanotechnology and nanoscience, but discusses these topics from either a technical/research angle, or from a commercial/business perspective. On the magazine's website, articles are sorted into each of these categories.

Unlike the op-ed piece, the article published in this case was written by the journalist, Liam Critchley, under the magazine's research category. Titled "MOFs: An Advanced Materials That's Finally Coming of Age for Nanoscale Commercialisation" and published digitally in August 2023, the article provides background context on what MOFs are, and some of the real-world applications they can be used for. Driven by the journalist's attendance at The Advanced Materials Show, and speaking to the Promethean team at the company's exhibition booth, the article highlights Promethean's role in bringing MOFs to the fore as a commercially-viable class of advanced materials, rather than being viewed as merely 'of academic interest'; this is a sentiment in line with Promethean's ambitions.

Pertinent sections of this article from Nano Magazine are shown in Figure 10, while the full digital article can be accessed from the Nano Magazine website ([here](#)).

Metal-organic frameworks for carbon capture

How the industrial-scale, cost-effective manufacture of MOFs and speciality nanomaterials could enable energy-efficient carbon capture and storage

James Stephenson
Promethean Particles

Leading scientific opinion increasingly points to human activity having a large, detrimental impact on our planet. One effect of this activity has been an unprecedented rise in global warming driven predominantly by increased emissions of greenhouse gases such as carbon dioxide (CO₂). The issues and consequences surrounding global warming have been well studied. Global surface temperatures have already reached 1.1°C above pre-industrial levels (IPCC, 2023). Exceeding a 1.5°C rise in average temperatures could risk the earth's stability and life support systems (IPCC, 2018).

This startling recognition has led to an acceleration in demand for new solutions to help tackle climate change and, with it, a particular emphasis on decarbonisation. There are multiple decarbonisation approaches that can be employed to reduce the overall carbon footprint, which we have coined the 'Decarbonisation Mix'. Many climate change proponents advocate strongly for the prioritisation of energy efficiency improvements and fuel switching to less carbon-intensive variants. However, many hard-to-abate industries (power generation, steel, cement, chemicals) cannot simply switch to different fuels or efficiently electrify their processes, at least in the near term. As such, a third element of the mix has to be carbon removals.

Carbon capture is therefore increasingly being recognised as a critical technology in the range of solutions needed to effect decarbonisation and help limit climate change. Despite the views of some, it is not an underhand way to 'greenwash' the continued use of fossil fuels. The UK government, the German government,

and the Intergovernmental Panel on Climate Change (IPCC) have all recently opined that CO₂ removal and carbon capture are now necessary approaches for the world to have any chance of limiting global warming to the 1.5°C goal established in the Paris Agreement. The UK government's recent announcement of £20 billion in funding earlier this year to support the development of carbon capture and storage (CCS) projects highlights this emphatically.

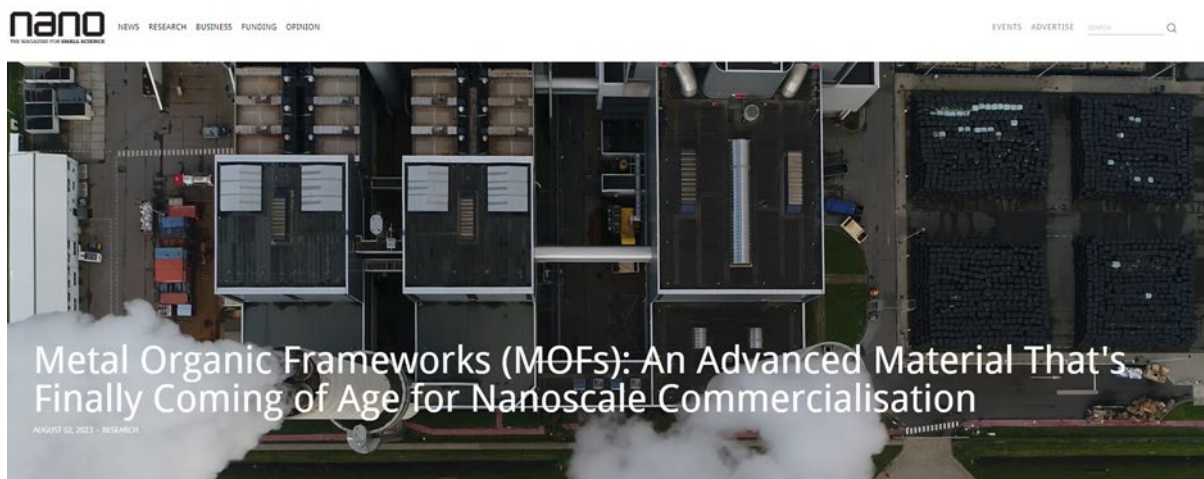
Carbon capture is increasingly being recognised as a critical technology in the range of solutions needed to effect decarbonisation

Current technological options for CCS systems are limited

The most widely used commercial carbon capture technology today is amine scrubbing. The first amine scrubbers were designed and implemented in the 1930s, and the process is largely the same today, despite some significant improvements in the performance of the amine solvents used.

A typical configuration for a CO₂ scrubbing system is shown in **Figure 1**. CO₂ containing flue gas enters the bottom of the absorber and rises upwards. The CO₂ is absorbed by the downward flowing amine, which then flows out of the bottom of the absorber and into the stripper. Here, the CO₂ rich amine is intensively heated to desorb and separate the CO₂. The reboiler at the bottom of the stripper provides

Figure 9. A snapshot of the first page of the Op-Ed article published in the August 2023 issue of Decarbonisation Technology magazine.



So, while there has been a hesitancy to use MOFs based on their ill-informed production levels, recent discussions that I had with multiple MOF companies at the Advanced Material Show this year seem to suggest that this landscape is changing—and end users are becoming more wise to the production volumes possible with today's MOF manufacturing technologies.

So, now that MOFs are finally starting to gain some level of commercial validity in the wider industry, let's look at a few key application areas where MOFs are already having an impact and are likely to penetrate much further in the coming years.

Carbon Capture

When MOFs are discussed, [carbon capture](#) is often brought up because the pores of the MOF can be specially designed to remove carbon (in the form of carbon dioxide) from our atmosphere. There are already a couple of well-established companies working in this area.

The first of these is the UK-based company, [Promethean Particles](#). While Promethean Particles are also developing MOFs for energy storage (fuel cells and batteries) and hydrogen storage applications, the main area where they are developing MOFs for is carbon capture—in both direct air capture and post-combustion air capture scenarios.

These MOFs at Promethean Particles have been specifically developed to capture carbon dioxide (MOFs for other applications are tailored in other ways). In direct air capture applications, the carbon dioxide molecules are removed from the general atmosphere. For post-combustion applications (where there is the most carbon content), the MOFs remove the carbon dioxide from the flue gas streams in power plants.

Promethean Particles have huge reactors for making MOFs and can produce MOFs on a scale of 1000 tonnes per annum. Production levels on this scale highlights the real large-scale potential for MOFs and really shows how it is not just a lab-based or pilot-scale material anymore. It's a material that is here in large quantities.

Figure 10. Snapshots showing the headline and relevant section of the article published in Nano Magazine, which describes Promethean's work in industrial-scale MOF production and material development for CCS applications.

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