Bio-based Bottles – Recyclable but more Ecological?

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1. Background + Aims

The introduction of a new generation of biorefineries into the market presents a multi complex problem, where questions like environmental sustainability, economic feasibility and conceptual exploration need to be answered beforehand. The biorefineries of the second generation need to tackle the objective of how chemicals can be produced from biomass, and not compete with the food production. Lignocellulosic biomass presents a raw material with a high potential to replace corn or sugarcane. Innovative production routes from wood to chemicals have to be included within the biorefinery concept. The quest of finding the optimal biorefinery concept is becoming even more complex by considering besides the conventional also innovative processes for the production of chemicals. The approach for finding the optimal concept is that generic optimization algorithm, developed by EPFL in Lausanne, is able to integrate different processes in order to find a biorefinery concept under the objective of profit maximization and environmental impact minimization.
A major part of the research project is the modelling of the different production paths to produce either platform chemicals (e.g. Glucose, Ethylene, Succinic acid) or high value added chemicals (Polyurethanes, Polyesters, Vinyl polymers). For the production routes conventional concepts as well as innovative concepts are considered for finding the optimal production routes. The concepts are evaluated through environmental indicators (Global Warming Potential, Ecoindicator 99, Cumulative Energy Demand) and economic indicators (Profit, Operational costs, Investment cost).

2. Methods + Results

The usual approach for a biorefinery concept is the replacement of petrochemicals by chemicals, which can be produced from renewable resources. Another approach is the production of entirely new monomers based on bio based materials. The monomer 2,5-furandicarboxylic acid (2,5- FDCA) can serve as an replacement for terephthalic acid. The promising polymer poly(ethylene furandicarboxylate) (PEF) can be produced from 2,5-FDCA. PEF is seen as a possible replacement for PET. Regarding to thermal properties, PEF is more interesting than PEF as it has higher thermal stability combined with lower processing temperature. Furthermore PEF is recyclable with the common machines, which are used for PET. For realizing the production of PEF a key chemical is 5-hydroxymethylfurfural (HMF). For the production of PEF different processes were modelled and optimized:

1. Glucose production from wood by acidification
2. Fructose production by Glucose isomerization [1]
3. HMF production by dehydration of Fructose [2]
4. 2,5-FDCA production through oxidation of HMF
5. PEF production by polymerization of 2,5-FDCA with ethylene glycol

The different production steps were evaluated to answer the question if plastic bottles made of PEF are more ecological friendly or economical feasible than from PET.

3. Summary/Conclusion

In this research project the production from alternative plastic bottles made of PEF were evaluate from an environmental, economic as well as from a safety point of view. As an outcome of this study the main environmental burden in the production route was pointed out.

References

[1] Method of Producing High Fructose Corn Syrup from Glucose using Noble Gases, 5,593,868, 1997
[2] Method and Apparatus from preparing Hydroxymethylfurfural, US 2012/0016141 A1, 2012