IL02 INVITED LECTURE · ENERGY SECTOR

Towards Sustainability and Circular Economy in Biofuel Production

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Abstract

Sustainability and circular economy have become increasingly vital to be met in any successful translational research. Keeping this in mind, a serious of innovative processes have been developed for the volarization of biomass to biofuel. We present series of innovations made in the processes leading to the production bioethanol and biodiesel, with a specific emphasis on the sustainability and circular economy. Adopting a standard microalgae culture for the extraction of carbohydrate from harvested biomass, we have established a cost-optimized cultivation strategies for *Arthrospira maxima* using an alternative culture media based on NPK–soil extract–NaCl. A self-flocculation-based harvesting process to further cut-down production cost effected from the reduction in processing time and minimal chemical use. The harvested biomass subjected to cascaded biorefinery approach for integrating phycocyanin extraction, lipid recovery for biodiesel, and saccharification–fermentation to bioethanol. Techno-economic analysis of product portfolios and process configurations reveal how production cost, power demand and over-all carbon footprint is reduced. Our work demonstrated a financially sustainable model for biofuel extraction process in *Arthrospira maxima*. In another approach, conventional ethanolic fermentation was revisited for cost-reduction wherein sugarcane molasses and *A. maxima* dry biomass jointly function as substrate and nutrient matrix, enabling efficient ethanol production without a separate fermentation media and yielding a more cost-effective first-generation biofuel process. In the process of conversion of oil to biodiesel, a novel patented method of conversion, namely, a one-pot subcritical, catalyst-free and by-product-free transesterification process is developed for total conversion of diverse oils to biodiesel. Salient feature of the process is that by eliminating the use of catalyst, processes associated with its separation were eliminated. Further, the glycerol is also converted into additive products, eliminating the need to separate it. We thus developed a proof-of-concept of technology for total conversion of oil to biodiesel requiring fewer chemicals and processes. Interestingly, there was an in-built process of recovering the excess alcohol from the reaction mixture. We thus demonstrate a sustainable and circular economy approach in the production of biofuels and value-added products by means of utility of discard for subsequent value extraction, complete volarization of biomass, developing a process that inherently employ lesser chemicals as well as avoids generation waste water, uses minimum number of chemicals and reduces process steps significantly.

Keywords: *biodiesel; bioethanol; biorefinery; circular economy; microalgae; transesterification*