Innovative Energy & Research

Bhagia and Ragauskas, Innov Ener Res 2016, 5:2
DOI: 10.4172/2576-1463.1000e118

Editorial OMICS International

Potential Future Directions for Achieving Low Cost Cellulosic Ethanol

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Received date: October 04, 2016; **Accepted date:** October 05, 2016; **Published date:** October 06, 2016

Editorial

The dependence of a vast majority of the global population on petroleum has led to an acute concern regarding its negative environmental impact and long-term sustainability of utilizing this finite resource. The control of its reserves by some, has left others vulnerable, and has made decision makers and intellectuals alike to mull over practical alternatives. Climate damage is tied to radiative forcing that is affected strongly by carbon dioxide in the atmosphere, a greenhouse gas that had cycled between about 170 to 280 ppm from 800,000 BCE till the start of industrial revolution in 1760, and since then has been increasing continuously to today's level of near 400 ppm [1], largely due to anthropogenic activities such as transportation, power and electricity generation [2]. Cost, renewability, environmental impact, and availability are some of the most important considerations in finding substitutes for gasoline. Cellulosic ethanol satisfies many of such criteria with cost being its main hurdle to commercialization [3]. Its pursuit over other fuels comes from the learning that when produced through biological route from plant biomass, it is currently the only known liquid fuel that can be produced at the high yields and scale necessary to be able to compete with the well-established gasoline fuel and its infrastructure. While it has begun its journey to penetrate the fossil fuel supply chain, its cost needs to be lowered to a point at which profit margins appear lucrative enough to attract investment and satisfy requirements for sustainability. The high yielding biological route for ethanol production from lignocellulosic biomass involves pretreatment, enzymatic hydrolysis and fermentation. Enzyme and pretreatment costs need to be lowered for cost-effective conversion of polysaccharides into fermentable sugars [4]. High concentration of sugars at low cost and low inhibitor levels not only leads to lower cost cellulosic ethanol, but opens doors to industry to pursue fuel and chemical production using pathways originating from sugars. Chemically, this is being explored through dehydration of monomeric sugars and their further catalytic upgrading into fuel and chemical products [5]. Seeing the rapid advancement in the three fields of omics, many fuels and specialty chemicals would be possible to manufacture biologically by using proprietary microbes engineered with designer pathways [6]. Achieving low cost monosaccharides from plants requires the lowering of biomass recalcitrance and lignin has been a primary target of this effort as it is a primary hindrance to enzymes trying to cleave glycosidic bonds in cellulose. Recalcitrance can be lowered genetically through reducing lignin content or modifying lignin composition or bonds between lignin and carbohydrate by regulating genes involved in lignin biosynthesis [7]. This can also be achieved by finding wild plants that show naturally low recalcitrance and other traits desired in a dedicated biofuel feedstock [8]. Of importance is the characterization of plant cell wall structure to identify differences in plants that show reduced recalcitrance with plants that show relatively higher recalcitrance [9]. Feedback from such studies can be used to focus on genetic markers associated with recalcitrance. Investigation into pre-treatment mechanisms are being conducted to identify the structural changes that take place during pre-treatment as well as strategies to reduce enzyme loading [10]. Pretreatment technologies can be further developed to find pretreatment conditions which lower recalcitrance in a way that leads to high conversion of crystalline cellulose by enzymes while keeping degradation of sugars and inhibitor concentrations low, and costs at a minimum [11]. In the fermentation stage, improvements are being made in the tolerance of microbes to inhibitors formed during pretreatment and introducing in them pathways to assimilate all types of sugars and not just glucose [12]. Advancement in the field of lignin degrading enzymes from white-rot fungi is prospective as their addition can markedly upgrade the current enzyme cocktail for efficient deconstruction of lignocellulosic biomass. Currently, concentrations of lignin degrading enzymes are too low or growth rates of the white-rot fungi are often too slow for industrial applications [13]. Designer microbes based on the concept of thermophilic bacteria that carry out enzyme production, enzymatic hydrolysis and fermentation in-situ, also called as consolidated bioprocessing, will be a breakthrough in the field of cellulosic ethanol if high yields of ethanol can be achieved [14]. Instead of burning lignin in the biorefinery, recovery of its aromatic compounds to serve as intermediates for renewable chemicals can be very beneficial due to high profit margins such as that seen with petrochemicals in the oil industry [15]. In addition, low cost sugars are beneficial for production of single cell protein for malnourished regions of the globe with a low human development index as well as livestock industry that is heavily dependent on protein [16]. Thus, technologies originating from lignocellulosic biomass have tremendous room for advancement as the power to be able to utilize naturally sequestered atmospheric carbon dioxide to produce not only highly coveted cellulosic ethanol but also other fuels and chemicals is captivating.

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