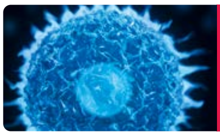

ADVANCED MATERIALS SCIENCE

Fields of Expertise TU Graz

Source: istockphoto.com

Christof Sommitsch, Advanced Materials Science

Source: Lunghammer – TU Graz

Only a few months back, we organized the Advanced Materials Sciences Poster Day in order to foster networking within the Field of Expertise. At this event, Marcus Ossiander, from the Institute of Experimental Physics, presented his new ERC Starting Grant, EUVORAM – Extreme-Ultraviolet Meta-Optics for Attosecond Microscopy. Afterwards, Eva-Maria Steyskal, from the Institute of Material Physics, presented the second part of the lead project: Porous Materials @ Work for Sustainability. These two presentations were followed by a poster session, including more than 50 posters from students and postdocs from our Field of Expertise. The event lasted for more than two hours and a lively scientific exchange took place. We are also happy to have restarted our meetings at member institutes after they were discontinued during the Covid-19 pandemic. The last *FoE AMS-update* event of this type took place on May 8th at the Institute of Chemistry and Technology of Materials and included a presentation of the institute and visit of the laboratories.

In the 17th call of the initial funding programme of TU Graz, we could finance three interesting project ideas in chemistry and geoscience. The awardees were Jurij Koruza with a proposal on “Piezoelectric Hardening by External Stimuli”, Franziska Stamm with the proposal “Climate change and thawing in alpine to glacial environments traced by hydroxyaluminosilicate (HAS) deposits” and Suman Mallik who proposed to work on “An expeditious approach towards highly efficient organic light-emitting diodes using organic radical emitters”. We wish them good luck for the proposal submissions, and we look forward to more submissions at the next call.

New items of infrastructure have been acquired in the Field of Expertise. These include a system for micro computed tomography, a 3D digital optical microscope, a high-resolution time-of-flight mass spectrometer and a thermal gravimeter combined with gas chromatography-mass spectrometry. More equipment will be acquired with the last matching grant that was awarded to our Field of Expertise by the Rectorate.

Cyrill Grengg, Florian Mittermayr

From Mineral Waste to Building Materials: CD Lab GECCO$_2$

Source: Lunghammer – TU Graz

The aim of this research initiative is to establish a cutting-edge interdisciplinary laboratory at the interface between waste and building materials, and the environmental, geo, and civil engineering sciences, with the aim of developing a novel generation of waste-based building materials following the concept of CO_2-neutral circular economy.

MINERAL WASTES – UNDERESTIMATED RESOURCES

The development of utilization strategies for wastes and industrial by-products is one of the central questions of our time in order to avoid increasing scarcity of finite resources and to reduce the environmental impact on society. Mineral wastes represent the largest waste stream in Austria with an overall production of 54m t/a, corresponding to 76 % of the entire waste production. Almost 60 % of mineral wastes are landfilled and 96 % of all landfilled waste (32m t/a) is mineral waste. Besides excavation materials, mineral wastes comprise metallurgic slags, mineral wool wastes, construction and demolition wastes, incineration residues, waste glasses and others. >

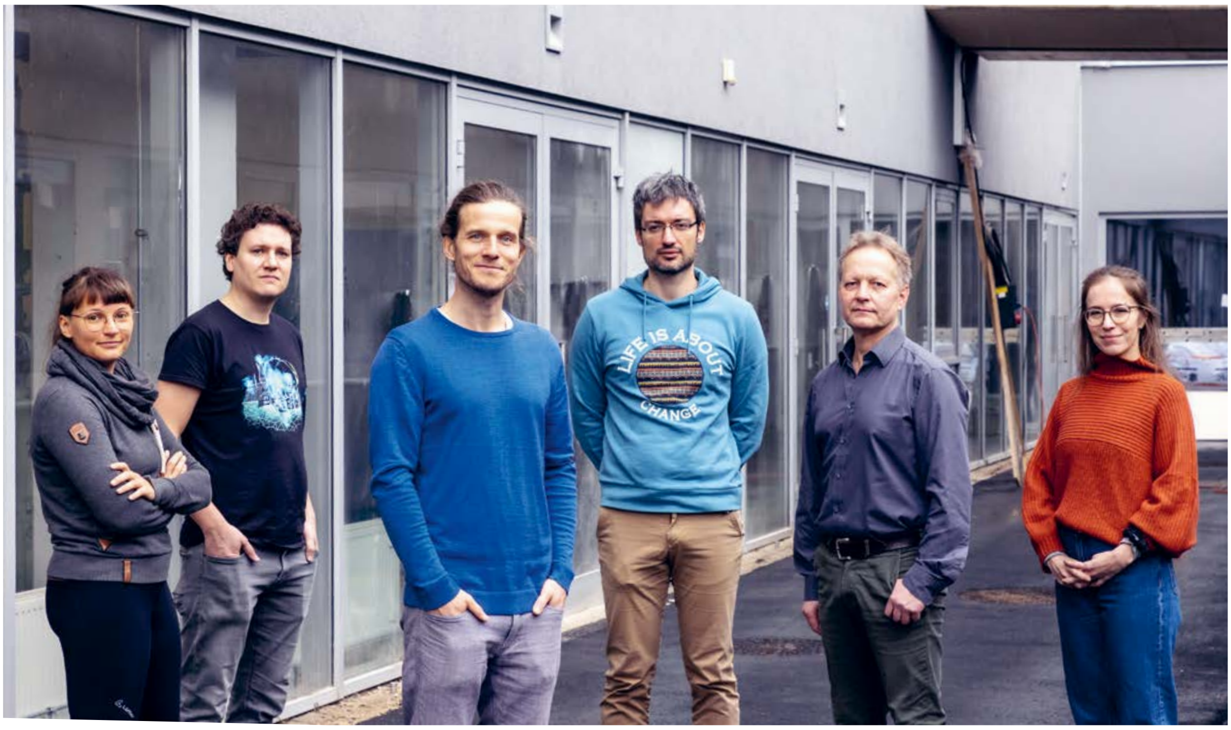

Figure 1:
Scientific team of the CD Lab GECCO$_2$, including researchers from seven TU Graz institutions, two institutes from the University of Leoben and one from the University of Graz.
Source: Lunghammer – TU Graz

ENVIRONMENTAL IMPACT OF CONSTRUCTION MATERIALS

The awareness of the environmental impacts that accompany the manufacturing of construction materials has risen significantly in the past decade. The construction sector represents one of the most significant sources of waste generation in the European Union and recent data indicate that 9 % of all greenhouse gas emissions generated worldwide originate from the manufacture of construction materials. In parallel with the increased knowledge about the environmental impacts of construction materials, the concept of circular economy emerged. The latter can be understood as a regenerative system in which emissions and consumption of resources are minimized by slowing, closing, and/or narrowing material and energy loops. In view of this, the constantly high material demand in the building sector, together with the increasing pressure to reduce the environmental footprint of construction materials, provides a stable platform for suitable industrial by-products and wastes to be further processed. In this context, alkali-activation technology presents one highly promising approach. In the most general description, alkali-activated materials (AAMs), also often referred to as geopolymers, consist of two main components – a precursor and an alkali activator. Due to the very few requirements for the suitability of precursors, there are many kinds of potentially applicable source materials, such as metakaolin, calcinated clays, fly ashes, volcanic ashes and Si and Al-rich wastes. Depending on the choice of raw materials, the chemistry of AAMs may differ widely, and can thus be tailored to exhibit different material properties.

GECCO$_2$ APPROACH – MATERIAL DEVELOPMENT

The proposed research structure of this CD Laboratory combines several major novel approaches to tackle existing barriers (chemical, environmental and economic), so far limiting the utilization of major inorganic and organic waste and industrial by-product reservoirs. In this context, the central challenge is to design the chemical and physical composition in such a way as to control the microstructural framework and corresponding physicochemical material properties in order to enable a tailored material manufacturing. Therefore, waste materials will be considered as a potential source of precursors/binders, aggregates, as well as raw materials for alternative activator production. The production of waste-based alkaline activator solutions is based on innovative experimental set-ups using advanced multi-reactor systems in order to achieve desired activator solution reactivities.

TOWARDS CO$_2$-NEUTRALITY

One main novelty of this research approach is the implementation of carbon-rich wastes, such as (waste) oils (e.g. from the food industry) in the material microstructure. Oil addition has resulted in the formation of stable metal soap phases which significantly modified the porous

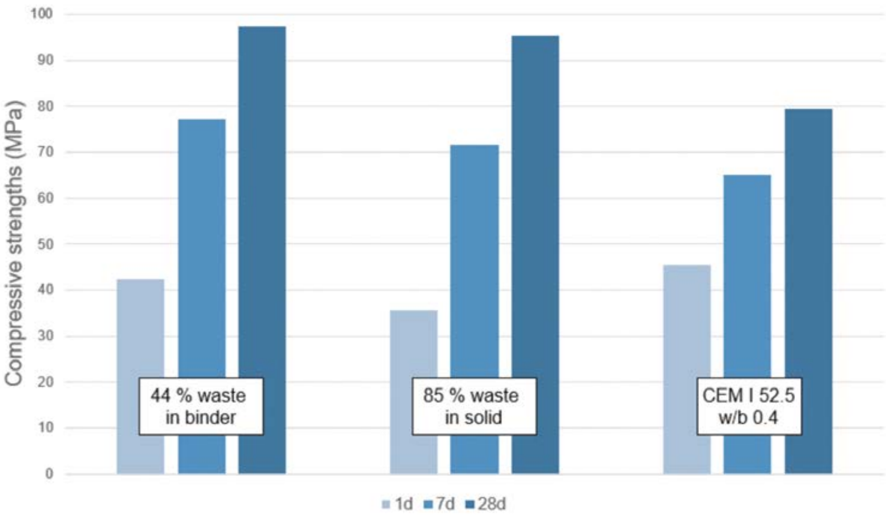

Figure 2: Strength evolution (1, 7, 28 days) of waste-based mortars, compared to a CEM I 52.5, with a water/binder ratio of 0.4.

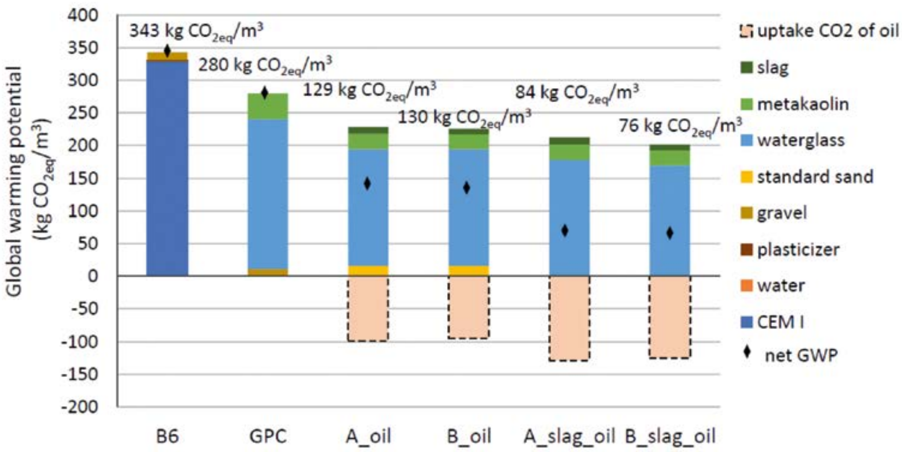

Figure 3: Global warming potential [kg CO_{2eq}/m^3] of a standard B6 concrete compared to alkali-activated materials based on metakaolin (GPC) and different metallurgic slags with oil addition (A_oil, B_oil) and siliceous sand aggregates and with oil addition and waste-aggregates (A_slag_oil, B_slag_oil).

Source: Lunghammer – TU Graz

microstructure, reducing the inner specific surface area by a factor of up to 15 for mortars. These promising results will help solve well-known weaknesses of AAMs, such as high drying shrinkage, low carbonation and chloride resistance, and therefore increase the range of potential future applications. In addition to improvements of the material properties, the utilization of vegetable oils permanently binds carbon in the construction material. Lifecycle assessment calculations have revealed that when new vegetable oil is used, near carbon neutrality can be achieved. When waste cooking oil is modelled, a negative GWP was achieved. These new findings highlight the potential of AAM-vegetable oil composites as a future high-tech and negative-carbon construction material.

Cyrill Grengg

is a senior scientist at the Institute of Applied Geosciences and head of the CD Laboratory GECCO$_2$, and specializes in concrete – environment interactions and the development of alternative low-CO_2 binder systems

Source: Lunghammer – TU Graz

Florian Mittermayr

is a senior scientist at the Institute of Technology and Testing of Construction Materials. Main research topics focus on mineral-based building materials, applied mineralogy, geochemistry and microanalyses.

Source: Privat