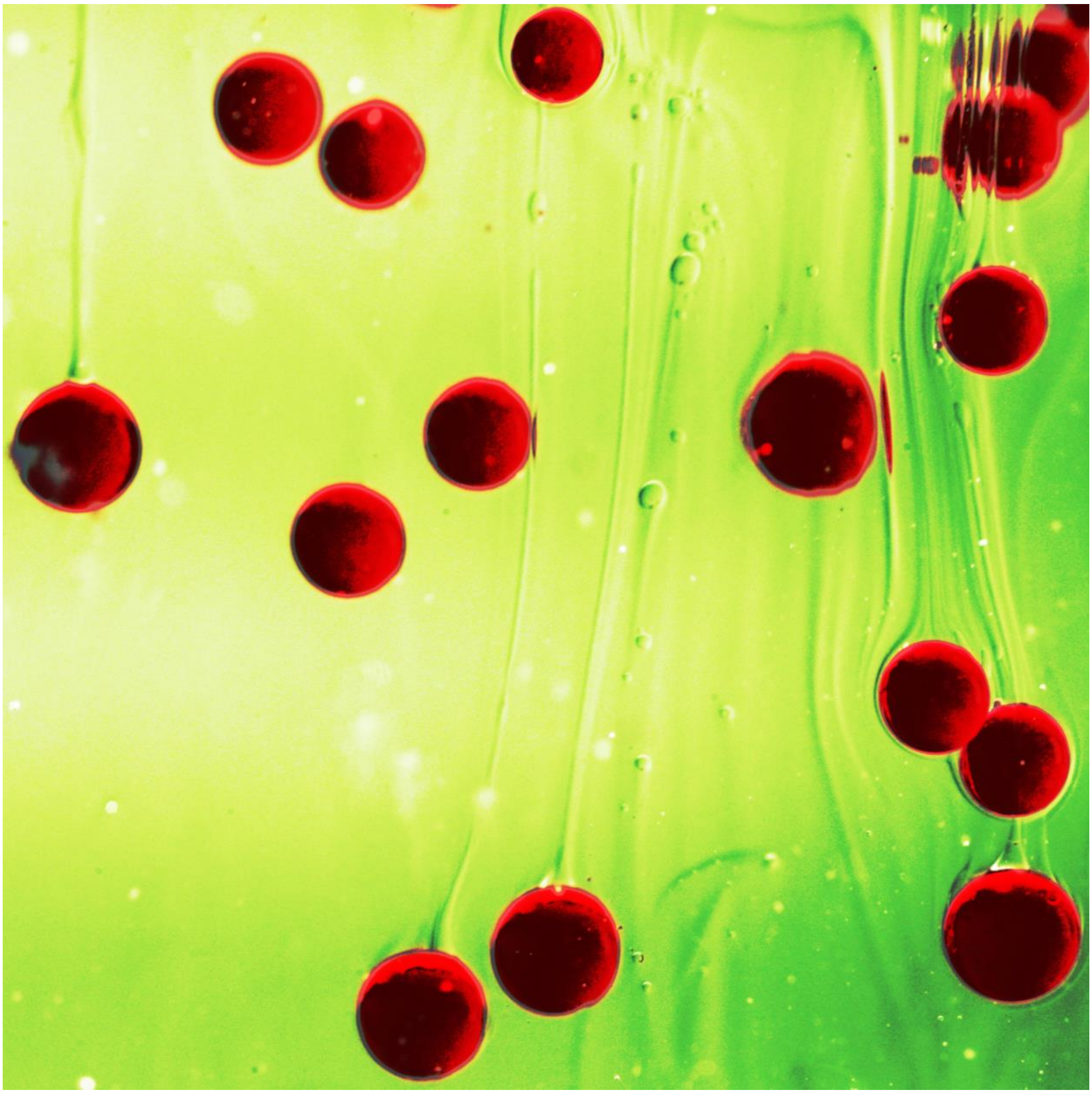
Separation and Purification



2022

Content

title photo by: Ajalaya Boripun with assistance of Rossarin Ampairojanawong

Dear Reader

Looking back to 2022, we have returned to normality with great respect after the restrictions imposed due to COVID-19. Nevertheless, some have become infected, fortunately so far without long-term consequences.

Our research this year was, on the one hand, concerned with deepening previous research such as the ReDrop simulation of settler behavior, with our tool now also available, for example, in Professor Dr. Matthias Kraume's group in Berlin.

On the other hand, we started the project with a newly proposed process structure, which is especially efficient for the separation of complex mixtures, e.g. in urban mining. For this new structure, we have since been able to show that it actually works as we expected. At the same time, we have developed a fundamental understanding of the interaction between key process parameters, so we know how to adjust parameters to optimize process performance. Comparison with processes from the literature has shown that the new structure performs at least comparably, or in some cases even better, than previously proposed processes. And no, unfortunately you will not find a description of this process structure in this annual report, as this is not possible for intellectual-property reasons.

The cooperation with the TGGS (Thai-German Graduate School of Engineering) in Bangkok also developed fruitfully on the basis of the Memorandum of Understanding that has since been signed. Within the framework of this cooperation, phase separation enhanced by alternating electric fields is being investigated and will be described in one of the contributions to this annual report.

Outside the field of chemical engineering, a lot of time was devoted to sustainability this year, jointly with colleagues from Scientists for Future, Germany.

Finally, social activities and conference visits were resumed, some of which are presented in corresponding articles of this annual report. One outstanding event was certainly the ISEC (International Solvent Extraction Conference) in Gothenburg, which was actually planned for 2020 but was then finally postponed to 2022 due to COVID-19 restrictions. Nevertheless, the consequences of COVID-19 were noticeable, as the number of participants – although in principle quite reasonable – was significantly lower than in previous years.

So: Enjoy reading!

Andreas Pfennig

Electrocoagulation Separation Process

Tawiwan Kangsadan, Ajalaya Boripun, Rossarin Ampairojanawong, Sayan Ruankon

Starting Point

Electro-separation technique has a potential in the separation of multicomponent mixture for various applications. However, the application in the biodiesel-glycerol separation has been rarely investigated. In this study, the electrical separation process with applied AC voltages was utilized to separate glycerol and other contaminants from the biodiesel product mixture. AC was preferred due to shorter separation time, high removal efficiency as well as effective energy consumption, and low corrosion rate of electrodes.

Under the influence of electric field, the small drops approach each other and eventually merge to form larger drops (coalescence). After that the larger drops have formed, they can easily settle and be precipitated by gravity at higher sedimentation rate. Increasing the electric field can also accelerate the coalescence rate and increase the speed of migration droplets, which facilitates phase separation. Therefore, the application of electrical separation offers enormous potential for separating products, by-products, and impurities in the multi-component mixtures with less complexity and high separation performance due to the increase of coalescence rate, improvement of migration rate of droplets and shortening of the process.

The aim for this study was to design and investigate the optimum conditions of the electrical separation process by comparing between the applied AC low and high voltages for the separation of biodiesel mixture (refined palm oil as a raw material) from crude glycerol. Separation efficiencies were obtained for varying electrical voltages (low and high) and vertical distance between electrodes (cm). The final biodiesel product was analyzed for the remaining soap and catalyst contents, the methyl ester content, and the quality according to EN14214 and ASTM D675 standards.

The Method

High ester content of biodiesel was produced via transesterification reaction of refined palm oil with methanol in the presence of sodium methoxide as a homogeneous catalyst at the optimum conditions as presented in the previous study. At the end of the reaction, the product mixture containing biodiesel, glycerol, methanol, remaining catalyst, and unreacted reactants was transferred to the separation chamber and then separated biodiesel from glycerol and other components using the electrical separation (ES) and the gravitational settling (GS).

For the ES, AC source of 50 Hz with the desired voltage was applied to the test chamber. The test chamber comprised of a pair of Fe electrodes that were filled with the product mixture for the separation test. The test chamber was made of glass with a PTFE Teflon lid to reduce interference and conduction. Iron electrodes (Fe) with sharp tips were used in the point-to-point electrode arrangement. As presented in the previous study, this point-to-point electrodes configuration can produce a non-uniform electric field distribution that generates strong electrical field strength near the electrode tips. Experiments were carried out with both high voltage of 1, 3, 5, 7, and 9 kV and low voltage of 72, 96, 120, 144, and 168 V.

Separation efficiency of 99.9% was achieved with an applied AC high voltage of 3 kV at a distance between the electrodes of 3 cm and with an applied AC low voltage of 168 V at a distance between the electrodes of 0.1 cm. The following chemical analysis was performed at these optimal operating conditions. The separation time was significantly reduced by approx. 360 times with the applied AC high voltage and by approx. 20 times with the low voltage.

All remaining catalyst, which was mainly in the glycerol phase, including a small amount of water and methanol, were completely removed from the biodiesel product by the shortest time of 240 s with the used of ES with applied AC high voltage as shown in Fig. 3. This is a significant improvement over the GS (no electrical field), which required more than 24 h to completely remove all remaining catalyst. With applied AC low voltage, the removal efficiency for the remaining catalyst was still better than the GS, even though more than 1 h was required.

In addition, the remaining soap in the biodiesel final product was less than 900 ppm with the applied AC high voltage after the separation time of 240 s as shown in Fig. 2. However, according to the ASTM limit, the remaining soap in the biodiesel product must be less than 41 ppm. Therefore, a further purification process with warm water washing was necessary. The same removal efficiency was observed with the applied AC low voltage after the separation time of 1 h, while the GS required more than 24 h.

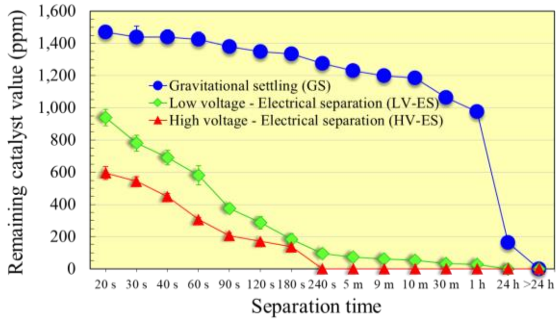


Fig. 1: Remaining catalyst values in the biodiesel final product

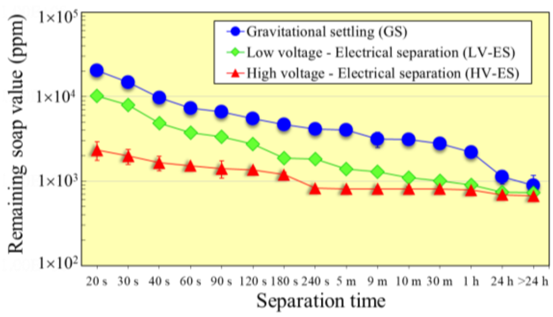


Fig. 2: Remaining soap values in the biodiesel final product

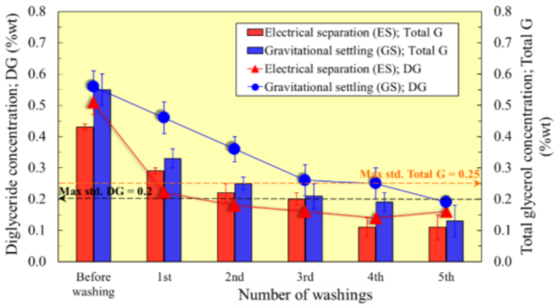


Fig. 3: Diglyceride (DG) and total glycerol (Total G) concentrations in the biodiesel final product from GS and ES with an applied AC high voltage before and after water washing process

After separation, the applied AC high voltage required only three times of washing to achieve an ester content higher than 96.5 wt% with the content of mono-, di-, tri-glycerides, free glycerol and total glycerol within the EN14105 limits. GS, on the other hand, required washing with water at least five times to achieve the same quality of final biodiesel product. Importantly, the soap content was less than 41 ppm (the standard limit).

This current research has demonstrated that the separation process with applied low and high electrical voltage performed better than gravitational settling (without applied electrical field) in separating glycerol and other impurities from biodiesel. As observed in the experiments, the glycerol droplets moved toward the electrode tips where the electrical field was generated, while the charge on the surface of the glycerol droplet changed. The more droplets were in the electrical field, these droplets would align along the streamlines and the coalescence of droplets were occurred. This phenomenon took place in a shorter time than the gravitational settling. Therefore, the electro-separation technology has potential to be applied to other multi-components and emulsion mixtures.

Acknowledgements

The authors would like to thank King Mongkut's University of Technology North Bangkok together with the government and the non-disclosure local biodiesel producer in Thailand for the financial support.

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P-Recovery-Process Trial:
Case on Input Material from Vietnam

Khang Vu Dinh

Background

Waste sludge from rubber-latex processing wastewater-treatment plant (RWWTP) at Dong Nai Rubber Corporation is used as materials for pilot trial to recover phosphorus (P). There are 2 types of sludge generated from RWWTP, including biological sludge (BIOS) and chemical sludge (CHES). The P-recovery process was developed based on the experimental result and approaching the SEPHOS process (Schaum 2018). Pilot trial is designed and installed at the laboratory of Industrial University of Ho Chi Minh City, Vietnam. The process diagram for P recovery is shown in Fig. 1, in which P is recovered from the dry sludge through acid leaching followed by precipitations and dissolution at dedicated pH to remove main impurities such as Al, Fe to achieve a high-quality product.

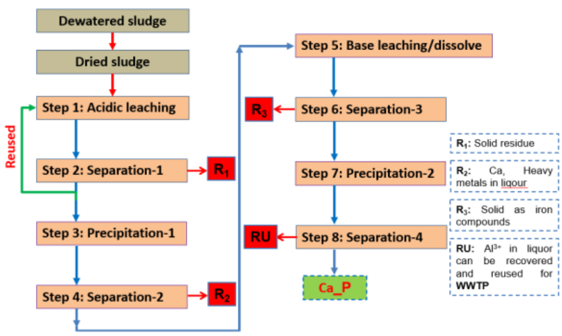

Fig. 1: Flowsheet of P-recovery process

The Pilot

The pilot trial is designed to operate in batches with a capacity of 1 kg of dry sludge per batch. The pilot includes a reactor that performs extraction, precipitations, and dissolution corresponding to the successive stages of the P-recovery process. Vertical inverter stirrer, chemical dosing pumps, pH meter and drying oven equipment are used. Solid-liquid separation multistage filter is also used. The pilot plant is shown in Fig. 2. A video of a pilot test can be consulted under the following link: https://1drv.ms/v/s!ArrU6VKP0Uzg11QZes3KWF-yauHU?e=AacIL8

Fig. 2: P-recovery pilot at Industrial University of Ho Chi Minh City, Vietnam

Performance and Results

BIOS and CHES differ significantly in input concentrations for the pilot tests, as shown in Fig. 3.

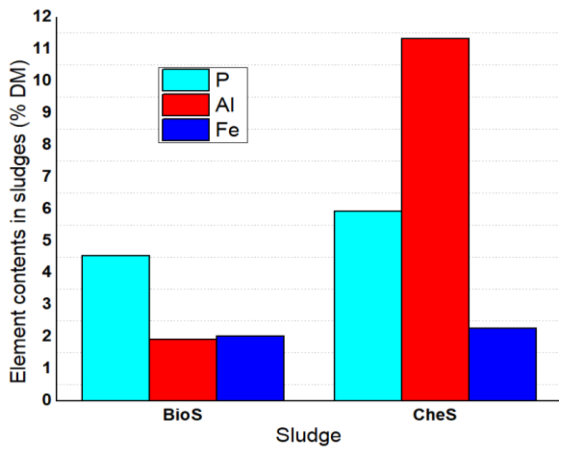

Fig. 3: Element composition in different sludges

After leaching, the mixture of insoluble matter and liquid solution is separated with a multi-stage filter with a membrane pore size of 300 and d20 μm, respectively. The remaining insoluble and highly acidic substance is washed with water before being disposed of. The leach liquor containing dissolved P and metals is used as input for the first stage of precipitation at defined pH to remove Ca. The resulting precipitate mainly consists of compounds of Al, Fe, and P, such as the minerals berlinite (AlPO4), strengite (FePO4.2H2O), gibbsite and geothite. The separation of the precipitate and the liquid is performed based on a multi-stage filtration with pore size of 10 and 1 μm, respectively. The precipitate after drying is stirred in a high alkaline environment with NaOH solution with the solid to liquid ratio of 1:100 g/ml to dissolve Al compounds, mainly Al-P. Fig. 4 shows the solubility of compounds at the chosen pH.

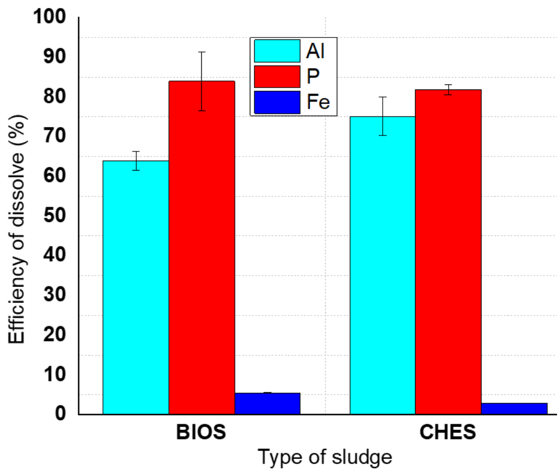

Fig. 4: Element extraction efficiency during pilot trials with different sludges

Insoluble compounds, including iron compounds, are removed from the liquid solution by a multi-stage filtration with membrane pore sizes of 300, 10 and 1 μm, respectively.

The composition of the final product obtained from the different sludges is shown in Fig. 5. The products of the P-recovery process have a rather high P content of about 17 g P per 100 g of dry product for input material of BIOS and CHES. The P to Al and Fe ratio from final product of BIOS and CHES are 19.06; 179.60 and 3.31; 119.50, respectively.

From the pilot-test results, it can be concluded that the P-recovery process proposed can be applied to different types of sludge, especially suitable for sludge containing high Al content.

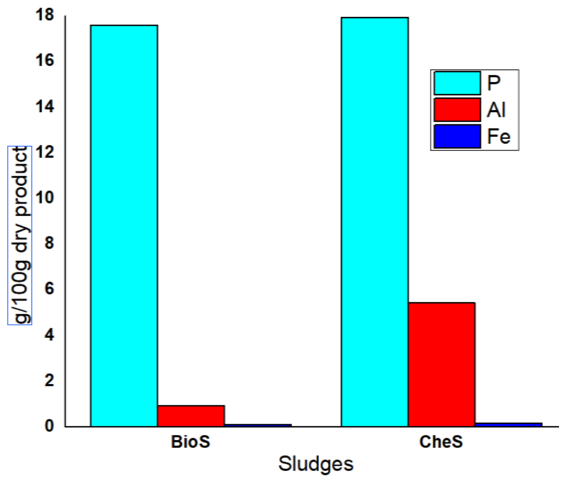

Fig. 5: Composition of the product obtained from P-recovery process

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Mass-Transfer Kinetics Experiments

Marc Philippart de Foy, Ezgi Uslu

Introduction

To design liquid-liquid extraction processes, it is essential to know the mass-transfer kinetics of the material system studied. This allows to determine the contact time between the phases necessary to reach the desired mass-transfer efficiency, depending on other parameters such as the drop diameter or the hydrodynamics. Models are used to predict the mass-transfer behavior in liquid-liquid extraction. These models can be adapted to specific material systems, using relevant experimental data. Two lab-scale equipment are used here to obtain data for any material system, and thus apply the mass-transfer models to them.

Single-Drop Cell

The first piece of equipment is the mass-transfer single-drop cell. A schematic representation of the cell is shown in Fig. 1.

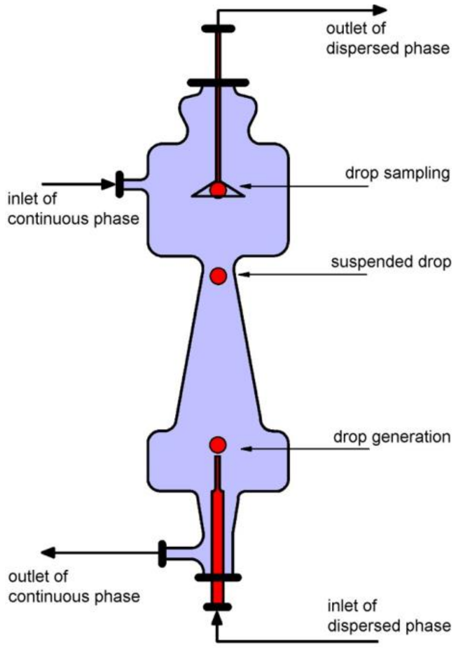

Fig. 1: Representation of the single-drop cell

This cell brings into contact a drop of dispersed phase with a continuous phase, in counter-current. The drop is generated at the bottom of the cell, and rises into the cell where the continuous phase flows counter-currently. When the drop reaches a certain height in the cell, the continuous flow is adjusted to stop the movement of the drop and levitate it. The two phases are then in contact, and the transfer component is transferred between them. Once the desired contact time is reached, the continuous flow rate is stopped and the drop begins to rise again until it reaches the collection funnel at the top of the cell. The dispersed phase is then collected and the amount of transferred component it contains is evaluated. Knowing the initial concentration of the transferred component in the dispersed phase, the mass-transfer efficiency is calculated. Several drops are generated and collected successively until a sufficient amount of dispersed phase can be collected for characterization.

Nitsch Cell

If on top of mass transfer, reaction kinetics is required to design a reactive-extraction process, it can be measured with a Nitsch cell as shown in Fig. 2. This cell is a modification of the commonly used Lewis cell.

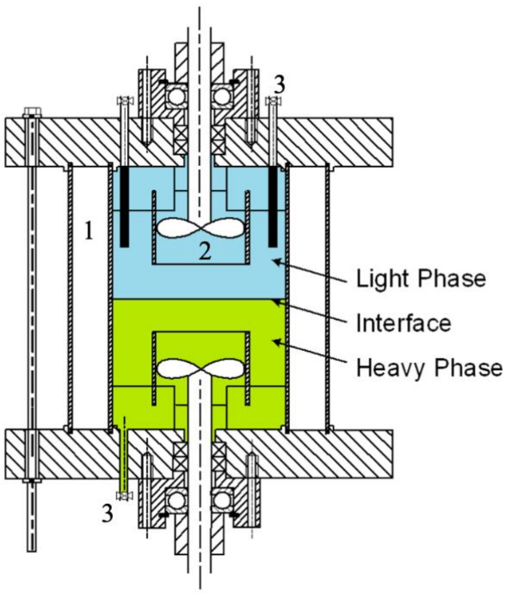

Fig. 2: Representation of the Nitsch cell: (1) heating jacket, (2) mixers, (3) sampling port

The Nitsch cell is widely used for the determination of kinetic parameters of interfacial reactions and their rate-determining step. The two phases can be stirred independently of each other by two different stirrers that are adjusted so that the Reynolds number is identical in both phases. During the experiments, the interface is well defined and the measurement of the concentrations in the two phases allows to determine the amount of substance transferred. In this way, it is possible to determine the area-specific mass-transfer rate (Bertakis, 2008).

First Results with Single-Drop Cell

The objective of the experiments performed with these two pieces of equipment is to obtain experimental data for a studied material system, under well-defined conditions. Only a few drop diameters, contact times and fluid velocities are considered in the experiments. The experimental results for these few cases are used to fit the parameters of the mass-transfer models. The obtained models are thus applied specifically to the studied material system. The Nitsch cell is used to predict the mass transfer at a planar interface while the single-drop cell experiments are used for the mass transfer to or from drops. The objective is therefore to conduct both experiments for a chosen material system, predict the mass-transfer kinetics and consistently model its behavior for both configurations.

During this year, experiments were performed with the single-drop cell. A student completed her master thesis on reactive liquid-liquid extraction and performed various extraction experiments (Thonus, 2022). Before using the single-drop cell, she first prepared protocols for equilibrium extraction experiments. These equilibrium experiments are necessary to calculate the maximum mass-transfer efficiency that can be achieved at equilibrium for a given material system. Different systems were tested for equilibrium measurements, namely reactive extraction of nickel, cobalt and neodymium with D2EHPA and Cyanex 272.

The next task was to use the single-drop cell for reactive extraction of nickel with D2EHPA. Nickel-containing water was used as the continuous phase while the dispersed phase was a mixture of D2EHPA and kerosene. This first case study provided results on the mass-transfer kinetics of the nickel-D2EHPA system and served as the basis for the further development of protocols for standardized use of the mass-transfer single-drop cell.

The results obtained for the Ni-D2EHPA system are shown in Fig. 3, and are compared to the results obtained with the single-drop cell for reactive zinc extraction with D2EHPA by Altunok (2012). The y-axis in Fig. 3 corresponds to the dimensionless mass transfer of metals. It is calculated from the metal concentrations in the organic phase at a given time and the maximum concentration that can be reached at equilibrium. When y^+ equals 1, no mass transfer has occurred, whereas when y^+ reaches 0, the amount of ions transferred is equal to the maximum that can be achieved when the reactive extraction equilibrium is reached.

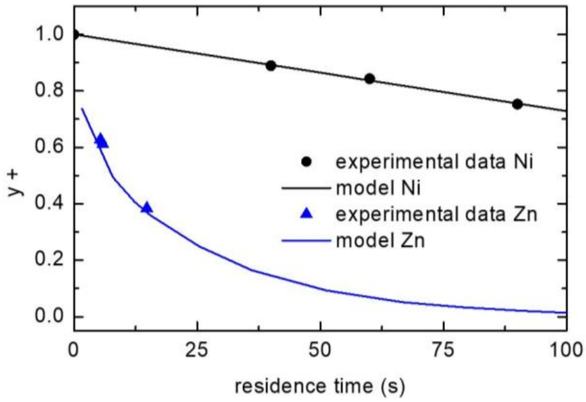

Fig. 3: Mass transfer of nickel (Thonus, 2022) and mass transfer of zinc (Altunok, 2012) both with 10 wt.-% D2EHPA for a drop diameter of 3.22 mm

For nickel extraction, the equipment was filled with a 10 mM/L nickel chloride solution at a *p*H of approximately 4.5. The organic phase contained 10 vol.-% D2EHPA and 90 vol.-% kerosene. All experiments were performed at room temperature. The organic phase drops were generated with a diameter of 3.22 mm, assuming spherical drops. Three different residence times were considered: 40 s, 60 s and 90 s. For each residence time, 250 drops were generated before collecting the organic phase for nickel characterization by UV spectroscopy.

In Altunok (2012), a concentration of 30 mM/L zinc was used, at *p*H 4.7 and 20°C. Zinc was extracted using 10 wt.-% D2EHPA in isododecane. The same drop diameter of 3.22 mm was used. Since isododecane and kerosene are aliphatic diluents, it is assumed that the extraction of D2EHPA is very similar in both cases.

It can be observed in Fig. 3 that the mass transfer of nickel is slower than that of zinc. To understand this slow transfer of nickel, Thonus

(2022) used a method proposed by Henschke (2004) to calculate the mass-transfer coefficients on both sides of the interface between the drop and the continuous phase. Based on the calculations, it appears that the mass-transfer resistance is higher on the dispersed phase side of the interface. According to Dreisinger (1989), the reaction kinetics between D2EHPA and nickel is also slower than with zinc. The combination of inner mass-transfer resistance and slower reaction kinetics may therefore be responsible for the slow mass transfer of nickel.

Thonus (2022) also attempted to perform single-drop experiments for neodymium extraction with D2EHPA. Unfortunately, these experiments could not be performed because the organic drops turned to a gel texture upon contact with the aqueous phase. The gel formation prevented the generation of the drops, rendering the experiment impossible to perform. One reason for this gel formation may be the polymerization of the metal-extractant complexes due to a high load of the extractant. More details are given in Thonus (2022). This gel formation is a challenge to overcome when using the single-drop cell. Another challenge encountered when using the single-drop cell is the precipitation of metal hydroxide in the cell if the *p*H limit for solubility is exceeded. Preliminary beaker experiments are therefore highly recommended to observe and anticipate the behavior of the material system before starting the single-drop experiments.

Nitsch Cell Preparation

The Nitsch cell is a device that will be used for the first time at the department. The equipment, which was originally built at RWTH Aachen University, had been transferred to ULiège. Its installation is still in progress in the laboratory. Since there is no user or installation guide or video, it is tried to be installed with the existing drawings and pictures. Currently al missing parts like tube fittings, valves and inlet and outlet pipes have been acquired or rebuilt. The cell today is essentially operational. It is expected that first test experiments will be performed during the first weeks of 2023.

Future Work

In 2023, two students will complete their master thesis on mass-transfer kinetics study for liquid-liquid extraction. They will use both the mass-transfer single-drop cell and the Nitsch cell. The objective is to develop a model that will allow the results of both cells to be described simultaneously in a consistent manner.

Different systems will be studied, for reactive and non-reactive extraction. From the results obtained with the two equipment, mass-transfer kinetic models will be adapted to the studied material systems. The experiments and the corresponding models should allow to predict the mass-transfer efficiencies and highlight the potential limits of mass transfer.

A protocol for the use of the Nitsch cell will also be prepared. Together with the already existing protocol for the use of the single-drop cell, it will allow to systematically conduct the experiments. The standardized procedure for the experiments will enable to obtain data also for significantly differing material systems in a consistent manner. Based on the results obtained for the different material systems, optimal material systems will be selected for further experiments and simulations.

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Zukunftsbilder – Visions for Future

Andreas Pfennig

Background

It is meanwhile impossible to overlook the fact that climate change has arrived in the present. The weather is becoming more and more extreme and nature is reacting with fatal consequences such as widespread forest destruction or unimaginable floods after intense rainfall. We also know the causes: The burning of fossil carbon-based energy sources. Thus, we know what we have to do to stop climate change, namely to burn as few fossil fuels as possible and to stop this burning as soon as possible. When measures to combat the climate crisis are discussed, they often involve prohibitions, restrictions and sacrifices.

At the same time, however, the goal must be to positively motivate people to act sustainably. Prohibitions and requests for sacrifices certainly won't do the trick. Scientists for Future, Germany, has therefore launched the nationwide project 'Visions for Future' (Zukunftsbilder). The aim is to create positive visions for life in Germany in the year 2040. It is certainly not possible to really predict such a distant future. Only potential future developments can be described.

The Idea

Accordingly, the idea of the Zukunftsbilder project is to develop several Visions for Future that are different and realistic, but at the same time do not contradict any scientific insights.

At first, four such Visions for Future are developed. A Vision for Future consists of a maximum of about 40 so-called facets, each of which describes one aspect of future life. On the one hand, some facets deal with everyday life, i.e. with how we as citizens experience their future in their everyday lives. A second group of facets describes the future from a system perspective. Finally, a third group of facets describes the state of nature in 2040. Examples of such facets are mobility as it is experienced and realized by citizens on an everyday basis, the transport system, which describes what lies systemically behind the everyday experience, and, for example, the facet climate and atmosphere, which describes the influence that the reduction of CO_2 emissions has on the climate in the respective Vision for Future.

In the end, the goal of the Vision for Future project is to make the visions accessible to the general public, based on scientifically founded ideas, for example via a creative website, which conveys a tangible impression of the future envisioned for each case. In addition, a journalistic team will translate the initially rather factual texts into generally understandable language and corresponding stories. The aim is thus to convey already today a well-founded and at the same time vivid positive vision of sustainable life in Germany in 2040.

The Realization

As a Scientists for Future project, obviously care must be taken in developing the Visions for Future to ensure that they are sound. To ensure this, the facets are initially written by teams of authors with a broader background. After an initial text optimization by a lectorate team, the texts are then reviewed by at least two reviewers who are selected independently. The resulting requests for modifications and comments are processed and responded to individually. While this is not a rigorous review process like for a journal article, it ensures that expert input is considered. Once the final scientifically based text is available, a final text optimization is performed. The texts are then typeset and published on Zenodo:
https://zenodo.cern.ch/communities/zukunftsbilder/.

These initially rather factually formulated texts then form the basis for an illustrated website, with which the Visions for Future are to be brought to life, as well as for generally comprehensible texts.

The Four Visions

Currently, four Visions for Future are being developed: Slow, Grassroots, Large, Focused. In the 'Slow' vision, which is more of a dystopia, politics tends to react too slowly, as it does today, so that the climate targets are missed. In the 'Grassroots' future scenario, citizens develop the drive to implement the necessary changes, while in the 'Large' scenario, the initiative tends to come from the political sphere, but citizens follow along to such an extent that the climate targets are reached on time in both of these future scenarios. The future image 'Focused' now considers that in 'Grassroots' and 'Large' very many, sometimes small-scale measures are taken to achieve the sustainability goals. The abundance of measures is drastically reduced by focusing on the really important measures:

- fast renewable-energy transition,
- energy saving where it makes a difference,
- vegan food transition,
- intensification of development cooperation.

This focus also prevents people from concentrating on the small measures that tend to be more convenient to implement and postponing really important measures in return. In the case of energy saving, for example, it has been shown that many of the frequently discussed measures, such as reducing room temperature, avoiding food waste, or avoiding plastic, are more than a factor of ten less beneficial for the climate than the most effective measures, such as switching to e-mobility or using public transport. The very informative data on this were compiled and analyzed in a meta-study by Ivanova et al. (2020). Focusing also on the vegan food transition will free up the 80% of fertile land area we use today globally to produce animal-based food. This land can then be used for bio-based methods of capturing carbon dioxide from the atmosphere such as reforestation, peatland re-watering and BECCS (bio-energy with carbon capture and storage), which are necessary to stabilize the climate at a lower global mean temperature than today. This is the only way to stop the long-term consequences of climate change for the Earth system, such as rising sea levels. Other, technology-based alternative options are so expensive, that humanity can foreseeably not afford their realization. It should be emphasized that Visions for Future do not attempt to predict the future, but rather describe plausible future developments in a rather broad context. They can be seen as scenarios, i.e., as descriptions of possible futures.

The Vision for Future 'Focused' was coordinated by the author and developed in many videoconferences this and last year with a small team and brought into a first final form:
Alexander Graf,
Thomas Lehmann,
Bernadette Menacher,
Regine Rehaag,
Paul C. Sommerhoff and
Frank Waskow,
who have contributed to the facets in varying composition based on their expertise, for example, on the carbon-dioxide balance of vegetation, on the global food system, on the psychology of sustainability, or on sustainable building. Currently, all facets of the Vision for Future 'Focused' have been developed in a first version, a whole series is already available in the final version at Zenodo and the others are currently undergoing the review process.

The Impact

One of the main goals of the vision for future project, the website, is currently under construction for the first facets. At the same time, already today the Visions for Future are used by some Scientists for Future as well as others as a basis especially for creative realizations.

One example is the "Ultima Ratio" performance at the Sommeblut Festival. The performance takes the form of a bus trip to the lignite mining area Garzweiler. During the performance, visitors are asked to actively participate by, for example, throwing a small lump of lignite back into the mining site. Throughout the performance, many imagination-filled pictures are used to show the visitor what is going wrong and what we can do about it. In the preparation for this performance, the author provided the director of Ultima Ratio, Christoph Stec, with texts of the Vision for Future 'Focused' and explained the ideas. In the performance, the author even appeared at one point with a short video – besides short videos of many colleagues.

Now everyone involved is eagerly awaiting the first realization of the website, and at the same time trying to make the Visions for Future project better known.

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SFGP: First International Conference

Marc Philippart de Foy

SFGP

The SFGP stands for “Société Française du Génie des Procédés”. Since 1988, the SFGP has been promoting scientific exchanges, in particular by organising international conferences. The SFGP brings together all professionals from the academic and industrial world who are active in the field of process engineering, from all sectors of activity such as chemistry, pharmaceuticals, food processing or water treatment. It has about 500 members. The language used in the conferences is French, although papers and slides may be written in English.

The previous conference was held in Nantes in 2019, and the 18th SFGP conference took place in Toulouse in November 2022. This year's conference slogan was “Science and Technology Solutions for Transition”. The conference focused on sustainability and how to address society's major challenges from a process engineering perspective. The lectures were divided into different subtopics such as water treatment, modeling, energy transition or agricultural research.

Topic presented

This year was the occasion to present the ReDrop program to the researchers participating in the SFGP. A 15-minute presentation was given on the principles of the ReDrop algorithm, an example of a single-drop experiment and different applications of ReDrop. This presentation was part of sub-theme “Modelling and simulation” and was attended by an audience of about 30 people. Fig. 1 gives an idea of what the audience saw during my presentation. An 8-page paper describing ReDrop was also accepted for publication. It will be published soon by the EDP Sciences publisher.

Outcomes of the Conference

From a personal point of view, attending the SFGP conference was a very rewarding experience. It was actually the first international conference I had attended, so I was able to learn what conference life is like. Changing rooms between presentations to follow the most interesting one, chatting with foreign researchers during breaks and participating in events offered by the organizers was my daily routine for four days. Even though the SFGP conference is quite general and some of the topics were not so relevant to my thesis, some very interesting presentations were given, and the conference was an opportunity to broaden my knowledge on scientific topics that I would probably never have covered otherwise.

The presentation at the SFGP was also my first experience as a presenter in an international event. Everything went well, although I had to face an unexpected challenge: presenting in French! Being a native French speaker, I would never have thought that presenting in my language would be a problem, but after two years of doing a PhD in English on the subject, I struggled to find my words in the beginning. Fortunately, with a daily rehearsal, I got my French back before presenting!

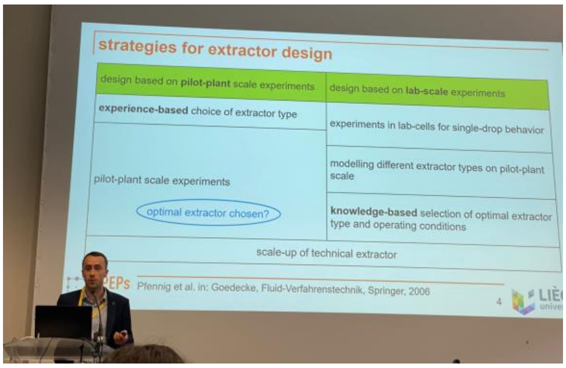

Fig. 1: Marc Philippart de Foy presenting at the SFGP conference

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SFGP - Société Française de Génie des Procédés, 2022: https://www.sfgp.asso.fr/

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Life in the Department and at the University

Ezgi Uslu

With the decrease in the effect of the Covid 19 epidemic, the number of collective events increased compared to last year. With the arrival of many new Ph.D. students, including myself, to our department, we have become a crowded, fun, harmonious, and international team. Lunches eaten together, department barbecues held every year, after-work events, being together at the university festival held again after a long break and being together in the team-building event allowed us to have a fun time together outside of work. The pride of being a team outside of work and the value of time spent together are brought through such events.

Daily Lunches and Ph.D. Lunch

It's lunchtime for the students of our department every day at 11.40. With a joint decision, we meet at 11.40 in the university cafeteria with anyone who does not have a course or a private job or experiment. We really enjoy having lunch together. Afterward, we drink our coffee together and disperse to our offices. Thus, we get the chance to get together and chat with our colleagues who are not in the same building or in the same groups, at least during lunchtime.

On the first Wednesday of every month, we hold the pre-planned Ph.D. lunch. This tradition has been around for many years. On the first Wednesday of the month, almost all department students (Ph.D., post-doc, and research engineers) gather at a predetermined place and have a meal, and we discuss our department-university life, requests, and criticisms with the Ph.D. students of our department. This way, we are informed about the new announcements that we need to know in the department, and we have the chance to convey our expectations from the department.

DOC'trail

DOC'trail event organized by ReD (Réseau des Doctorant.es ULiège), which took place in June, started with the competition of teams consisting of Ph.D. students at the university. In teams of 4 people were formed to represent our department, Marc Philippart de Foy, Jean-Luc Hoxha, Tom Servais, and François Chaltin competed to represent us. The goal is to collect the most points by participating in sports, intellectual, and speed events at various locations during the time limit. Even if they don't get degrees or awards, we always support them. After this competition, we had a pleasant time eating, drinking, and playing various team games at a garden party as shown in Fig. 1. This outdoor event was great to kick-start the summer.

Fig. 1: DOC'trail garden party

Annual Barbecue

Another unbroken tradition is the Chemical Engineering department's annual barbecue. Department offered us the chance to both welcome new friends and spend quality time with all the professors and administrative staff. Almost all academic staff of our department participated in the event, which took place in extremely beautiful and sunny weather in June at 'La Halle' (ULiège, B17). We had a good time at the lunch, which was accompanied by good food and pleasant conversation.

After-Work Events

After-work events are open to all university staff members. Thus, these are activities that we take care to attend as Ph.D. students of our department, where we can establish environments and provide networking opportunities while relaxing together at the end of the day and making new friends.

In September, we participated in a very large after-work event at the Sart-Tilman campus.

Foods and drinks were offered by the university and live DJ performances beside the concert of Belgian Band. In addition to all these, illusionists, cocktail stands, and ice cream trucks were present at the event, which allowed us to have a pleasant time. In the event, which lasted until the late hours of the night, we did not neglect to have fun, dance, and take photos together, as seen in Fig. 2., even though the rain made it very difficult for us.

Fig. 2: Chemical Engineering Department Ph.D.'s / Post-Docs and researchers in the After-work

Team Building

On 21.09.2022, we went to Aywaille together for a team-building event which is organized by Chemical Engineering Department. After a warm welcome and briefing, we split into groups and played a game called 'manhunting' on the site. With the help of a map and compass given to each group, we had to find two people who were hidden in the village in accordance with the instructions given and get the passwords and return to the starting point. The group that completed the task in the shortest time would be the winner. We held an event that was very entertaining, surrounded by greenery and enjoying the sun.

Afterward, we had lunch together at the 'Guinguette des Elfes' as shown in Fig. 3. and had a beer tasting with local Belgium beers. After all this, we visited the Brewery and learned about the brewing processes and packaging. We returned home after a wonderful day.

It was very good for all of us to get out of our routine, closed offices, and spend time together in the open air.

Fig. 3: Lunch in Aywaille

Uni Fest

Another event organized by the university every year is the university festival that they called "Uni Fest". The event, which was held for the 16th time in Sart-Tilman in October this year, was open to all students. The interest in the festival was quite high. In addition, to live music groups and DJ performances, it was also possible to come across many universities' stands and sponsors' stands in the festival area. In addition, food and beverage trucks offered you the opportunity to fill your stomach and cold drinks during the festival. As seen in the Fig. 4., we enjoyed the music, food, and drinks at this event, which doctoral students also attended after work. The concerts, which lasted all night, hosted many musicians and groups on 3 different stages.

Fig. 4: Chemical Engineering Department Ph.D.'s in 'Uni Fest'

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Technical and Academic Visit to Vietnam

Khang Vu Dinh, Andreas Pfennig

In August 2022, Andreas Pfennig, with the support of the cooperation program between WBI (Wallonia-Brussels International) and the Vietnamese government, as part of Project 2.22, visited Vietnam for a technical and academic trip of about one week. The activities in Vietnam were organized by the Institute of Environmental Science, Technology and Management of the Industrial University of Ho Chi Minh City (IUH).

The academic program consisted of two presentations. The first presentation was part of an academic seminar with the theme 'Phosphorus Recovery from Waste Sources: Potential and Solutions'. With the aim of opening a new research direction with many gaps in its application in Vietnam, we were very happy to present our study results to researchers, lecturers, experts and companies. Fig. 1 shows one of us presenting the results of PhosForYou project. Research on the application of phosphorus recovery in Vietnam has until now not been seriously considered, although phosphorus-containing waste sources from agriculture, industry and households have very large reserves. This was demonstrated by Khang Vu Dinh who compared the different sources from agriculture and wastewater treatment plants in South Vietnam. Our two presentations led to very lively discussions with and among the audience.

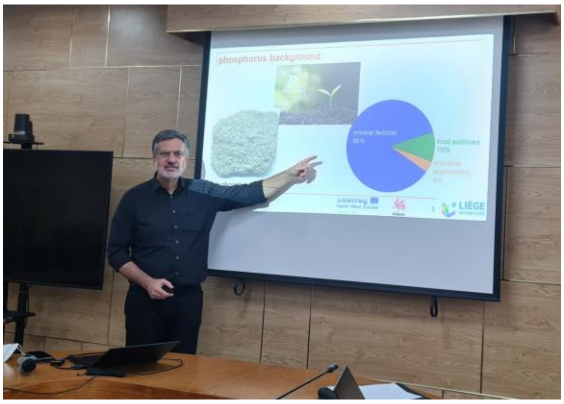

Fig. 1: Seminar at IUH, August 2022

Andreas Pfennig not only exchanged ideas with researchers and lecturers, but also held intensive discussions with students of the program 'Environmental Engineering, Resource Management and Chemical Technology' on the topics of climate change, energy and nutrition in a sustainable world. It is this talented young generation that will have to develop, implement, and operate the technologies in a sustainable world in the future. The author's descriptions of young people's activities around the world, such as 'Fridays For Future', inspired the audience, especially the young people at IUH, to fight and act for environmental protection. Students enthusiastically participated in the event, as shown in Fig. 2. Among the audience, there were also some visiting students from Germany who are currently studying at IUH. Again, the discussion after the presentation was quite lively.

Fig. 2: Andreas Pfennig and IUH students after the seminar on sustainability

On the other days of the visit, the Dong Nai Rubber Corporation (DONARUCO) in Dong Nai Province and the Binh Hung wastewater treatment plant in Ho Chi Minh City were visited. Rubber processing generates significant amounts of wastewater that must be treated before discharge into a river. Treatment is carried out in the conventional way with a sequence of chemical and biological steps. As shown in Fig. 3, DONARUCO's wastewater treatment plant is of considerable size, which is quite impressive for an agriculturally oriented company.

Even more impressive was the visit to the Binh Hung domestic wastewater treatment plant in Ho Chi Minh City. During the visit, it became clear that so far only a small part of the wastewater in Ho Chi Minh City is treated in two wastewater treatment plants. In the coming years, about ten more plants are planned to eventually treat the entire municipal waste water. The size of the feed pipe to this plant, with a capacity of 500 000 cubic meters of waste water per day, was impressive in itself, as Fig. 4 shows. The area occupied by the plant is equivalent to about 20 hectares.

Fig. 3: Waste-water treatment at DONARUCO

Fig. 4: One of us and our guide besides the feed tube

Some days were also devoted to tourist activities. A whole day was dedicated to exploring Ho Chi Minh City with most of the tourist sites, which required a walk of almost 8 hours and more than 30 km. Fortunately, the cell phone was an excellent guide even through the narrowest paths in the city. Another day was spent visiting Ba Den Mountain, on top of which a statue of Buddha can be visited as shown in Fig. 5.

Finally, it is imperative to mention the Vietnamese food. Vegan options were available in various restaurants. Especially exciting was a restaurant with a vegan buffet, where the diversity could be tasted. The dishes were varied, fascinating and always very tasty.

Fig. 5: Buddha statue on top of Ba Den Mountain

Fig. 6: Photos for the photo album

Acknowledgements

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An up to date list of publications is available at: https://orbi.uliege.be/ph-search?uid=U222548

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exam question:
Please indicate two cases, in which solvent extraction may be favored over rectification?

student answer:
When we want a slow mass transfer and a low tray efficiency.

exam question:
Please draw a schematic representation of an absorption process in a YX-diagram.

student answer: