Education for Chemical Engineers xxx (2018) xxx–xxx

Contents lists available at ScienceDirect

Education for Chemical Engineers

journal homepage: www.elsevier.com/locate/ece

BIOPRO World Talent Campus: A week of real world challenge for biotechnology post-graduate students

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ARTICLE INFO

Article history:
Received 12 March 2018
Received in revised form 5 August 2018
Accepted 26 August 2018
Available online xxx

ABSTRACT

Focus on sustainable processes and renewable raw materials, combined with rapid advancements in technology developments across scales, makes bio-based production processes a subject of great interest to both industry and academia. Despite this increasing prominence of bio-based production processes, there is a lack of a single course that can provide a thorough overview of the state-of-the-art industrial scale bio-based production, to early stage practitioners and researchers such as post-graduate students. BIOPRO World Talent Campus (WTC), developed and initiated in the year 2013 by the BIOPRO Strategic research consortium, was specifically designed and developed to address this shortcoming, and has thus far trained more than 120 post-graduate students from related yet diverse academic backgrounds from all across the globe. This manuscript describes the general and technical organisation of BIOPRO WTC, and the unique academic and industrial collaboration that exists in Denmark, which makes WTC a reality. A special focus is also placed on discussing a 48 h industrial challenge that is set by leading Danish bio-based production companies and its impact on young post-graduate students, who get hands on experience in dealing with "real world" problems. Results from student surveys carried out during the five years of WTC are reported and discussed to understand the impact of the course. A future perspective is also presented with the focus on the possibility of employing emerging technologies to extend the outreach of the program.

1. Introduction

Currently, there is a significant body of work as well as continuing research and development efforts within both academia and industry that are directed towards improving the process understanding of bio-based production. Collectively, these works are multi-dimensional across scales, multi-disciplinary and multi-sectoral in nature (Mansouri et al., 2017; Udugama et al., 2017a). For example, the development of accurate mathematical models for biogas production processes from the waste of bio-based production processes requires both laboratory and industrial scale information (Feldman et al., 2017), while the development of practical control structures also requires both industrial scale information together with fundamental process models, be it fermentation (Mears et al., 2017a; Mears et al., 2017b) or fine chemical distillation (Udugama et al., 2017b; Udugama et al., 2018). This type of work requires a collaborative academic and industrial effort which pools together knowledge, expertise and equipment. In Denmark, the BIOPRO Strategic Research Centre (www.biopro.nu) was established with the explicit aim of promoting this industry-academia collaboration, where large scale industrial partners, who are in most cases world leaders in their industry, work together with start-ups and universities in developing innovative industrially applicable solutions for improving bio-based production processes (Biopro, 2018).

Starting from a set of renewable bio-based raw materials, the production of valuable final and intermediate products through chemical reactions and/or microbial fermentation in large scale

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https://doi.org/10.1016/j.ece.2018.08.005
1749-7728/

production processes has been an area of interest to both academia and industry in the past decades (Mansouri et al., 2017; Udugama et al., 2017a). Denmark has historically been a front runner in realising this trend, where companies have been employing bio-based production processes for production of bio-pharmaceuticals, food ingredients, biofuels as well as industrial enzymes (Biopro, 2018). However, despite a rapid growth, deep fundamental understanding of these types of processes is not as well established compared to many traditional chemical processes such as industrial chemical production.

From an educational point of view, covering the topic of industrial scale bio-based production processes can be complicated. Firstly, industrial scale bio-based production requires an individual or a project team to have multi-disciplinary knowledge encompassing the areas of chemical engineering (Udugama et al., 2017a), biochemical engineering, systems biology, process modelling (Feldman et al., 2017), and process monitoring and control (Boiocchi et al., 2017), as all of these areas are relevant and hot topics for ongoing research. As a result of the above factors, as well as the relatively novel nature of industrial-scale bio-based production processes, there is a lack of graduate-level reading material and courses that provide a good and thorough overview of the opportunities and challenges of bio-based production at an industrial scale. For example, the Brac Bioprocess Engineering Course held in Croatia is a well-recognised course in the area of Bioprocess Engineering for graduate level students. The course focuses on delivering a good in-depth theoretical and practical understanding but somewhat lacks the hands-on experience and the focus on full scale industrial processes (Brac Bioprocess Engineering Course, 2018). At The Technical university of Denmark (DTU), only three out of 11 graduate level summer courses are related to bio-based production, while only one of these courses focusses on biological processes (bio-refineries).

Multi-disciplinary areas have been an area of active interest in chemical engineering education. For example, a multi-disciplinary lab experiment for coke combustion in a fluidized bed has been designed to teach graduate students mass transport and reaction concepts (Silva et al., 2017). Meanwhile, soft skills such as employability (Fletcher et al., 2017) or team work (Najdanovic-Visak, 2017) as well as more technical concepts such as process safety (Meyer, 2017) have also been of interest to educators in the area of chemical engineering.

From an educational perspective there is an urgent need for development of courses and/tools that can impart students with relevant applied knowledge as well as transferable skills to adapt and excel in a rapidly evolving multi-disciplinary, inter-sectoral area of industrial biotechnology manufacturing

BIOPRO World Talent Campus, an intensive one week program, was developed to address these needs, with the following objectives: 1) impart cutting edge, industrially relevant knowledge about industrial scale bio-based production processes; 2) build relevant soft skills of a select group of post-graduate level students from all over the world; and, 3) facilitate working in a multi-cultural and multi-disciplinary group.

In 2017, the BIOPRO strategic research centre organized the 5th edition of WTC in Denmark, with 25 graduate students from universities across the world participating in this week-long course. The following factors make this course distinct from other similar modules in the area of biotechnology-based production:

- The course is a true collaborative effort between academia and industry with both sectors getting an opportunity to carry out lectures and presentations in an auditorium setting.
- The lectures are conducted by subject matter experts and cover a large range of relevant topics that are important in gaining a thorough understanding of challenges and opportunities in industrial scale bio-based production processes.
- The 48 h industrial challenge is set by the industrial partners, where students work in groups on solutions to a real problem faced by an industrial partner.
- The course balances academic activities with extracurricular activities such as team building as well as showcasing Danish culture and allowing participants to develop group dynamics.
- It gives students a unique practical exposure to the bio-based industry which is extremely useful for those wishing to work in industry in the future.

As a result of these factors, WTC is currently the only course that allows graduate level students to get a thorough overview of the challenges of the industrial bio-based production industry.

In this manuscript we provide a comprehensive description of a unique multi-disciplinary, multi-dimensional and industrially relevant graduate level course, BIOPRO World Talent Campus (WTC) by reviewing and consolidating the outcomes of the latest WTC (2017) as well as how they are allowing graduate students to get a thorough understanding of challenges and opportunities relevant for industrial bio-based production processes.

2. Campus organisation structure

The first edition of WTC was conducted in 2013 and since then, the organisational structure has remained the same. Fig. 1 illustrates the overall organisational structure of WTC with the responsibilities of each partner listed. The BIOPRO strategic research centre, Technical University of Denmark (DTU), University of Copenhagen and Novo Nordisk A/S are involved in the major planning, administration and execution aspects of WTC. The industrial partners of the consortium: Novo Nordisk A/S, Chr. Hansen A/S, CP Kelco A/S, Novozymes A/S and Xellia Pharmaceuticals ApS are involved with the teaching modules of WTC, as well as outlining case studies and providing information for the 48 h industrial process challenge.

Financial and administrative aspects are handled by the Process and Systems Engineering Centre (PROSYS), Department of Chemical and Biochemical Engineering, Technical University of Denmark. Neither the participants nor their universities incur any fees to partake in this course thanks to the generous donation by the Novo Nordisk foundation.

The objective of the WTC is to achieve a good balance of technical content, while allowing participants, company representatives and organisers ample time to network. This allows participants to improve their knowledge base on both theoretical and practical developments in bio-based production processes. WTC also allows participants to build long lasting strategic relationships with their peers as well as industrial representatives that will potentially lead to better international, inter-sectorial, multi-disciplinary collaborative efforts in improving bio-based production processes.

The course is conducted over a period of eight days in which the participants get a good balance of lectures, problem solving, social activities as well as team building activities as described in Table 1.

3. The participants

The participants for WTC are selected from a wide pool of applicants who are currently enrolled in graduate or post-graduate studies in areas related to or of vital interest to improving the competitiveness of industrial bio-based production processes. The course is mainly promoted through the academic networks and in recent years through social media groups where an active community of former participants are found. The course is also promoted

Please cite this article in press as: Udugama, I.A., et al., BIOPRO World Talent Campus: A week of real world challenge for biotechnology post-graduate students. Educ. Chem. Eng. (2018), https://doi.org/10.1016/j.ece.2018.08.005