ETHANOL PRODUCTION FROM LIGNOCELLULOSIC BIOMASS

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For all kind of applications and especially for those in the transport sector, bioenergy will play a key role in reaching the EU 2020 climate and energy targets, and in contributing up to 14% of the EU energy mix and up to 10% of energy demand in transport. Currently, commercially deployed feedstocks and conversion technologies already provide a significant contribution, but will be not be sufficient to reach these targets. Moreover, with the Renewable Energy Directive (2009/28/EC) and the Fuel Quality Directive (FQD), legal requirements for biofuel sustainability have been introduced in the EU and biofuels have to meet certain criteria to count towards the 10 % goal. Significant R&D and pilot activities have been carried out during the past decade in the EU Member States to enlarge the feedstocks basis with additional sustainable and competitive resources, and to develop processing technologies to deal with a wider feedstock basis. The efforts have focused on enhancing feedstock conversion into valuable energy and co-products, minimizing overall energy consumption and meeting EU sustainability criteria. As a result of the R&D efforts, a wide variety of advanced biofuels conversion technologies already exists, but they are not commercially available yet. This presentation will provide a brief overview of the EU strategy to accelerate the commercial deployment of the technologies to produce second-generation biofuels within the European Strategic Energy Technology Plan. Among second generation biofuels, cellulosic ethanol is one of the most promising technological options available for the near future. Cellulosic ethanol has the potential to perform better in terms of energy balance, GHG emissions and land use requirements as compared to starch-based biofuels. Cellulosic ethanol can be produced from agricultural and forest residues, wood wastes, the organic part of municipal solid wastes (MSW) and energy crops such as energy grasses and short rotation forestry. These lignocellulosic raw materials are more abundant and generally considered to be more sustainable, since they have low or no additional land requirements or impacts on food and fibre production and they can comply with the sustainability requirements of the RES Directive. However, the processing of cellulosic feedstocks into ethanol is more complex than processing sugar- and starch-based crops and it will not become fully commercial nor enter into the market without a significant improvement in technology. The biochemical processes to produce cellulosic ethanol involve the pretreatment of lignocellulosic biomass to increase the accessibility of hydrolytic enzymes and the conversion of cellulose and hemicellulose into bioethanol through a saccharification stage followed by fermentation. The pretreatment step is vital to partially deconstruct the barrier constituted by the strong interactions between polymers of the cell wall, thus allowing the access of depolymerizing enzymes into cellulose. Development of an “ideal” pretreatment process is difficult, given that cellulosic biomass includes very different sources with a different composition. The choice of a pretreatment method is strongly affected by the type of feedstock used. Once the material has been pretreated, it is submitted to the hydrolysis step through the action of specific enzymes called cellulases and hemicellulases. After the enzymatic hydrolysis step, glucose released to the media is fermented by microorganisms, commonly by the Saccharomyces cerevisiae yeast, which is employed in the firstgeneration- ethanol industry. However, the wild type S. cerevisiae has limitations since it is able to ferment glucose coming from cellulose hydrolysis, but unable to metabolize xylose, the main hemicellulose sugar derived from hardwood and agricultural residues, into ethanol. To overcome this drawback, during the last few years, significant effort has been made to develop engineered microorganisms for co-fermentation of pentoses and hexoses. The integration of the different steps along the whole conversion process is one of the most important strategies to improve the conversion efficiency and reduce capital requirements. The Simultaneous Saccharification and Fermentation process, in which the presence of yeasts, together with the cellulolytic enzyme complex, reduces the accumulation of sugars within the reactor, is one of the most promising options so far to increase yields and hydrolysis rates. The Biofuels Unit at CIEMAT has a large experience on developing processes and technologies to produce ethanol from lignocellulosic biomass. In this presentation, a brief summary of R&D activities in the field of pretreatment, enzymatic hydrolysis and fermentation developed recently by CIEMAT will be presented.