NICER PROGRAMME & INNOVATE UK CIRCULAR ECONOMY FOR SMEs

Porcement

UKRI Interdisciplinary Centre for Circular Chemical Economy

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UKRI Innovate UK

Recycling tiles into a concrete alternative

The Challenge: What we were trying to achieve

Today in the UK alone, 100k tonnes of unused and 800k tonnes of used porcelain tiles or sanitaryware is being turned into low-level aggregate for roads or even going to landfill. Meanwhile, the consumption of Portland cement, a highly energy intensive product responsible for about 8% of global carbon emissions, exceeds the million tonnes/year mark in the UK and is responsible for a significant share of building sector emissions. We are tackling these two challenges by applying circular economy thinking, capturing the value of waste tiles in the production of a novel cement substitute.

The partial to complete substitution of Portland cement in concrete is a formidable challenge for the construction industry, and several options are under investigation worldwide. Whilst the substitution of cement in the mix with alternative cementitious materials is perhaps the most straightforward option, as it does not require changes in the supply chain and production line, complete substitution of Portland cement with binders with different chemistry has been widely studied.

One of these options is to use alkali-activated binders, a process which, when applied to concrete, has been shown to reduce CO_2 emissions by 70%, from circa 330 to 120 kg CO_2e/m^3 (Bianco et al., 2021). The chemistry of waste ceramic and porcelain powder makes it suitable for its use both as a Portland cement partial replacement and as binder in alkali activated systems. When used as supplementary cementitious material in Portland cement concrete, substitution rates up to 20% can be achieved, leading to a 20% reduction in CO_2 emissions. Their use as binders in alkali-activated systems and as a source of silicate and aluminate, can further lower the emissions of concrete manufacture by 30 – 40 kg CO_2e/m^3.

The critical functionality and selling point of our product (Porcement powder) is that we demonstrate that it is possible to replace in excess of 20% of Portland cement in Portland cement-based concrete, or 70% of ground-granulated blast furnace slag (GGBS) in alkali-activated concrete with Porcement reducing the environmental impact of the product whilst retaining suitable mechanical and physical properties.

We view tiles as partial or total substitution for cement in concrete applications and we are also looking at other suitable source materials.

The Barriers: What are the common barriers and how can these be overcome

There are three key barriers:

1. **Finance.** Both private equity and venture capital firms continue to measure project potential according to outdated methods which do not fit well with the long-term returns of many CE models. Although new funding avenues are arising, they continue to prioritise projects which offer high returns in the short term.
2. **Legislation.** Although the legislative landscape is changing, this is not happening quickly enough and lacks detail. Political aspirations are not reflected in practice and commercial pressures are acting on the economy. Lack of certainty on carbon credits is stifling innovative ideas on how these could support a low carbon economy.
3. **Sourcing.** Despite sufficient quantities, since there is no existing infrastructure to capture the value of porcelain tiles, securing a stable incoming stream of raw materials is challenging.

"Our vision is simple - to treat all the available tile and sanitaryware waste material into our zero-carbon cement alternative, for the benefit of the marine and construction industry"

The Approach: How we tackled the challenge

We saw a potential solution which brought together the joint challenges of porcelain tile waste and the high environmental impact of Portland cement. To test this solution, we secured research and development support from the University of Exeter and funding support from Innovate UK. We then developed and clarified a series of potential business model plans which would bring this solution to market.

Unexpected outcomes: What we learned along the way

This project has highlighted several challenges, some of which were unexpected, others less so.

- Lack of appetite from funding institutions to address the challenge.
- Lack of co-ordination between public governing bodies (i.e. joined up recycling legislation and outputs, communication between policy makers).
- Lack of central governance and regulation for carbon credits, impacting on clarity and transparency for innovative small businesses.

Given the high impact of Portland cement, alongside its wide usage, we believe that this research is world-leading. The difficulties surrounding funding and support have therefore been surprising. Looking beyond the UK to the international market, we would very much welcome a multinational UK corporation to support the overseas growth plan.

Support from Innovate UK has been excellent and their guidance and continued mentoring has been vital to the success of this project.

Key Learning: What we would do differently next time

This is a difficult question to answer, as every day we learn something new. Perhaps one of the key learnings is how difficult it is to reach decision-makers to market the new product. Despite genuine interest commercially, reaching directors at large corporations has proved challenging.

Another key learning is how much resistance there is to the solution, in terms of critical feedback and doubt surrounding the environmental benefits. This has shown us the importance of measurement and quantification in telling a transparent and compelling story about the new product.

The Outcome: What we achieved and how it has impacted the business, society and key stakeholders

We have collaborated with the University of Exeter to mill waste porcelain tiles and use the resulting powder as a cement substitute through alkali activation technology.

Looking forward: Next steps and future directions

As the project is still very much in development to achieve its vision, the focus is on pursuing it until its full potential has been realised and all available materials are treated and tested.

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