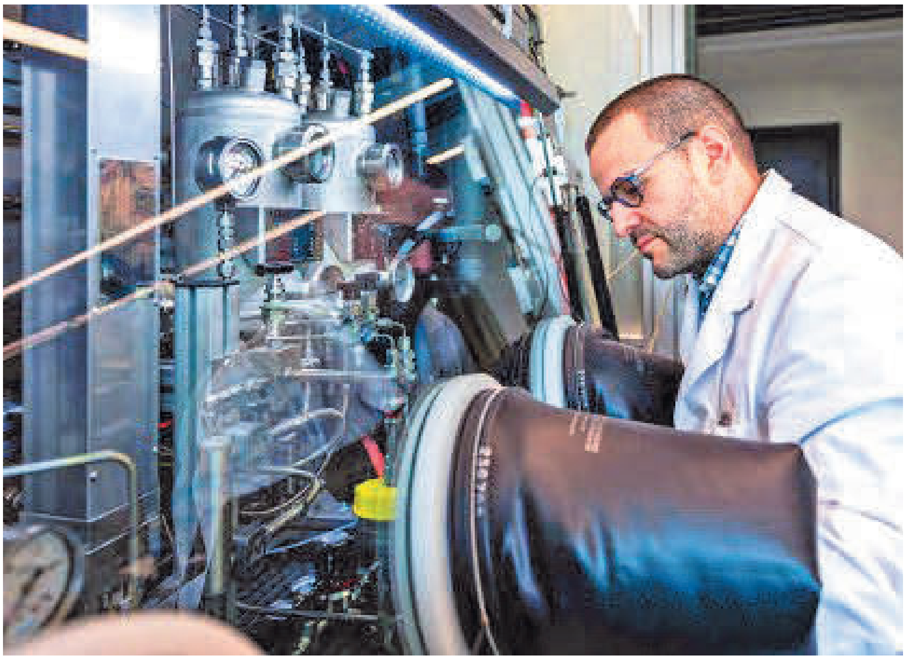
# Chemical process engineering – safety first!

*Author: Sonia Thomson (HLS FHNW)*

**Andreas Zogg brings together companies and students of chemical engineering to achieve joint progress in process safety.**



*This Zahnd performs the flow reaction in a safety glove box. (Source: Joël Karlin, FHNW School of Life Sciences)*

Prof. Dr. Andreas Zogg has a passion for process safety. He joined the FHNW School of Life Sciences in 2018 after several years as a safety expert at Novartis and as a process development chemist at F. Hoffmann-La Roche and Ciba SC. He now heads the Process Development group at the FHNW Process Technology Centre. He is the founder and president of the Miniplant 4.0 association.

"Safety, sustainability and quality are the three drivers of innovation in today's Swiss chemical industry," says Zogg. "If you ask me, safety always comes first!"

Many chemical reactions carried out to produce ingredients for detergents and cosmetics involve fire and explosion hazards. Switching from batch or semi-batch reactions to continuous flow processes can offer safety advantages.

Secondly, companies looking to reduce their energy consumption see the opportunity to carry out some reactions in continuous operation to avoid costly energy peaks. This is creating demand for continuous reactor systems that can be used at smaller, decentralised production sites.

Finally, the quality of chemicals produced in Switzerland must be a distinguishing feature, as the price is high. The expansion of flow chemistry helps to promote the fine chemicals sector at the national level.

In the Innosuisse project Simulation-based safety concept for the scale-up of safetycritical continuous processes, which is being carried out in collaboration with MSc students from the FHNW School of Life Sciences and industry partners, Zogg addresses all three elements.

Zogg's team is working on a model that can be used to scale up a continuous ethoxylation reaction and determine when an explosion is likely to occur. The first model is based on data from scientific literature on thermodynamics and reaction kinetics, combined with small-scale differential scanning calorimetry (DSC) measurements collected in the explosion reactor at the FHNW Process Technology Centre.

To determine when the ethoxylation reaction is likely to lead to an explosion, Zogg's team modelled two scenarios and carried them out in a unique explosion reactor, using the resulting vapourliquid equilibrium data to refine their model. Although they had modelled a maximum explosion pressure of 12 bar, the reaction was carried out at up to 20 bar before it exploded.

In addition, the Zogg team designed the basic layout of the continuous ethoxylation plant, including a comprehensive risk analysis (HAZOP). They then carried out the flow reaction in a safety glove box specially designed for this purpose. The box provides a nitrogen atmosphere, monitors the oxygen and ethylene oxide content and has an integrated safety scrubber that prevents ethylene oxide vapour from escaping.

Fluitec, a developer and manufacturer of reaction systems, is contributing a small continuous reaction calorimeter to the project. This special device, located in the safety glove box, measures the heat released during the reaction. The data collected in real time with the Fluitec device at FHNW is used to adjust the process model.
"The use of our flow calorimeter in an experimental environment and the contribution to new models for the scaleup of flow chemistry provides valuable insights into how the calorimeter works on a small and production scale," says Marlies Moser of Fluitec.
The FHNW model, based on data collected with the Fluitec calorimeter, is being used by project partner Schärer & Schläpfer AG, a manufacturer of surfactants for the pharmaceutical and chemical industries. The aim is to enable direct scaleup from the laboratory to production quantities.
"The process safety models developed by the FHNW enable safer, more energyefficient reactions that produce high-quality surfactants. We look forward to applying the models to expand production in our plants," says Roland Borner, Schärer & Schläpfer AG.

In addition to industrial innovation, the project also offers practical training opportunities. Two parttime MSc students, This Zahnd and Benedikt Brönnimann, are working on the Innosuisse project while completing their Master's degrees in Chemical Engineering at the FHNW. Some of the work is also being carried out by bachelor's students in chemical engineering. The FHNW's miniplant facility, with its unique explosion reactor for testing the thermal process safety of explosion reactions, enables students to gain direct experience in modelling and managing hazardous processes.
"For Master's students in particular, it offers the opportunity to deepen their knowledge in practice before they graduate and move fully into industry," says Zogg. "At the same time, we can expand our knowledge of how to safely scale up flow chemistry processes to promote their adoption by industry."

**Key data**

**Contact:**
Prof. Dr Andreas Zogg, FHNW School of Life Sciences
Email: andreas.zogg@fhnw.ch
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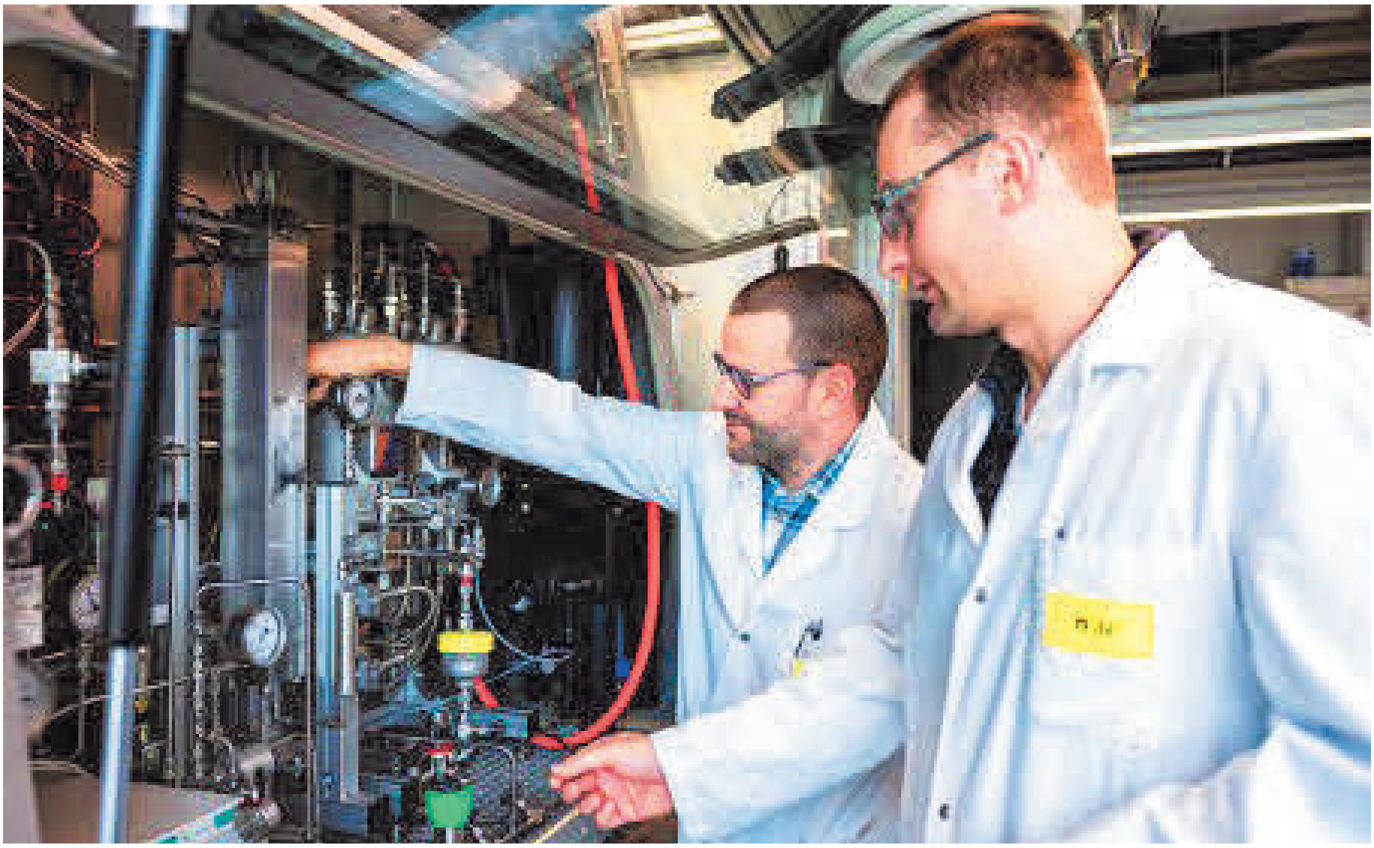

*Master's students This Zahnd and Benedikt Brönnimann are gaining direct experience in modelling and managing hazardous processes in collaboration with industry partners. (Source: Joël Karlin, FHNW)*