Science for Society

BY SISKA WAELKENS

Sustainability is an important policy issue for KU Leuven. The university promotes sustainability at all levels, with efforts to reduce waste and to favour rational energy use and sustainable transport. Sustainability also has a place in education and in research. Science@leuven met two researchers committed to develop knowledge and technology for sustainable materials management. Professor Koen Binnemans is head of the Laboratory of Metallurgical Chemistry, while Dr. Ir. Peter Tom Jones is IRF Research Manager Sustainable Metallurgy. Together they are the founders of SOLVOMET, KU Leuven's Industrial Service Centre of Solvometallurgy.

What is SOLVOMET?

Koen Binnemans: SOLVOMET is quite unique within the Faculty of Science. The centre's aim goes beyond blue sky research, as we explicitly want to take steps towards valorization of our research results. SOLVOMET aims at developing processes for the recovery of metals, including rare earths metals, from different materials, in a sustainable way. We have unique expertise in solvometallurgy, which means that in the extraction and leaching processes we are replacing water by other solvents, from non-polar organic solvents to ionic liquids.

Peter Tom Jones: The SOLVOMET Centre is part of a larger KU Leuven initiative : SIM² KU Leuven. SIM² KU Leuven's mission is to develop, organize and implement problem-driven, science-deep research and future-oriented education, contributing to the environmentally friendly production and recycling of metals, minerals and engineered materials within a circular-economy context. SIM² covers a number of different research lines, and brings together groups from the faculties of Science (Chemistry, Geology), Engineering Science (Chemical Engineering, Materials Engineering, Civil Engineering) but also from Economy, Law and Psychology.

KB: It involves a unique collaboration with KU Leuven's Industrial Research Fund IOF. IOF has appointed research managers (like Tom) that work in a cluster of chosen themes. This collaboration stands for a synergy with professors involved in research in the different domains. I can focus on science and development of new concepts, while Tom finds industrial partners that provide a sounding board and possible funding. This concept is still rarely used in exact science, we don't have an established tradition in contract research with industry.

PTJ: Colleagues abroad look at our IOF managers concept with envy. Both industry and universities benefit; a group of professors will "yield more". And metallurgy is a field with an urgent need for effective solutions. Climate challenges are well known, we obviously need a drastic "decarbonation" of our society. The transition to a low carbon economy will require substantial amounts of specific metals: not only base metals but also critical ones. Without critical metals, we can't produce things like motors for electric cars and bikes. Neodymium is an example: there is enough neodymium in the world, but it is not readily accessible and right now 80 percent of neodymium on the market is produced in China, with methods that we may have reservations about. We want to be able to produce neodymium with clean primary mining processes, and we want to recover and recycle neodymium from process residues and end-of-life products. The same goes for lithium, cobalt …

Mini-pilot scale equipment at SOLVOMET

SOLVOMET's approach focuses on solvometallurgy instead of hydrometallurgy. Solvents stand for more sustainable processes than water?

PTJ: Water may sound like the harmless alternative but you do not leach metals from ores with pure water, it takes strong acids or basic solutions to do so. In gold mines cyanide is used for recovery of the gold, not exactly "green chemistry".

Peter Tom Jones and Koen Binnemans

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So it is a double-sided interaction: we offer our knowledge and we find new research questions.

Furthermore, in our solvometallurgical flow sheets the organic solvents are recycled, as the intention is to develop closed-loop processes with no net outflow of solvents.

KB: Classical hydrometallurgical processes generate a lot of waste water that should be treated appropriately, sometimes at high cost. Moreover, many mining areas are located in very dry places, like the deserts in Chile or Australia. So in these locations there is a need for metal extraction processes that do not require vast amounts of water.

PTJ: Even in Europe some mines can be found in dry areas, such as Portugal and southern Spain.

KB: We offer our expertise to companies that are looking for ways of improving or replacing their processes. And this not only covers primary mining, we also develop processes that can effectively recover metals from industrial residues or urban waste.

What type of research projects does SOLVOMET tackle?

PTJ: The centre covers a large range of Technology Readiness Levels (TRL). TRL is a concept that measures where a research project stands in relation to industrial practice: SOLVOMET thus covers a wide range of TRLs, from basic research up to solutions that are tested at the (mini) pilot scale. Further upscaling at even higher TRL requires partnerships with industrial partners like Shell, ArcelorMittal, Umicore …

KB: As a scientist, your natural inclination is to purely look at how things work, but it is a pity if you're not interested in making an invention useful for society. We want to take our knowledge of molecular processes further towards applications and we want to make a difference in industry. Moreover, talking with industrial partners gives you the occasion to gain insight in what is really needed.

Upscaling to industrial level often brings up problems you didn't have to take into account at the lab scale. An impurity that doesn't occur in the lab may accumulate and block the process; dissolved silica may cause transformation of the leaching solution into a gel. Also, as we have very clear applications in mind, economic viability is an important part of the question.
Our solutions must be scientifically sound, but if they don't come at a reasonable price they are useless.

PTJ: Often researchers investigate processes that may work in the lab but that have no chance of ever becoming an economic success. In my opinion, even in curiosity-driven research in metallurgy, one should take economic potential into account. Saying "upscaling and industrial feasibility is not my area of expertise" is a bit weak, in my eyes. Research in ionic liquids, for example, can yield very interesting results, but these solvents are between 100 and 500 times more expensive than classical solvents. Research into how to use ionic liquids in the recovery of cheap metals like lead from low-grade industrial process residues is not meaningful. Let's wield the "horses for courses" principle: depending on the race course, you'll need a different type of horse. Let's use ionic liquids only for recovering high value metals, such as PGMs, from high-grade waste types.

KB: And even then, think carefully. Scandium, a metal needed for the production of certain types of fuel cells, is quite expensive; it costs 3000 euro per kg. Bauxite residue, which is a waste product from aluminum production, contains 100 g of scandium per ton. So it would take a process costing less than 300 euro per ton of waste to be profitable. That process won't involve ionic liquids.

PTJ: In process technology, you have to consider OPEX (operational expenditure – the cost to run the process) and CAPEX (capital expenditure – the investment in development, upscaling and plant building). There's no need for every scientist to be an OPEX-CAPEX-expert, but a bit of realism won't come amiss. Even the European Horizon 2020-programme hasn't always been careful in financing high TRL-projects, some of the current projects have no chance ever to be relevant, because of OPEX-CAPEX issues. That is a shame.

As a Faculty of Science, we do tend to advocate the importance of curiosity driven, blue sky research …

PTJ: I'm certainly not saying there shouldn't be any fundamental research. But a Horizon 2020 Innovation Action project targeting TRL-levels of 6 to 8 is not an ERC grant or an FWO project.

KB: As a scientist, your scope is different from what engineers do. Engineers want to solve problems, scientists want to understand at the molecular level what is happening. But even in a problem solving context, this can be a unique competitive advantage, because you can explain why problems occur, and this may open ways to better solutions. We don't renounce our fundamental background, but we take into account what's needed out there. I find this is a most fruitful approach.

PTJ: At SIM² we say we have a problem-driven, science-deep approach. We do want to solve real-life problems, but we want to have a scientifically sound explanation. It is a perfect compromise, that leads towards smart approaches. Thanks to high-throughput systems, you could follow an approach in which you change every variable in every way, and analyze output data to find optimal combinations. But with thorough knowledge of chemistry and careful reasoning, you can limit the number of variables that need to be tested. That greatly limits the number of experiments.

KB: As compared with commercial service companies, we have the advantage that we do more than optimize existing processes. If you really understand how and why something works or doesn't work, you are able to make more substantial improvements.

What is the story and the scope of SIM² KU Leuven?

PTJ: SIM² started in 2011-2012, as an informal cluster. It is currently embedded in KU Leuven's Materials Research Center (MRC), but it has outgrown this situation, with about 200 researchers involved. Now it would make more sense to become an independent institute. That would improve visibility and would offer new possibilities for interaction with the outside world. As it is, the SIM² story is well documented on the SIM² website, which is a dynamic website that is smartly linked to many other EU project websites that we run, to our LinkedIn company pages and our YouTube channel.

For our EU projects we have produced several animation films that have won a lot of interest and even some prizes. SIM² KU Leuven's ETN DEMETER PhD student Gwendolyn Bayley became a bit of a star through her movie on recycling of electric cars.

What was this movie about?

PTJ: An important aspect of studying sustainability is the life cycle assessment (LCA), which demonstrates if a new process is really more sustainable than the existing one. We can't just claim our process is better, we need to prove it. Gwendolyn works on the LCA of recycling of electric cars, and this is what her movie is about.

KB: There is not much recycling of electric cars yet as there are few end-of-life full electric cars around at the moment. Right now batteries are taken out of a retired electric car, but there is a problem recovering the rare-earth permanent magnets in the motor of electric cars because of the way the permanent magnets are built into the motor. In practice, end-of-life e-cars end up in scrap yards and shredder installations, where they are treated no differently than ordinary cars. The rare earths embedded in the motor are irreversibly lost. This kind of thing should be avoided by smarter design of e-motors so that the motors can be recovered prior to shredding.

PTJ: This example shows the need for policy research. The research community should interact with the European Parliament and the European Commission. We have a part to play in giving advice on what should be done.

So SIM² is not only committed to science and economy, dissemination and communication are also important goals?

PTJ: Sustainability is one of the main policy goals for KU Leuven, and SIM² is working on sustainability in the area of inorganic materials flows. If we want to achieve anything in the domain of sustainability, it is not going to happen if scientists remain in their ivory towers. They need to interact with industry, and with other stakeholders in society. Transdisciplinary research is one of the keys, as is interaction with society. Awareness amongst the general public is essential.

An important notion related to the metallurgical process industry is the Social License to Operate: the metaphorical permission society gives to a company to implement a specific process. In densely populated areas, companies like for instance Umicore, need to make a continuous effort to obtain and maintain this license. They need to interact with local residents and with society at large. Developing sustainable processes includes societal as well as ecological sustainability.

KB: For many people, words like “chemistry” and “solvents” have a bad connotation. That won’t go away if we don’t make an effort from our side. The processes we are developing use solvents that are as environmentally-friendly as possible. We maximize recycling of solvents. When we can’t absolutely exclude that something may end up in nature, we make sure to use biodegradable solvents. And we use as little of them as feasible, which is good for the environment and makes economic sense.

PTJ: Those “green chemistry principles” are the minimal requirements to obtain this Social License to Operate. And they don’t only work for recycling or urban mining plants, they are just as important in primary mining, where likewise continuous interaction with local residents is required. At SIM² KU Leuven we are really committed to approach this from a process psychology angle. In several of our on-going Horizon 2020 projects, such as NEMO, CROCODILE, which deal with the recovery of base and critical metals, we lead a specific work package on this Social License to Operate issue.

But ultimately, if we want to make sure the metallurgical processes of the future are sustainable, we also need better processes …

PTJ: Apart from our work in SOLVOMET, we also collaborate with Prof. Bart Blanpain of the Materials Engineering Department in pyrometallurgical processes. In today’s complex industrial flowsheets, the different types of metallurgical processes will all have a place. Solvometallurgy is an emerging domain in metallurgy and still needs to prove its value. Pyrometallurgy has been around for more than 100 years. But even there, we can still make improvements, especially in the area of energy footprint and effectivity in raw material use.

Finding industrial partners is more challenging for SOLVOMET as compared to the established pyrometallurgical industry. Many Flemish companies use pyrometallurgy, whereas solvometallurgy is the new kid on the block, with no established commercial successes so far. The breakthrough will come though. Koen has planted this flag recently, with an important position paper in 2017. I have no doubt that solvometallurgy will become important.

KB: I’m not claiming that solvometallurgy will solve every problem in the industry, but it will for a number of applications where current processes fall short. And our group seems to have a special position: in several future oriented EC projects, we are the only partner from a research department, among many more industrial partners.

PTJ: Since the transition from FP7 to Horizon Europe, the EC has decided to invest more research money in industry rather than in universities. Obviously, I’m not convinced that this is a sound strategy.

For Horizon 2020 project calls with really high TRL levels, the so-called Innovation Actions, industrial partners are not always that interested in sharing knowledge with a large number of project partners. When innovations are really close to commercial implementation, companies prefer to work on their own or in very small teams, not in gargantuan multi-partner settings. In my view the EC should provide, all else being equal, more funds for slightly lower TRL levels, the so-called strategic basic, precompetitive research.

KB: Well, obtaining EC funding is always a challenge.

PTJ: But that it is not and should not be the ultimate goal, even if that’s the way we are evaluated. It’s a means to an end: the real focus should be to develop green metallurgical processes that assist the transition to a low-carbon, circular economy.

KB: That is true, making a valuable contribution to solving grand societal challenges is possibly what gives the most satisfaction.

SIM² KU Leuven is an interdisciplinary research cluster, which addresses the European and global demand for more cleantech innovation and research on resource recovery and recycling.

https://kuleuven.sim2.be/

Solvomet is KU Leuven’s Centre for solvometallurgy. They support their partners in the development of more sustainable solvometallurgical separation processes and new mining chemicals.

https://solvomet.eu/