Biotechnol. J. 2015, 10, 1844–1846

DOI 10.1002/biot.201500627

European's Biochemical Engineering to face the megatrends and associated challenges beyond 2020

ESBES
European Society of
Biochemical Engineering Sciences

It is nowadays clear that the world is changing rapidly. It is accepted that global changes of today will significantly impact the future of individuals and societies, the culture, and the business landscape. Several recent studies have identified and clustered these global megatrends, which impact everyone on the planet (Megatrends 2015, Making sense of a world in motion. Ernst and Yung report, 2015: http://www.ey.com/Publication/vwLUAssets/ey-megatrends-report-2015/$FILE/ey-megatrends-report-2015.pdf; World's top global mega trends to 2020 and implications to business, society and cultures, Frost & Sullivan report, 2015: www.frost.com/prod/servlet/cpo/213016007). On one hand, these megatrends provide great opportunities for new businesses; however, on the other hand,they also bring significant challenges which need to be addressed. Appropriate strategies are needed to face these challenges, especially focusing on increasing international cooperation, promoting behavioral change in individuals and societies, and seeking proactive measures and technologies to mitigate undesirable impacts.

In Europe, these megatrends and challenges were identified in a report recently published [1]. The report identifies the major challenges related to the growing and ageing population, the establishment of a rising global middle class, connected societies and individual empowerment [1]. Societal challenges are also the target addressed in the Horizon 2020 program. From the seven societal challenges addressed in this program, Biochemical Engineers can certainly contribute to:

- Health, demographic change and wellbeing, aiming a better health for all and enabling an active aging;
- Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bioeconomy, focusing optimal and renewable use of biological resources, sustainable primary production and processing systems, to secure the production of more food, materials and other bio-based products with no waste and minimized environmental impact and greenhouse gas emissions;
- Secure, clean and efficient energy, supporting the transition to a reliable, sustainable and competitive energy system while facing increasingly scarce resources, growing energy needs and climate change;
- Climate action, environment, resource efficiency and raw materials to achieve a resource and water efficient and climate change resilient economy and society, to enable the protection and sustainable management of natural resources and ecosystems, and to secure a sustainable supply and use of raw materials;

The role of Biochemical Engineers

Biochemical engineering is based on interdisciplinary activities, bridging biologists and chemists to bring processes developed at laboratory scale to large-scale manufacturing. Typically, biochemical engineers are involved in the design of equipment and processes to be used for large scale (e.g. hundreds of cubic-meters) cellular cultures in order to develop and produce bio-fuels, native or recombinant proteins, antibiotics and other biologically active molecules, improve the efficiency of drugs and pharmaceutical processes, and also develop new biotherapeutics to cure diseases. Biochemical engineers are also involved in designing and developing analytical and control systems required to monitor and control the production processes and also to generate operating specifications for product manufacturing and release. Biochemical engineers apply engineering problem-solving skills to study and better understand the relevant biological systems, typically aiming at optimized processes and procedures, and manufacturing in efficient, cost-effective and sustainable ways.

The biochemical engineering community is thus the task force having the knowledge, tools and skills to successfully address the major global challenges. The growing world population and increasing living standards by one hand require more natural resources consumption, but on the other hand demand higher quality of the products with significant ecological and economic demands. More food, better health, active aging, cleaner water and better air are some of the major demands of the growing societies. A transformation in the industry is needed to meet these demands with low or no waste production, reduced release of greenhouse gases, in energy efficient and still cost effective and cost competitive manufacturing processes.

Also driven by the concerns of fossil fuel depletion and climate changes, this so called sustainability revolution already initiated some years ago. The concept of biorefinery is probably one that better fits this new industrial paradigm. By definition (National Renewable Energy Laboratory, 2015, http://www.nrel.gov/biomass/biorefinery.htm), biorefinery is a facility that integrates biomass conversion processes and equipment into several products, including fuel, high-value chemicals, materials, food, and feed. All of the elements of biomass are explored, valorizing all the secondary products and wastes by converting them into valuable products and/or using them to generate energy. While the use of all components of the biomass is expected to have a positive impact on both economy and environment, significant challenges are yet to be solved to make bioeconomy and biorefineries a full success. In fact, when compared with the chemical industry, the bioindustries are still immature and the production costs are still high. In general, yields need to be increased and production costs need to be reduced. Several progresses are required to support this transition for the bio-industry, including optimization of strains and fermentations for new carbon source feedstreams, screen and engineer enzymes with optimal activity for instance in very viscous solutions or even solid matrices, design of new bio-reactors ensuring good distribution of nutrients and oxygen with minimal or no generation of gradients, increase production scales and/or titers, intensify processes and develop novel separation technologies and processes suitable to process both the large volume/low value and low volume/high value products from the biorefinery [2, 3].

In the biopharmaceutical industry, the maturation of technologies and tools such as genomics, proteomics, systems biology, and molecular modelling, and also the emergence of novel technologies, including biochips, stem cell technology, microfluidics and high throughput screening, also drive significant developments in biochemical engineering. The integration of the knowledge in cross-disciplinary biochemical engineering activities and its translation in bioprocesses brings new opportunities to design better therapies, based on genes, stem-cells, monoclonal antibodies and nanobodies. Currently more than 200 monoclonal antibodies products reached the market and over 1000 are in clinical trials. To support this fast growing biopharmaceutical industries, significant technological advancements are needed. In this field, an unbalance of process technologies is also observed. The significant knowledge on omics sciences and tools (e.g. genomics, proteomics and metabolomics), gene manipulations and screening (including high throughput methodologies) led to the rapid improvement of cell lines and microorganism strains. The titer of recombinant biomolecules increased 100-fold over the last decade from below 0.5 g/L to 50 g/L and higher. While some research and developments have been observed in bioprocesses in general, including novel bioreactor designs and purification operations, the scale of improvements have not yet matched those of upstream genetic manipulation and cell lines and strain improvement. Further developments are needed to bridge this gap and fully exploit this productivity potential.

The pressure over biochemical engineering to deliver better, more efficient and cost effective processes is high. While aiming at maximized yield and product purity, bioprocess development nowadays also requires a complete overview of all process streams, not only for the identification of potential co-valorization of side streams, adding to the overall process economics, but also to integrate process stream recycling strategies to recover and re-use salts, water and heat/energy reducing the overall eco-footprint of the industry.

Continuous manufacturing is a common tread crossing both biopharmaceuticals manufacturing and biorefineries. In theory, continuous processing provides significant costs reduction (both capex and opex), lowers equipment and facility size, and improves product quality [4]. While common in most chemical-based industries, fully continuous bioprocesses are yet far from reality. This is certainly a field of major future development in biochemical engineering.

The European Society of Biochemical Engineering Sciences

Biochemical engineering is pivotal to further develop and support the full transition to a bio-economy era. The new *European Society of Biochemical Engineering Science* (ESBES) has a relevant role in promoting the platform for excellent scientific discussion and bridging academia and industry together to take innovation into action. ESBES brings together national chemical and biochemical engineering societies from across Europe, academia and industry, to help translate knowledge into processes and products and advanced education.

ESBES organizes top level conferences and workshops to shape and design the future of process technology and industrial biotechnology to develop future economic activities, based on efficient, clean and sustainable manufacturing. The major activities of the Society are the *European Conference of Applied Biotechnology* (ECAB) series, focusing more on the biorefinery and industrial biotechnology developments, and the European Symposia of Biochemical Engineering Science, a series of conferences focusing more on the newest scientific developments in bioengineering.

With its sections especially active in the fields of Downstream Processing; Bioreactor Performance; Biocatalysis; Bioeconomy and Bioenergy Systems; Regenerative Medicine Manufacturing, Microalgae Bioengi-

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neering, and M3C-Modeling, Monitoring, Measurement, and Control, the ESBES follows its vision to contribute to solve major societal challenges associated with population changes and limited resources and to improve the quality of life.

References

[1] Hoorens, S., Ghez, J., Guerin, B., Schweppenstedde, D. et al. (Eds.), *Europe's Societal Challenges: An Analysis of Global Societal Trends to 2030 and their Impact on the EU*, Rand Europe, 2013.

[2] Ragauskas, A. J., Williams, C. K., Davison, B. H., Britovsek, G. et al.,The path forward for biofuels and biomaterials. *Science* 2006, *311*, 484–489.

[3] Zhang, Y-H. P., Production of biofuels and biochemicals by in vitro synthetic biosystems: Opportunities and challenges, *Biotechnol Adv.* 2014, DOI:10.1016/j.biotechadv.2014.10.009.

[4] Zydney, A. L., Continuous downstream processing for high value biological products: A review. *Biotechnol. Bioeng.* 2015, DOI 10.1002/bit.25695.

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Cover illustration

This special issue, in collaboration with the Asian Federation of Biotechnology and edited by Professors Yoon-Mo Koo and Penjit Srinophakun , covers advances in bioprocess engineering. Several articles in this issue discuss different aspects of lignocellulose-based biorefining. Miscanthus (shown on the cover) is one example of a plant whose lignocellulosic biomass can be used for bioethanol production. © M. Schuppich, Fotolia.com

Biotechnology Journal – list of articles published in the December 2015 issue.

Research Article

Phenolic compounds: Strong inhibitors derived from lignocellulosic hydrolysate for 2,3-butanediol production by *Enterobacter aerogenes*

Sang Jun Lee, Ju Hun Lee, Xiaoguang Yang, Sung Bong Kim, Ja Hyun Lee, Hah Young Yoo, Chulhwan Park and Seung Wook Kim

http://dx.doi.org/10.1002/biot.201500090

Research Article

Salt tolerant chromatography provides salt tolerance and a better selectivity for protein monomer separations

Noriko Yoshimoto, Daisuke Itoh, Yu Isakari, Ales Podgornik and Shuichi Yamamoto

http://dx.doi.org/10.1002/biot.201400550

Research Article

Dual utilization of NADPH and NADH cofactors enhances xylitol production in engineered *Saccharomyces cerevisiae*

Jung-Hyun Jo, Sun-Young Oh, Hyeun-Soo Lee, Yong-Cheol Park and Jin-Ho Seo

http://dx.doi.org/10.1002/biot.201500068

Biotech Method

Phosphonium alkyl PEG sulfate ionic liquids as coating materials for activation of *Burkholderia cepacia* lipase

Yui Matsubara, Shiho Kadotani, Takashi Nishihara, Yoshichika Hikino, Yukinobu Fukaya, Toshiki Nokami and Toshiyuki Itoh

http://dx.doi.org/10.1002/biot.201500413