Thermogravimetric analysis for the development of sustainable cementitious materials

The COWIfonden grant allows the purchase of a thermogravimetric analysis (TGA) instrument for investigations of cementitious materials at the Department of Chemistry and iNANO at Aarhus University.

In building materials, cement paste is the glue that binds other particles such as sand and stones together. The binding is associated with the “hydration”, which occurs gradually after the addition of water to the cement powder, and results in the consecutive formation of water-containing minerals. The properties of cement-based materials originate mainly from the different types of hydration products formed and their spatial arrangement.

Concrete is the globally most used construction material, because of its low price, high strength, long lifetime and general availability. Limestone consists mainly of calcium carbonate ($CaCO_3$) and it is the principal raw material of Portland cement. During heating in the cement kiln, it decomposes and releases CO_2. Thus, the application of Portland cement in concrete makes a substantial contribution to the man-made CO_2 emissions (5 - 8%) and global warming while providing the backbone of the infrastructure for our society.

The TGA instrument enables us to detect changes in a material by monitoring its weight loss during heating, which can be used for the quantification of several key minerals in cementitious materials. The data obtained from TGA will be combined with the relative distribution of water between water-filled pores as determined by nuclear magnetic resonance spectroscopy (NMR). The aim of this investigation is to elucidate the relationship between the pore-size distribution, chemistry and strength of cementitious materials. This project is part of the development of new, more sustainable cementitious materials with reduced CO_2 emissions during production.

In recent years, our research group at Aarhus University has focused on developments of heat-treated clays for partial replacement of the Portland cement binder. In this context, we have explored structural features on the molecular- and nano-scale level that contribute to the strength and durability of cementitious materials. To unravel these questions, we use different characterization techniques, of which TGA is a quantitative, complementary tool to our NMR investigations. In addition, the TGA instrument will be used in research studies, which focus on the durability of concrete to ensure a long service life in harsh chemical environments.

Finally yet importantly, the TGA instrumentation will enrich the education of scientists and engineers at iNANO and the Department of Chemistry, Aarhus University.