Engineering zero emissions cement from electric arc furnace waste

Supervisor (primary) Imperial College London: Dr. Rupert J. Myers

Applications are invited to fill a PhD position funded through either a Dixon Scholarship, another internal or external scholarship, or from a student's own funding.

The PhD student will develop a highly novel and promising low carbon cement from steel electric arc furnace slag that has only recently been invented and is in the initial stages of research and development. This material has the potential to avoid substantial amounts of CO_2 emissions from both cement and steel production processes, which together currently account for ~20% of total global CO_2 emissions.

The PhD will be based in the Materials Section of the Department of Civil and Environmental Engineering (Skempton Building, South Kensington Campus). On a day-to-day basis they will work alongside ~30 PhD students and ~10 postdoctoral research associates in the Materials Section, including several in their same research group, which is led by Dr. Myers. The PhD student will also collaborate with research partners and non-academic organisations external to Imperial including colleagues at the University of Cambridge. This PhD project offers a wide range of excellent training and development opportunities in a highly stimulating environment, as well as access to internationally leading academics and industrial partners, research facilities, and networks.

Project details

The key aim of this PhD project is to optimise both the chemical and mineralogical compositions of slag produced in an electric arc furnace, and the mix design of the cement produced from this slag, to create a low carbon cement with excellent engineering properties that comparable to conventional high carbon Portland cement.

Today, electric arc furnace slags are usually made with a limestone flux at 1500-1600 °C. However, this flux can be changed from limestone to a material like end-of-life cement or concrete (from construction and demolition waste), which contains both significant amounts of Ca (also present in limestone, which is $CaCO_3$) as well as Si. Very early experimental trials indicate that this novel flux produces a slag that is similar in composition and thus reactivity to Portland cement clinker. These results have motivated a need to demonstrate and optimise the performance of cement derived from novel electric arc furnace slags based on this idea, including its feedstocks (e.g. end-of-life cement), processing conditions (e.g. temperature), mix designs (e.g. gypsum addition), hydration mechanisms (e.g. C-S-H formation), physical properties (e.g. microstructure), and mechanical properties (e.g. compressive strength).

This PhD project will take an experimental and thermodynamics-led approach to understanding this novel cement, including modelling of the slag composition at high temperatures in the electric arc furnace and cement paste composition at ambient conditions in concrete. The focus will be on using currently available thermodynamic data and software to understand the fundamental physical and chemical properties of the cement (and cement paste), and then using this fundamental knowledge to engineer excellent structural materials.

This is a heavily experimental PhD project that will utilise the suite of state-of-the-art materials characterisation equipment available in our Advanced Infrastructure Materials, Structures, and Environmental Laboratories, which is a facility that is essentially unparalleled in terms of quality within the UK.

Academic requirements and experience

Required

- A good first class degree (or international equivalent) in a STEM subject, e.g., Chemistry, Metallurgy, Physics, Materials Science, Chemical Engineering, Environmental Science, Geology), or a course with strong emphasis on chemistry.
- A masters level degree qualification in any course with a strong emphasis on chemistry, as indicated above, alone or in addition to an undergraduate level degree.
- Laboratory experience.
- Strong interest in materials research.
- Excellent English communication skills.

How to apply

Applicants wishing to be considered for this opportunity should send the following application documents to Dr. Rupert J. Myers (r.myers@imperial.ac.uk):

1. Current CV including degree result and, if possible, class ranking

Application via the Imperial College Registry is not necessary at this stage.

Applications will be regularly reviewed until the position is filled.

Funding notes

A Dixon Scholarship is available that can provide funding to cover Home tuition fees for 3.5 years. The funding can also be used to partially support an EU or International student.

Applicants interested in this project and seeking funding via another scholarship scheme (see here: https://www.imperial.ac.uk/study/pg/fees-and-funding/scholarships/) are welcome to apply.