A Novel Biorefinery Approach

Sustainable Production of Biofuels, Pharmaceuticals and Functional Food

Part I. Overall View of an Integrated Process

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Biorefinery’s Fundamentals

**Novel Features**
- Multi-product facility with a renewable and sustainable feedstock
- Production of bulk chemicals, biofuels, food and specialities
- Market competitive products

**Hypothesis Statements**
- The by-products produced by a core process can be effectively used as feedstock for secondary processes.
- The integration of independent processes can significantly improve the economic feasibility of a non-profitable process.

**Objectives**
- Design an green ethanol production process fed by a lignocellulosic feedstock
- Use the CO₂ coming as algae plant to produce functional food and pharmaceuticals

**Operational Scheme**

1) Bioethanol plant: fed with corn stover, which is treated with a physical and biological pre-treatment to obtain the sugars within its structure. These sugars will feed a Zymomonas mobilis culture that will produce the ethanol. Using distillation columns and molecular sieves ethanol will be extremely purified.

2) Spirulina/APC plant: it is fed on Zarrouk medium and CO₂ produced in the raceway ponds and CPhycocyanine (C-PC) is obtained by homogenization and purification of the algae produced.

3) Biogas plant: it uses the biomass coming from the bottoms of the distillation columns. Upon this biomass an anaerobic digestion will be performed so as to transform this useless biomass into a valuable energetic resource.

**Processes**

**Biocatalysts**

- *Zymomonas mobilis*
- *Arthrobacter platensis*

**Anaerobic consortia**

- Hydrolytic/Acidogenic
  - Main genus: *Butyrivibrio, Propionibacterium, Cellvibrio, Clostridium*
  - Substrates: Complex organic components
  - Products: Short volatile acids (VFAs), formic, acetic, propionic, butyric and propionic acid.

- Acetogenic
  - Main genus: *Sequence and Syntrophobacter*
  - Substrates: Short volatile acids (VFAs)
  - Products: Acetates and H₂

- Methanogenic
  - Main species: *Methanobacterium sulci* and *M. mobilis*
  - Substrates: H₂, CO₂, lactic acid
  - Products: CH₄ and CO₂

**Economic Analysis**

**Operational Cost Distribution**

- Utilities, specifically standard power, implies the major annual cost for the biorefinery. Nevertheless, the biogas used and increased in the CHP engines mitigates this percentage, saving part of the utilities cost.

**Annual Cost Composition**

- The economic feasibility of the plant is subjected to the number of the integrated processes.
- A higher number of coupled processes implies an increase of the initial investment.
- Utilities and transport prices are the bottleneck of this project.
- The algae and the biogases processes are significantly sensible towards the environment and substrate conditions, respectively, which may cause them to fluctuate.

**Results – Comparison between processes**

- Three scenarios where studied: an single ethanol plant, a coupled algae an ethanol plant and a biorefinery of ethanol, algae and biogas. As result, the following matrices where formulated:

- The algae cost has the greatest impact upon ethanol’s price.
- The biogas process saves a considerable amount of energy, enough for significantly improve the economy’s plant.

**Conclusions**

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**References**