US–China collaborative biofuel research: towards a global solution for petroleum replacement



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Despite biofuel's potential as an economically and environmentally sustainable alternative to petroleum-based transportation fuel, the transition to biofuels for transportation has yet to be realized because of several major challenges [1]. The key technical barriers for the development of a mature biofuel industry include the availability of sufficient quantities of feedstocks; issues with existing infrastructure compatibility; environmental sustainability concerns; and uncertainty about long-term economic viability, all of which depend on the overall efficiency of converting sunlight to biomass to fuel [1]. For example, the new US Renewable Fuels Standard requires the production of 36 billion gallons of renewable biofuels by the year 2022, of which 21 billion must be advanced biofuels. In order to reach this goal, we will have to produce 4.636 billion GJ liquid fuel energy (using gasoline as the standard). If we were to meet that goal using ethanol produced under current technology, approximately 58.6 million ha, which is approximately 17% of the US total farmland (36% of cropland), would be dedicated to growing the necessary biomass to feed biorefineries. Similarly, the rapid development of emerging economies, such as China and India, has also imposed serious challenges regarding natural resource constraints, both locally and globally. Considering the limited land and the tremendous need for food and fiber for their large populations, it is very unlikely that China and India will be able to dedicate a large proportion of their cropland to bioenergy feedstock production. To ensure that farmland resources are not strained and prime farmland is reserved for growing essential food, feed and fiber crops, overall efficiency must be enhanced for biofuel production so that fuel production per hectare is maximized [1,2]. In addition, proper biofuel production strategies and feedstocks need to be selected and optimized for different regions and countries. The biofuels industry and biomass utilization strategies have to be tailored toward various unique agricultural production systems, transportation infrastructures and socioeconomic structures that

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are emerging in different countries and regions. All of the aforementioned challenges call for international collaborative bioenergy research; in particular, among developed countries with the most the advanced biofuel research and developing countries with tremendous need for petroleum replacement and sustainable economic growth.

Various conferences, organizations and initiatives have been assembled to address the impending needs of collaborative biofuel research in the international community. In particular, a group of scientists from China and the USA held a joint forum on bioenergy research as part of the high profile US–China Relationship Conference in Beijing in October 2009. As a result of the conference and other activities, many collaborative initiatives have been initiated to address several important areas including feedstock improvement, biomass conversion, product processing and utilization. Some of these studies consist of fundamental research to improve the overall biomass to fuel conversion efficiency, whilst others are translational studies to address the regional issues for implementing the lignocellulosic biofuel platforms.

This special focus issue highlights some of the collaborative research that has resulted from the conference and other initiatives for US–China collaborative research. The issue includes research updates in feedstock development and evaluation, biomass conversion platform development, fundamental study for biocatalyst discovery and policy updates for both the USA and China.

From the feedstock perspective, several studies highlight different choices of feedstock suited for various regions. Xue *et al.* present the progress with comprehensive analysis of lignocellulosic biomass feedstock produced in North Dakota, USA, a cold and dry region [3]. This study can help to evaluate the biomass production strategies in northern China with a similar climate or other regions of the Great Plains in the USA. Baxter *et al.* present the potential of winter wheat straw as biomass feedstock for biofuel production in China [4]. This collaborative study will help to establish winter wheat straw and other intercropping feedstock for bioenergy purposes. In addition to the original research, Xin and Wang review sorghum as a potential bioenergy feedstock for broad niches [5]. Owing to the unique drought tolerance and capacity as feedstock for both food and fuel, sorghum has the potential to be widely applied in the southwestern USA and northwestern China. The future collaborative research between the two nations on sorghum will have a profound impact on the implementation of biofuel platforms.

From the conversion perspective, several areas of progress in biomass conversion have been reported. In particular, Du *et al.* report on the development of a consortium of microorganisms for biomass degradation [6]. The utilization of multiple microbes in biomass conversion has been an emerging concept with the potential to revolutionize various biomass conversion platforms. In addition, Ma *et al.* present their recent work of using white rot fungi to pretreat biomass for improving thermoconversion properties [7]. The research integrated biological and thermochemical conversion and provided an alternative route to improve thermoconversion. Two other works are relevant to enzyme discovery and improvement, with one from Shi *et al.* about discovering a new enzyme from grasshopper gut [8] and another from Wu *et al.* about the improvement of a traditional *Trichoderma reesei* strain for cellulase production [9]. Both fundamental studies of enzyme technologies could be used to improve the biomass conversion efficiency and reduce the production cost. Overall, collaborative research between the USA and China is providing the necessary techniques for the emerging biofuel industry in both of the nations and around the world. We believe that the further development of such a collaboration will have a profound impact on sustainable economic growth and environmental stewardship globally.

In addition to the aforementioned articles, two policy updates are also been included in this special focus issue [10,11]. These two updates provide the latest policy and discussion regarding bioenergy development in the USA and China.

Overall, the special focus issue presents some of the latest collaborative bioenergy research between China and the USA, along with policy updates that will impact scientific and industrial development. We believe this collaborative research will both address the impediment needs of higher efficiency for the entire biomass to fuel system and the regional challenges of implementing the latest scientific developments into industrial developments. Realizing that more than just scientific research is needed for a mature biofuel industry in different countries, we encourage each government to adapt a strategy to encourage basic research, intellectual property protection, technology transfer and biofuel subsidies to foster the development of the emerging biofuel industry.

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