Process Intensification and Optimization for Sustainable Biofuels Production Systems

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Background

The International Energy Agency has anticipated a powerful decline in the oil production from 70 million barrels/day in 2007 to 27.1 million barrels in 2030 [1]. In the coming decade, the promotion of rational energy policies in the existing plants and the definition of new bio-products to replace their fossil counterparts will be the major research challenge.

Fuels derived for biomass materials are today an important resource to assure a more stable and sustainable energy policy. The biofuels production includes different unit operations like pretreatment of feedstock, reaction section, separation and purification operations, and so on.

So far, research on the respective production processes for bioethanol and biodiesel have received considerable efforts, however, little attention has been paid on the hybrid production systems of these two renewable fuels.

The aim of this proposal is the study of the whole process for the biofuels production and the possibility to integrate the bioethanol-biodiesel in a more intensified system at both process and equipment levels. One focus will be on energy-efficient intensified distillation technologies for reactions and separations.

Questions to answer

i. Is it possible and profitable to integrate the bioethanol and biodiesel processes in one single flow sheet design?

ii. If integration is profitable, how much energy and equipment size you can save by using intensification strategies?

iii. What kind of separation technology does it properly work for every design?

Some references

[1] International Energy Agency (2008) World Energy Outlook 2008, OECD/IEA Paris.

[2] Huang H.J., Ramaswamy S., Tschirner U.W., Ramarao B.V. (2008) A review of separation technologies in current and future biorefineries. *Separation and Purification Technology*, Vol. 62, pp 1-21.

[3] Rong B.-G. (2011) Synthesis of dividing-wall columns (DWC) for multicomponent distillations - a systematic approach. *Chemical Engineering Research and Design*, Vol. 89, pp 1281-1294.

[4] Errico M., Rong B.-G., Tola G., Spano M. (2013), Optimal design of distillation systems for bioethanol separation: Part II. Extractive distillation with complex columns. *Industrial & Engineering Chemistry Research*, 52, 1620-1626.

Summarized description

Objectives

The objective of this project is to define a whole integrated bioethanol/biodiesel production process for both process level integration and unit operation level intensification, with a focus on intensified reaction and separation technologies. Most of the analysis and evaluation work will be done with the help of Aspen Plus, Matlab and optimization software licenses, as well as developing our own methods and tools.

Hypothesis

A simultaneous, process and unit operation integration and intensification, can achieve newer and robuster strategies than a single-step approach in order to get a final and global flow sheet design.

Methodology

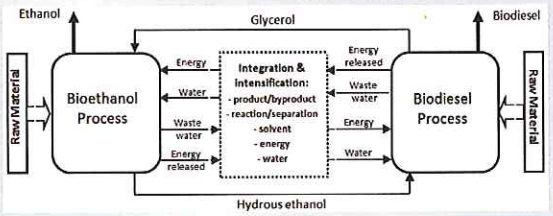
Process synthesis and integration will be used to formulate the promising alternatives and scenarios taking into account of different raw materials and technological routes [2]. The synthesis and integration will be done following systematic strategies at process level:

- Solvent Integration
- Water Integration
- Energy Integration

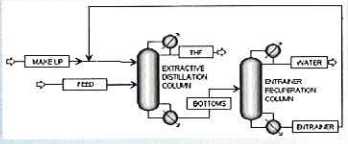
At unit operation level, technologies and equipments will be investigated at this level, including modeling and simulation, optimal design and optimization [3, 4]:

- Novel reactive distillation systems
- Extractive dividing-wall-column distillation systems
- Azeotropic dividing-wall-column distillation systems

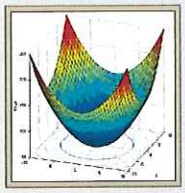
Bioethanol and biodiesel integration and intensification possibilities



Aspen Plus® of Aspen Tech



Optimization tools



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