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Do-Able Biofuels

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As the new-year begins, it is perhaps time we reflect where society has come over the past five years since it decided that our future energy resources need to be broadened beyond petroleum. The good news is that most major oil-consuming countries have now implemented renewable fuel standards and these mandates are beginning to impact fuel consumption patterns. To-date, global bioethanol production has grown to 22.7 billion gallons/ year in 2010 with the US and Brazil being the top two producers and future demand is expected to grow by ~80% in the next 4 years. Although the level of cellulosic ethanol in the US has not yet met the projected levels of production over the last 5 years, its production capacity is increasing as several commercial cellulosic ethanol plants are now being built using the best available tested technologies. Meanwhile, researchers are addressing many of the current technical limitations of cellulosic 2nd and 3rd generation biofuels. Starting with basic plant resources, research has shown that native plants have tremendous diversity which can be used to identify bioresources that are productive and have a reduced degree of recalcitrance thereby facilitating their biological conversion to simple sugars, which remain the primary feedstock for ethanol and fungible fuels. Likewise, our fundamental understanding of plant cell wall recalcitrance is growing tremendously providing new genetic tools to engineer the next generation of agro-energy crops that will have reduced recalcitrance while also addressing issues of sustainability and crop productivity. Supplementing these efforts, our knowledge of pretreatment science and engineering has advanced substantially in the last five years providing reduced recalcitrance biomass with lower demands for process water, capital and operating costs. Finally, advances in cellulases, cellulosomes and consolidated biomass processing (CBP) all suggest that in the near future the conversion of plant polysaccharides to ethanol, butanol and/or related alcohols will only become easier and more cost competitive. Figure 1 shows how biofuels research is simplifying the overall conversion process and Figure 2 illustrates the enormous growth in research interest in biofuels.

Likewise, advances in the thermal conversion of biomass to

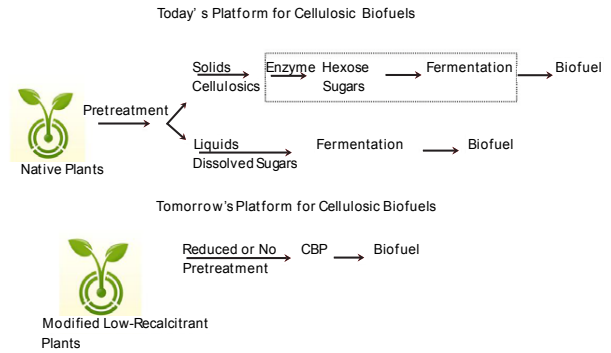

Figure 1: Today and tomorrow's cellulosic biofuel biological production platform.

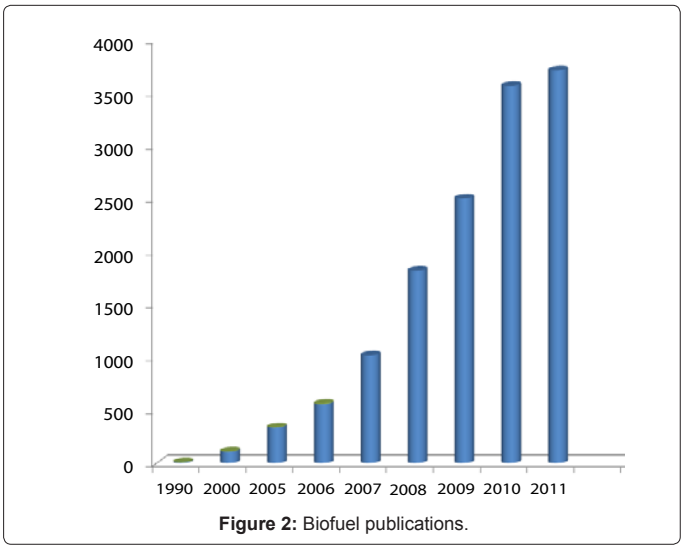

Figure 2: Biofuel publications.

biofuels have been equally impressive. The pyrolysis of woody biomass to biofuels has been given a notable 'boast' as several companies have announced pilot plant/demonstration plants focused on the best current pyrolysis technologies and subsequent upgrading to green diesel/gasoline. Of equal importance, several announcements have recently come about centered on the generation green diesel by the gasification of biomass. As these technologies evolve and become more efficient it will most certainly become more wide-spread. Certainly, there are now numerous academic researchers, innovators and entrepreneurs exploring a broad spectrum of technical solutions to (i) enhance the overall pyrolysis process and simplify subsequent upgrading of pyrolysis oils to green gasoline and diesel, (2) reducing the capital intensity of gasification and (3) improving the efficiency of catalytically converting syn gas to fungible fuels.

In terms of day-to-day biodiesel operations, several commercial operations have succeeded by converting waste cooking oils/fats to biodiesel thereby addressing environmental issues and contributing to today's need for renewable fuels. Alternatively, plant oils are being developed from several plant resources including palm trees, softwoods,

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and jatropha. Although the total volume of fuel from these resources is currently limited on the global scale they can provide technical solutions on a regional scale. Furthermore, research into algae-oils is being aggressively pursued to address the remaining cost-issues with this resource which will release the productivity of this renewable oil resource.

Although some sectors of public opinion have begun to express skepticism towards the development of biofuels, one need only examine how far humankind has come in the development of computers. From the first IBM 701 computer with a total memory of 2048 words of 36 bits each, to today's mobile phone, to see that the revolution in renewable fuels is readily 'do-able'. Based on scientific first principles and the utilization of recent advances in plant/algae science, genomics, green catalytic chemistry, process engineering, nanotechnology, biotechnology, advanced computational modeling and analytical chemistry, we will be able to fulfill the visions of Karl Benz and Henry Ford to propel internal combustion engines with renewable resources.