

The pathway for graphene-powered green cement

In the race for low-carbon cement and concrete, interest in First Graphene Ltd's proprietary PureGRAPH® additive brand has been gaining traction. With the focus now moving upstream, Michael Bell, CEO and MD of the Australia-based company, explains how the first commercial trials at the Hope Cement Works in the UK aim to find a simple, safe method of introducing graphene to industrial-scale cement production.

■ by **ICR Research, UK**

CR: What is the background to the founding of First Graphene?

Michael Bell (MB): First Graphene was founded in 2017 with the opening of its world-class 100tpa commercial-scale graphene manufacturing facility in Perth, Western Australia.

The company has developed a proprietary capability to produce large quantities of consistent quality graphene in a range of material forms. Its products are marketed under the PureGRAPH® brand, providing high-performance graphene technology to customers around the globe. PureGRAPH enhances construction material performance and reduces carbon emissions in manufacturing processes, particularly in the cement and concrete sector.

ICR: How is PureGRAPH produced, and how is it being used in the cement and concrete industries?

MB: PureGRAPH is First Graphene's premier graphene product, used as a high-performing additive for a vast range of materials, including cement and concrete.

Graphene is created by the electrochemical exfoliation of graphite, where a voltage is applied, driving certain ions to intercalate into the carbon layers, pushing them apart. This results in microscopically-thin yet strong layers of graphene that can be incorporated into a variety of products as an additive. The resulting PureGRAPH is produced into masterbatch additives, powder, paste and pellet forms for use in different material manufacturing processes.

Research shows that adding PureGRAPH to cement can increase compressive strength of concrete by up to 34 per

Australia-based First Graphene is led by Michael Bell, CEO and MD (pictured), with a team of commercial managers and R&D scientists located around the world



cent and tensile strength by up to 27 per cent.¹ PureGRAPH also reduces the water permeability of concrete and enhances its sulphate resistance² – reducing its susceptibility to corrosion and spalling with the potential to enhance durability, ultimately increasing the lifetime of concrete structures.

Graphene only needs to be added at a range of between 0.01-0.07 per cent of cement for the full extent of its properties to be realised. This means adding a small amount of graphene can vastly improve the durability of cement, resulting in longer lifetimes for concrete structures.

ICR: What is the full range of applications and benefits across the building materials industry?

MB: PureGRAPH is applied as an additive and the range of materials the product can be applied to is wide. Cementitious materials are a key beneficiary of graphene. The enhancements it brings include improved material performance in terms of strength, durability, corrosion resistance and reduced permeability. Perhaps most importantly, graphene reduces the amount of clinker required in cement production.

Additionally, First Graphene has been working with a subsidiary of CEMEX at the UK-based Manufacturing Technology Centre (MTC) to trial graphene in railway sleepers, cast using recycled aggregates. Graphene was added to improve compressive strength and reduce porosity of recycled aggregate.

First Graphene is also actively partnered with GtM Action, providing commercially available graphene enhanced dry mortar known as HexMortar™ for shotcrete and pumping applications – formulated to increase flexural and compressive strength of dry mortars efficiently and effectively.

The company has also successfully proven the concept of 3D printing graphene, working with UK-based partners on national infrastructure projects.

First Graphene also supplies PureGRAPH solutions to other material applications and industries, including energy generation and storage, composites and plastics, coatings, adhesives, sealants, elastomers and foams.

ICR: What investment is being put into the development of PureGRAPH? Are there other investors and stakeholders behind the project?

MB: First Graphene is a publicly-listed company on the Australian Stock Exchange, with the FY22-23 performance recording annual revenue of more than AUD1m [US\$0.65m] (unaudited). First Graphene is actively working with more than 30 global partners in the cement and concrete sector, as the use of graphene continues to gain traction. This sector is our primary commercial focus, with the green cement market expected to be worth US\$56bn by 2027.

The company has worked closely with the University of Manchester (UoM) for

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more than five years and is currently a Tier 1 partner of the Graphene Engineering Innovation Centre (GEIC) at the UoM. The partnership provides access to world-leading research and development equipment, academic leaders in the study of graphene and further provides access to a collaborative ecosystem of commercial and academic partners focussed on the development and application of graphitic technologies.

Trial work

ICR: With the focus now moving upstream, First Graphene has announced the first commercial trial of PureGRAPH with the Breedon Group. Why was this partnership a good fit? Have any modifications been necessary at the plant to start graphene-enhanced cement production?

MB: The First Graphene-led trial commenced in June 2023, introducing

PureGRAPH into the ball mill process as a grinding aid at Breedon Group's Hope Cement Works, the largest cement plant in the UK.

Having involvement from this leading cement manufacturer, as well as sustainability innovator and leading construction and regeneration group Morgan Sindall, gives the trial great credibility. Our collaboration has the joint goal of showcasing the potential of green cement products, powered by PureGRAPH, in real-world construction applications.

Phase one of the world-leading trials involved developing a specialised dosing system to apply the graphene enhanced cement grinding aid using readily available equipment. The next phase of trials will focus on developing the application process further, optimising the formulation so that it can be applied into existing dosing lines.

ICR: How will the PureGRAPH 50 trials be carried out and what is the primary objective?

MB: The full trial will use approximately 1.2t of PureGRAPH across multiple trial phases, to produce up to 2000t of graphene-enhanced cement. Graphene is introduced into the process using multiple dispersion methods and dosage rates to determine the most effective and beneficial application process.

Our aim is to find a simple, low-cost and safe method of introducing graphene

The First Graphene-led trial, introducing PureGraph as a grinding aid at Breedon Group's Hope Cement Works, commenced in June 2023



"The initial focus of this trial is on assessing overall strength. The material will also go through standard quality assessment processes to further assess the properties of the poured concrete."

to industrial-scale cement production. We anticipate results will further validate PureGRAPH's potential to reduce the carbon footprint of the cement production process by up to 20 per cent by reducing the clinker factor of cement.

The emission reduction capabilities of PureGRAPH position it as an attractive additive across the industry, making it a readily deployable enabler to decarbonisation of one of the highest emitting industries in the world. This will ultimately change the approach to material choice in construction for the better. The beauty of the technology is that the company is in a position to deploy it at scale.

ICR: When might customers expect to see the initial feedback from the commercial testing of PureGRAPH?

MB: At the time of writing, the material produced is undergoing testing to assess its performance.

Cement produced through the trial will be supplied to Morgan Sindall Construction, who will use it in a real-world application. The details of the construction application and preliminary results are not available publicly at this stage. The consortium aims to provide further updates in the coming weeks.

ICR: What sort of concrete testing will be carried out on-site?

MB: The initial focus of this trial is on assessing overall strength. The material will also go through standard quality assessment processes to further assess the properties of the poured concrete. Concrete cubes are currently undergoing testing at Morgan Sindall's accredited laboratory facilities.

The graphene-enhanced cement was successfully delivered and offloaded at scale and converted into an industrial-grade concrete. This was successfully

poured using standard equipment with no changes to the on-site construction team's material handling process.

Adoption

ICR: Which directives will regulate the use of graphene as an additive and do you foresee any barriers to end users adopting the product?

MB: PureGRAPH products have already been approved for manufacture and import within the EU and Australia. Registration of our product into the US market is currently in progress.

First Graphene does not anticipate any barriers to consumers applying and using PureGRAPH products. We look forward to working with all industries to determine how graphene can enhance their industrial materials and address their application challenges.

ICR: What measures are being taken to ensure the First Graphene product is a low-cost product compared to other additives that are on the market?

MB: First Graphene continues to invest in improving its manufacturing process with readily scalable technology to cater for growing demand. In June 2023 the company commissioned and installed an enhanced grinding mill leading to reduced handling and work-hours required to process and produce PureGRAPH products.

Demand from the cement and concrete sector offers considerable economies of scale when supplying PureGRAPH, which will further enable the company to produce competitive solutions to its clients as production volumes ramp up.

The trial of PureGRAPH enhanced cement occurring in the UK will provide the company with the knowledge and best pathway forward to provide graphene as a cost-effective product for the industry.

Sustainability

ICR: What makes PureGRAPH® a sustainable product?

MB: First Graphene has stockpiled more than 600t of high-purity graphite with further graphite supply agreements in place to ensure the company is well positioned to access high-purity feedstock as demand increases. This secured supply ensures our material source is carefully managed and will remain sustainable.

First Graphene continues to modify the production process to improve the sustainability of PureGRAPH. This includes optimisation of our facility to lower power consumption while increase throughput. Additional modifications to the process are expected to further improve both power efficiency and production rates.

ICR: In earlier trials at the UoM, what conclusions could be made on potential CO₂ savings for the PureGRAPH® 50 grinding aid?

MB: Data from FGR development trials and testing has already been analysed by the UoM and found graphene enhanced cement to both offset CO₂ and demonstrate mechanical benefits.⁵ Since reporting these results, further enhancements have been made to the company's graphene production process, improving energy efficiency and reducing the associated carbon emissions by 20 per cent, which will likely improve the potential for further carbon emission savings.

The company looks forward to performing additional carbon lifecycle analysis as part of the Breedon trials programme with further potential to support commercial-scale solutions to reduce CO₂ emissions in the construction sector. ■

REFERENCES

- ¹ HO, VD, NG, CT, OZBAKKALOGLU, T, GOODWIN, A, MCGUCKIN, C, KARUNAGARAN, RU, LOSIC, D (2020) 'Influence of pristine graphene particle sizes on physicochemical, microstructural and mechanical properties of Portland cement mortars, 2020' in: *Construction and Building Materials*, 264, p4-5. <https://www.sciencedirect.com/science/article/abs/pii/S0950061820321930> [Accessed: 19 August 2023]
- ² CHETTY, K, WATSON, M, RAINE, T, MCGURGAN, T, LADISLAUS, P, CHEN, J, ZHANG, S, LIN, L, JIANG, G (2022) 'Enhancing concrete and mortar properties and durability using pristine graphene particles' in: *Coatings*, 12 (11), 1703, p3-9.
- ³ FIRST GRAPHENE (2023) 'World-leading graphene enhanced cement trials commence using PureGRAPH®' <https://app.sharelinktechnologies.com/announcement/asx/91f85b354581b67115002f0628af246d> [Accessed: 17 August 2023]
- ⁴ FIRST GRAPHENE (2023) 'Accelerating the drive to reduce CO₂ emissions in cement and concrete' <https://app.sharelinktechnologies.com/announcement/asx/121610428d45824f331c9e11f877b7ff> [Accessed: 17 August 2023]
- ⁵ TARPANI, RRZ, YUNUSA-KALTUNGO, A, SU, M, MANU, P, CHEUNG, C, WATSON, M, LADISLAUS, P, GALLEGOS-SCHMID, A (2023) 'Evaluating climate change impact of cement enhanced by graphene' <https://app.sharelinktechnologies.com/announcement/asx/121610428d45824f331c9e11f877b7ff> [Accessed: 17 August 2023]