A Brief Personal Review of Academic and Corporate R&D for the Chemical Process Industry

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Abstract

Lecture held on the occasion of the retirement of Professor Dr. Herbert Sixta at the Scientific Biorefineries Seminar, Department of Bioproducts and Biosystems, School of Chemical Engineering, Aalto University, Espoo, Finland, 30 March 2022

Dear colleagues, ladies and gentlemen!

Last year Michael Hummel and Herbert Sixta asked me to give a presentation at the annual Biorefineries Seminar, which Herbert organised for 15 years in December for the senior students of the "Department of Bioproducts and Biosystems" and for the interested industrial and academic community. Unfortunately, the seminar had to be cancelled because of Corona / SarsCov19. But with half a year's delay I'm grateful to give now a presentation about research and development

- in the fields of **Pulping chemistry and technology** with special emphasis on dissolving pulps,
- of **Cellulose chemistry** and the chemistry of the fractionation of biomass, in particular lignocellulosic biomass,
- about the chemical and mechanical **purification of pulps**, the oxygen delignification of unbleached pulps, about TCF- and ECF- bleaching techniques and about Organosolv fractionation methods with particular emphasis on GVL/water pulping of hardwood.
- This will bring me to the isolation and characterization of **lignin** and its valorization to monoaromatic structures, to bio-oil and as co-polymer in composite material with cellulose and to the valorization of **hemicelluloses** as furanic compounds.
- I will especially focus on the **valorization of cellulose** to regenerated cellulose fibers and to cellulose derivatives on **dry-jet wet spinning** of cellulose solutions and last but not least I will also cover **Cellulose textile chemistry**, novel dying technologies for cellulose-based textiles, and novel pathways of functionalization of cellulose-based textiles.

If someone in this room should ask what this comprehensive set of chemistry topics has to do with "a review of R&D for the chemical process industry", and how I will be able to do this in just the next 45 minutes, I have a very good reply:

I'm going to do it by talking about Professor Herbert Sixta!

Because the list of these topics is what he represents! It is the list of his academic and private interests, the list of topics of his publications and projects and – which is likely the reasons for his success – also the description of his hobbies: It cannot be but a hobby, which – without any external pressure – keeps you busy almost every day, until late hours, during weekends, and even during holidays spent around visiting other research institutions ...

Dear Herbert!

You told me that a "laudation" should not be part of this programme. You thought that nobody would be interested in what made you the person we like and admire, the person who managed to master both worlds of industrial and academic research and to bring this department to its present impressive condition.

You also told me that you don't really enjoy to be the centre of admiration! You asked me to talk about something that could be interesting for the young academics invited to this symposium.

I'm convinced that everybody here, who had the privilege to learn from you and to work or cooperate with you, is interested to understand how in a long and extraordinary career in Company-, and University-research you could acquire all the abilities needed to generate such impressive results. Therefore I will concentrate on the way how we jointly tried to manage an important section of **Research and Development in Lenzing AG** and on some of the conclusions we drew from it.

Professor Dr. Herbert Sixta

University

Herbert studied Chemistry at the University of Innsbruck. Coming from a background of medical doctors the legend tells, that his family for 1 year thought that he was studying Medicine.

He got his Diploma based on a paper on "Infrared reflection and electron energy-loss spectroscopy for the investigation of solid surfaces" and continued with a PhD-thesis in physical chemistry on "The interaction of CO, H2, O2 and simple saturated Hydrocarbons with Pt-, Ru-, Cu and Ru/Cu- supported Catalysts". Since I did my PhD in physical chemistry as well, this of course was a very good recommendation. But it also proved to be a very good recommendation for his wife Eva so he could start his family at that time.

Here I want to add a short remark on **studying chemistry** and the subjects of its curriculum. It is still a surprise to me that in the course of my professional life there was no chemical discipline, which I didn't need at one or the other occasion – maybe with the exception of statistical thermodynamics and some theoretical chemistry, but definitely including the basic understanding from having practised the H_2S cation separation procedures. For a technical position in the chemical process industry a broad chemistry knowledge is indispensable. Chemical processes are full of surprises and the ability to find out what a certain problem could be needs a general chemical "feeling". Early specialisation is not helpful.

Dr. Sixta receiving his PhD and with his wife, Innsbruck 1980

Environmental protection and biotechnological reserach

In 1982 Herbert and his family moved to Upper Austria and he started to work for Lenzing AG in the department for **Environmental Protection**. In fact, very soon he was practically in charge of the department because its formal head was a member of the Austrian Parliament who was extremely busy in politics.

In view of the dramatic growth of synthetic fibres at that time Lenzing Management had one more of its periodical panic attacks that Viscose fibre would soon be a dead product. In line with the glittering topics of industry success stories in the media they thought that Lenzing could survive as a "Biotechnological Company" and as a "High Performance Fibre Company".

Lenzing AG's production site in Upper Austria

As for a commercial person "Environment" is dealing with "Biotechnology" Herbert was asked to develop concepts for new "biotechnological products" based on the enzymatic and bacterial conversion of Lenzing process byproducts. Already during second world war Lenzing had a production of alcohol from lignocellulosic substrates and used the proteins of bacteria grown on Hemicelluloses to produce sausages. Later on there was a project to use Hemicellulose as a dietary substitute for wheat flour. So, in 1987 Herbert became head of a new Department for **Biotechnological Research** and did the best thing he could do: He started to concentrate on the **Lenzing pulping processes**.

Parallel to his Biotechnology assignment I was asked to work on "High performance polymers" after having joined Lenzing almost at the same time. Based on the Acrylic dry spinning technology owned by Lenzing I started to run a demonstration plant for "P84" high temperature-, and flame resistant Polyimide fibres. However, after 2 years I was asked to switch to Viscose technology, I moved to Indonesia and started to work for South Pacific Viscose, a Viscose fibre producing subsidiary of Lenzing. It was there, in about 1986, when I first professionally met Herbert. I was in charge of Production and Technology, and Herbert came to help me with the mass balances of sulphur containing gas streams in the Viscose fibre process.

Network on lignocellulosic substrates

It is a major problem that commercial people and most managers don't understand that successful **R&D needs special competences**. Driven by the latest Business Consultants Philosophy declaring that innovation just consists of "doing things differently" the Lenzing management in 1991 thought to add value to the business by reorganising R&D: Since operational managers know how "to do things", let them also manage innovation! No customer is willing to pay for the "intellectual satisfaction of R&D people" who want to understand things. The results of time-consuming discussions amongst scientists and literature studies can be saved. And – of course – if R&D then comes up with surprising innovation proposals with costly capex, things start to become really difficult. The central R&D group was dissolved and distributed to the operational units. Only a small central "Innovation scouting group" was kept. Part of Herbert's group went back to Environmental treatment and the Biotechnological activities were stopped.

Herbert's pulp related activities however could continue. They were kept as a small personal project directly under Dr. Zauner, Lenzing's Technical director at that time, who was guided by his dear friend, **Joe Gratzl**, an Austrian professor at the North Carolina State University in Raleigh, USA and one of the leading specialists in Pulp and Paper Science of that time. This turned out to be a fortunate constellation. In his regular consultations of Lenzing a long-lasting friendship between Joe and Herbert was established and Joe became a mentor for Herbert. Regularly, after a whole day of discussions about pulping, bleaching and wastewater treatment they continued with informal late hours sessions in the hotel. The ideas developed in these sessions became the base for a series of pioneering new pulping and bleaching technologies

Prof. Gratzl introduced Herbert also to **Prof. Rudolf Patt** from Hamburg University in Germany, who in 1987 developed the ASAM Pulping process. This resulted in the development of a close cooperation. They both recommended several excellent young scientists who started to work in Lenzing or in University cooperations. They jointly published several high impact papers. Herbert, by the way, was one of the first experts

in the German speaking pulp and paper community who published in English and in international journals. He started to build up scientific contacts with institutes, universities and companies first in Austria and Germany, finally all over the world.

Herbert started to work not only on **sulfite pulping**, but also on **soda**, **Kraft** and **ASAM pulping**. With the background of dissolving pulps for Viscose fibres he studied beech **wood** as applied in Lenzing and eucalypt as used by Saiccor. After Voest Alpine of Austria shut down their alkaline pulping engineering business Herbert took the chance to take over some of their project managers to keep the knowhow. In the years around 1993 they started to work on the development of the new **Continuous Batch Cooking** (CBC) process being a substantial improvement of Kraft displacement batch cooking, combining the advantages of batch operation with the continuous preparation of cooking liquors in the tank farm. The CBC Process for paper pulp was the base for the development of the VisCBC process. Herberts knowledge on eucalypt alkaline pulping and TCF bleaching was the scientific base to establish this technology in about 1995 in the Bacel plant, a new mill for very high quality dissolving pulp in Brazil, at that time a Lenzing joint venture which exceeded all expectations.

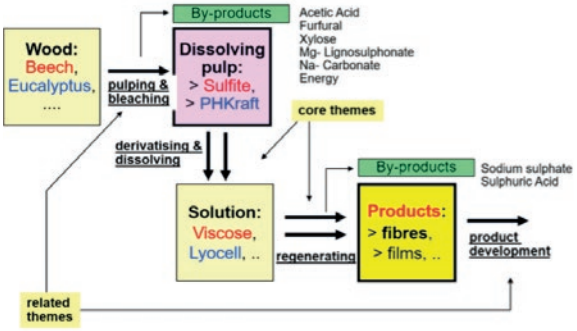
Dr. Sixta with Prof. Joe Gratzl (left) and with Prof. Rudolf Patt (right) with on the occasion of his habilitation 1995

Prof. Gratzl and Dr Zauner introduced Herbert also to Prof. Helmut Starck from the Institute for Pulp- and Paper- Technology of the Technical University of Graz. The high appreciation of Herbert's work resulted in the proposal of his habilitation by Prof. Starck. In 1995 an excellent paper on "Chemical Pulp Production considering environmentally friendly Cooking- and Bleaching processes" was rewarded by his habilitation at the Faculty for mechanical engineering at the Technical University of Graz.

In the years 2000 a Xylane Cold caustic extraction (CCE) process was patented, as a purification step for pulp and also as a means to transfer Xylane to other pulp qualities or to isolate it as a powder.

Industrial research and development supplemented by science

Some years after I came back from Indonesia, the Lenzing management realised that the 1991 reorganisation of R&D was maybe not such a good decision, as they had wished it to be. Day to day routine of operational business managers was not the environment to stimulate new ideas, to develop and implement new concepts. Innovations did not come just by themselves. In 1995 they asked me to re-establish a strong R&D function for the Lenzing group.



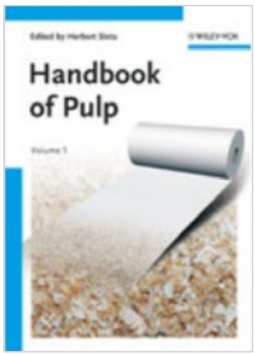
Overview about Lenzing core business around 1995

My concept for the new R&D-division deviated from the traditional perspective of Lenzing as a pure textile fibres manufacturer. Besides "Viscose R&D" and "Lyocell R&D" it included also "Pulp R&D" as an essential department focussed on dissolving pulp as a "product". So far the pulping processes were mainly dealt with as standard upstream technology. Since the quality of dissolving pulp is defined by its ability to give good solutions for the fibre spinning processes, the responsibility for Viscose dope manufacturing was added to the portfolio of this group, which was headed by Herbert. A smaller R&D services groups took care for IPR, literature and cooperations-administration.

This was the beginning of 13 years of successful cooperation with Herbert and of a growing, personally very rewarding relationship. We continued to be in close contact also after 2008 when I changed as CEO to Kelheim Fibres.

Herbert was not satisfied in limiting himself to practical development work. He realized the largely empirical state of knowledge about the Lenzing processes and their underlying chemistry. He understood that apart from small optimisation steps no substantial progress was possible on this base.

He started to add a scientific focus to the different practical projects he supervised and started to build up a strong **analytical group** specialised on lignocellulosic substrates. He introduced or developed several analytical methods for pulp and fibre characterisation. Amongst many other methods he adapted the DMAc/LiCl method to measure the DP-distribution of pulp, which was standardised in a round robin and is now the industry standard. The ISEC (Inversed size exclusion chromatography) method for pore size distribution was introduced and the CCOA and FDAM methods for cellulose carbonylic- and carboxylic groups were developed. The installation of new automatized and IT controlled small scale **pulping and bleaching pilot plants** turned out to be the key for the development of new and optimised pulping and bleaching processes. The rather obsolete old **Treiber Viscose equipment** was brought up to state of the art and together with a small Davenport viscose fibre spinning apparatus proved to be a reproducible testing tool for dissolving pulp quality.



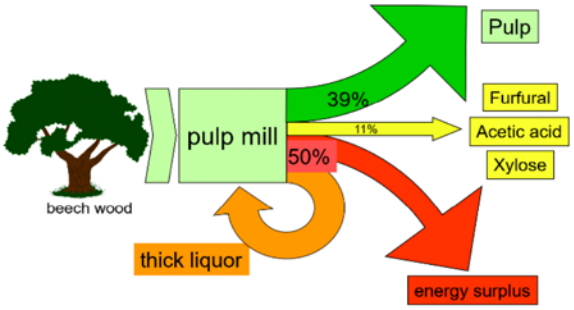
After a couple of years in this new Corporate Research constellation Herbert started to work intensively in his "leasure time" on his most important publication, the "Handbook of Pulp", which was released in 2006.

In this two volume set he brought together a team of authors to produce the first comprehensive handbook on the market. The aim of the book is initially to provide a short, general survey on pulping processes, followed by a comprehensive review in certain specialized areas of pulping chemistry and technology. It describes all traditional and modern processes for the pulping of Chemical Pulp and Mechanical Pulp, for Recovered Paper and Recycled Fibers as well as for waste liquor treatment, pulp bleaching and environmental aspects, while also covering the analytical Characterization of Pulps.

Wood biorefinery

Herbert's experience with the effluent treatment plant just degrading potentially valuable biomaterial at high costs triggered a big portion of his work in the next decades. He realised that this was one of the fundamental business relevant topics for Lenzing and as it turned out was key for its overall competitiveness and a major factor in its survival as a fibre producer in Europe's high cost environment. Several new technologies, processes and patents have been the consequence of Herbert's approach to innovation.

This type of fundamental topics to me is typical for companies in the chemical process industry producing commodities or semi commodities with usually very similar cost structures and very limited price elasticity. They are often neglected since these topics are only indirectly linked to the final product and since there is usually only an empirical state of understanding them. But they are key to improving the competitiveness by reducing the net costs of production: this is what innovation in process chemistry is about!



WOOD biorefinery in Lenzing [H. Harms, Lenzinger Berichte, 86 (2006) 1-8, figure 10]

Already in the 1970's Lenzing was forced by environmental regulations to restrict itself to the use of beech wood because of the lower BOD load to the effluent. In the beginning the ban of spruce was a severe blow for the company. However, in the end it turned out to be an advantage since the processes developed in the next decades – many of them masterminded by Herbert – ended up in the conversion of the Lenzing pulp mill into a true "Wood Biorefinery". The acetylated beechwood pentosanes are converted into food-grade acetic acid, furfural and xylose, increasing the recovery of dry wood matter from 39% to about 50% and substantially contributing to the income of the company. The combustion of the lignin containing fractions covers the energy of the pulp mill and most of the energy needed by the viscose fibre production. Innovative processes increasing the Xylose concentration in the thick liquor further increased the income.

Another topic intensively linked to government regulations and environmental trends was the development of the **Totally Chlorine Free** (TCF) dissolving pulp production process with new Ozone- and new EOP-Bleaching processes patented by Lenzing in about 1990. It was of special importance because of the public awareness related to Chlorine in hygiene products. This process however was economically not yet feasible since the ozone bleaching was developed at high consistency and at lab scale only. The breakthrough came in 1992 with the patented new medium consistency Ozone bleaching technology based on a new mixing technology implemented in Lenzing for the first time in the world. This TCF-pulp now met the environmental regulations imposed on Lenzing. Later the technology was also implemented in the Bahia and in the Paskow mill.

A purely inorganic problem had to be solved by Herbert's group in the context of the poor performance and excessive Sulfate formation in the **Magnesium-Monosulfite splitting** (MSS) plant of the tertiary SO_2 recovery in the pulp mill.

The key property of dissolving pulp, its reactivity, and the potential effects of an activating pretreatment have been of special interest to Herbert. They resulted in studies on pulp grinding, electron beam irradiation, enzymatic activation and tribological treatement. A **Chemical Slurry Ageing** (CSA) process for the Viscose technology was patented in 1998. It is an alternative process for Cellulose pre-ageing in an ageing drum and reduces the Hemicellulose load in the Viscose by removing the Hemis at an early stage and by reducing the Hemi formation. **Nanofiltration** was another process developed for the removal of Hemicellulose from the press-lye.

Lenzing did an intensive evaluation of several **pulp dissolving technologies** in the early 80's before making the decision for NMMO. But after this decision new approaches to dissolve cellulose had to be evaluated. An Australian formic acid process failed because the remaining acidic groups started to degrade the regenerated fibre. Professor Robin Rogers gave an impressive demonstration of a cellulose instantly dissolving in a beaker with hot ionic liquid, but he had not yet considered a depolymerisation reaction. Herbert's follow-up of the concept of **Ionic Liquids** with Professor Herwig Schottenberger brought first positive results and generated the initial knowledge which later on was used for the development of the Ioncell technology in Aalto.

The innovation system in the chemical process industries

From the beginning Herbert and I had very similar views about the principles of Corporate R&D in industries like Lenzing. In many cases these were quite different from what business consultants taught at that time. We both were convinced that product development in the Chemical Process Industries usually cannot be done without **process development**. Since the products are usually commodities or semi-finished goods which basically can be produced by everybody, success is intensively linked to being better in production. Like Viscose fibres or Wood pulp, both more than 100 years old, this type of products usually have very long **lifecycles**. They are typically produced using complex closed loop processes and very **capex intensive** plants and equipment. Improving the plant utilisation and innovative process steps to reduce the costs of production are always a key objective. Innovative technological concepts however are preferably limited to using the actually installed equipment. As a consequence the flexibility, and quality of new equipment define the long-term development potential of the company. Product innovation besides quality improvements is usually targeted at property modifications to generate additional applications or niche markets. Since the production facilities usually cannot be used for development work **appropriate facilities** like pilot plants and analytical methods are required and of course persons with **specialised experience**, who are not readily available on the market. It needs a lot of **time** to build up a versatile competence and continuity to keep it.

Business consultants employed by chemical process industries usually claim that it is wrong for a company to do **Basic Research**. In a competitive environment it is considered too costly. However the limited and predominantly empirical state of knowledge about many of the technological and chemical business aspects needs to be overcome to achieve a sustainable flow of innovation. Development work of corporate R&D needs to be supplemented by knowledge-based research / basic research: It needs to be done – by whomsoever! But of course it needs to be organised in a way compatible with industry: being precompetitive by nature public research institutions can be involved and the public interest justifies a public (co)funding.

Our analysis of the state of knowledge about the core processes and the key technologies in Lenzing showed an urgent need for a better understanding. Observations in many cases had no explanations. However,

we could not think of establishing all the fields of competences and the methods required by dramatically increasing our own R&D resources. We therefore started a search for competent research institutions. We tried to present and offer ourselves as a convincing "innovation company", as a competent partner to public research and research funding institutions, industry associations and individual industrial parties of the relevant research community.

A lot of efforts went into continuing **"Lenzinger Berichte"**, an internationally renowned and intensively quoted reviewed Journal referenced in Chemical Abstracts. Since 1953 it has been one of the most important publication platforms in the field of man-made cellulosic fibres and – in this context – of Wood and Cellulose.

Public accessibility to the generated knowledge in most cases is a virtual problem only: As long as such basic research is done in an active cooperation with a leading industry in its own field, this industry will be first in profiting from the results. "Cooperation", however, means that there is at least one competent person in the company responsible for the **transfer** of the knowledge. In some industries a **technology monitoring/ scouting** function is established which, however, will only work if a minimum of company activities in the relevant fields of interest and persons with the specific competence are available.

All these activities resulted in several longterm "Private Public research Partnerships" mostly managed by Lenzing Pulp R&D.

The **"Christian Doppler Laboratory for pulp reactivity"** was a cooperative project started in 1998 with Professor Paul Kosma from the Institute of organic chemistry of the University of Natural Resources and Life Sciences in Vienna (BoKu) as the academic partner. The Austrian CD-Research society explicitly focusses its funding to Industry/University cooperations doing 7 years of basic research and with annual budgets of presently up to 750.000 EUR. The research programme drafted by Herbert was about aspects from the isolation of wood cellulose, to the derivatization procedures and the regeneration of fibres with special emphasis on the physico-chemical structure, morphology and reactivity of cellulosic materials. It had more than 20 scientific staff, amongst them Thomas Rosenau and Antje Potthast, now themselves Professors at the BoKu University. The Lab in turn had several collaborations, amongst others with Joe Gratzl at NC State University, Professor Otto Glatter at the Institute for Physical Chemistry of the University of Graz, with Dr. Buchner at the University of Regensburg and Dr. Binder at the technical University in Vienna. The level of activities and the output was amazing. 134 publications and 38 conference contributions are listed in the Web.

In 2000 another academic collaboration, the **WOOD Kplus Competence Center**, was established with BoKu, the University of Linz and several industry partners from various wood processing chains. The area "Wood- and Cellulose-Chemistry" was located at the Lenzing site and started with Herbert as the responsible key researcher. The Area invested an "Analytic Center" in Lenzing which worked for the research programme but also sold analytical services to third parties. The partnership was continued until 2017.

Lenzing in these decades established several other CD-Labs besides Pulp also dealing with topics in the fields of Viscose and Lyocell fibre properties, manu-

CD-Lab Meeting 2000 in Lenzing: From left: Haio Harms, Paul Kosma, Thomas Röder, Thomas Rosenau, Herbert Sixta, Antje Potthast, Otto Glatter.

The WOOD Kplus crew stationed in Lenzing (2008): from the left in the Backline: Moritz Leschinsky, Gerhard Zuckerstädter, Mario Buchberger, Philipp Schröder, Benjamin Neuhaus, Andreas Stockinger, Herbert Sixta; Frontline: Sandra Schlader, Hedda Weber, Petra Wollboldt, Gabriele Schild.

facturing, processing and applications: these were CD-Labs on the "Chemistry of Cellulosic Fibres and Textiles" of Prof. Bechtold in Dornbirn, Prof. Stana in Maribor and Prof. Phillips in Manchester, on "Applied Thermofluiddynamics" of Prof. Brandstätter in Leoben, on "Advanced Cellulose Chemistry and Analytics" of Prof. Rosenau and Prof. Potthast in Tulln, on "Paper strength" of Prof. Schennach and on "Fibre swelling" of Prof. Hirn in Graz.

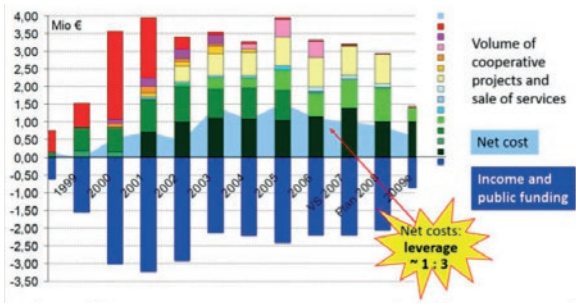
Apart from the scientific results and the improved understanding of Lenzing's chemistry and technologies, these activities produced a **network** of contacts and a multitude of medium and shortterm cooperative projects. They helped the participation in several EU projects, the "EU-carbohydrates centre of excellence" and the "forest-based products technology platform". Lenzing R&D also had substantial income from selling **research services** to third parties especially in industries active in the fields of cellulose films, casings and sponges and pulp manufacturing.

All this helped to reach the required **critical mass** of activities. The value of the cooperative activities directly managed by Lenzing Research in the years 1999 until 2008 was in the range of annually 3,5 to 4 Mio €. The majority was basic research. The corresponding financial coverage by Government- or EU-subsidies or payments by industry partners was between 2 and 2,5 Mio. €. The net costs to Lenzing therefore had a leverage of about 1:3.

The total activity level was substantially increased and even more important: work on themes of relevance for the Lenzing technology, which had virtually disappeared has sustainably been **reintroduced** at Universities in the region.

Herbert at the same time received widespread recognition in the international community of academic and industrial specialists. In 2005 he was one of the few scientists who like Hermann Staudinger (1951), Burkart Philipp (1982) and Joe Gratzl (1992) was awarded by **Zellcheming**, the platform of pulp- and paper-scientists in Germany, the **Alexander Mitscherlich medal** for outstanding work in the field of "Cellulose research and Cellulose chemistry".

Marketing of R&D Services at the exhibition of the International Cellulose Chemists Conference of Cellcheming in Wiesbaden 2001. From left to right: Haio Harms, Marina Crnoja-Cosic, Susanne Möderl, Tanja Kosch, Herbert Sixta.



Cost structure of Lenzing R&D projects in relation to sale of R&D services and public funding

Alexander Mitscherlich medal for outstanding work in the field of Cellulose research and Cellulose chemistry. Zellcheming, Wiesbaden 2005 (Robert Hock, Herbert Sixta)

Yet another R&D reorganisation

After about 10 years of almost undisturbed and very successful R&D, with the implementation of many fundamental innovations, making Lenzing the true "leader in Manmade Cellulosic Fibre technologies", a new group of inexperienced MBA business consultants was brought into Lenzing by shareholders who wanted to prepare the company for a sale to competitors.

Not willing to understand anything about relations management, knowledge generation and the complex activity leverage system, they identified an "enormous cost savings potential" by cutting the cooperative research activities and – as in 1991 – Management, with almost the same arguments decided "to add value to the business" by cutting R&D budgets, splitting up R&D and distributing it to different operational business units. It was obviously too difficult to care for R&D and for converting its results into profitable business at the same time.

I was made responsible for Lenzing group corporate services with subsidiary management, internal revision, legal services, IPR management and a small R&D scouting group. In 2008 I changed as CEO to Kelheim Fibres, a Speciality Viscose Fibre producer in Germany where I spent the most rewarding years of my professional career. At the same time Herbert accepted a call of Aalto University in Finland as a Professor for Bioproducts and Biosystems. He continued for some time offering his expertise to Lenzing but finally moved to Finland completely. About his activities and achievements here at Aalto University I need not talk: You know them better than I do! His group is amazing! The results of his work here are breathtaking!

Whoever is interested in the details of Herbert's research output in Aalto, the many doctoral theses he supervised, and the projects he managed, should look at his personal profile on the Aalto homepage:

https://research.aalto.fi/en/persons/herbert-sixta

Herbert, I'm grateful for the many years of very fruitful collaboration and for your friendship. I'm sure we will see many more fruits that have grown from your "hobbies" in the field of lignocellulosic substrates.

The group of the department for Bioproducts and Biosystems, 2022

Postscriptum in June 2022

It is only a couple of days when I received the first example of these fruits. It was the invitation from "The Marcus Wallenberg Foundation" requesting my attendance at "The Marcus Wallenberg Prize Ceremony in the presence of Their Majesties the King and Queen of Sweden" in honour of Herbert Sixta as one of the MWP 2022 Laureates. The price was awarded to him and Ilkka Kilpeläinen "for the development and use of novel ionic liquids to process wood biomass into high performance textile fibres."

Herbert: Congratulations again, and all the best for your future!

Last, but not least I want to thank Herbert's former colleagues in Lenzing Gabriele Schild, Thomas Röder, Gregor Kraft and Geri Meister who share my admiration for Herbert and helped mew to put my memory in order and to fill its holes.

Herbert Sixta and Ilkka Kilpeläinen