

AN INTEGRATED PROCESS FOR TOTAL BIOETHANOL PRODUCTION AND ZERO CO₂ EMISSION

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Increasing oil prices and global concern about climate change motivate the investigation of more efficient means of bioethanol production. An integrated process is proposed in this Thematic Project, aiming to maximize the productivity of bioethanol from sugarcane molasses, bagasse and straw, which give rise to, respectively, first and second generation bioethanol. The Greenhouse Gas carbon dioxide, produced in this two ethanol generations processes, is proposed to be used in the production of a third generation of ethanol, which comes both from algal/bagass biomass and catalytic transformation or biological fermentation of synthesis gas. This challenging integrated process has the major appeal of not emitting carbon dioxide and makes the best of the carbon-containing material for producing ethanol, turning it, when technically and economically feasible, a milestone for improving Brazilian bioethanol competitiveness.

The specific objectives of this project look for ways of turning this integrated process into a technically and economically feasible one, investigating new technologies for each part of processes, covering first, second and third generation aiming anhydrous low bioethanol production. In this way, it will be studied alternative fermentation processes (extractive units), eco-efficient pretreatments as a part of an integrated bioethanol from sugarcane bagasse and straw, development of high-performing enzyme formulations and process techniques of both enzymatic hydrolysis and fermentation, coupled with the development of suitable yeast to ferment sugarcane biomass carbohydrates. In addition, the possibility of microalgae consuming CO₂ from alcoholic fermentation, constituting energy generation cycle with environment protection and production of bioethanol through the synthesis gas, which is obtained from biomass will be investigated. Besides that, multiple effect operation of the distillation columns of the process will be studied in order to reduce steam consumption on reboilers and compared to alternative strategies, including the hybrid ones. The study of alternative entrainers (ionic liquids and hyperbranched polymers) for the extractive distillation process for anhydrous bioethanol production will be carried out. Process modeling and simulation, either of single units or for the large scale plant will be used as a tool for process evaluation and decision taking. Process optimization will be considered to extract the best yield of each routes so that quantitative discrimination will be possible. In any case, methodologies that may be necessary whenever a re-estimation of parameters is required and among other tools software sensors based on Artificial Neural Network will be developed to infer concentrations of biomass, bioethanol and substrate from secondary measurements, such as pH, turbidity and CO₂ flow rate. The global processes evaluation will make use of the experimental data collected in the experiments, industrial data and information and together with process simulation through commercial simulators and tailor made softwares. All the routes will be evaluated in the optimal conditions achieved by a set of suitable optimization algorithms including the deterministic and stochastic based ones.

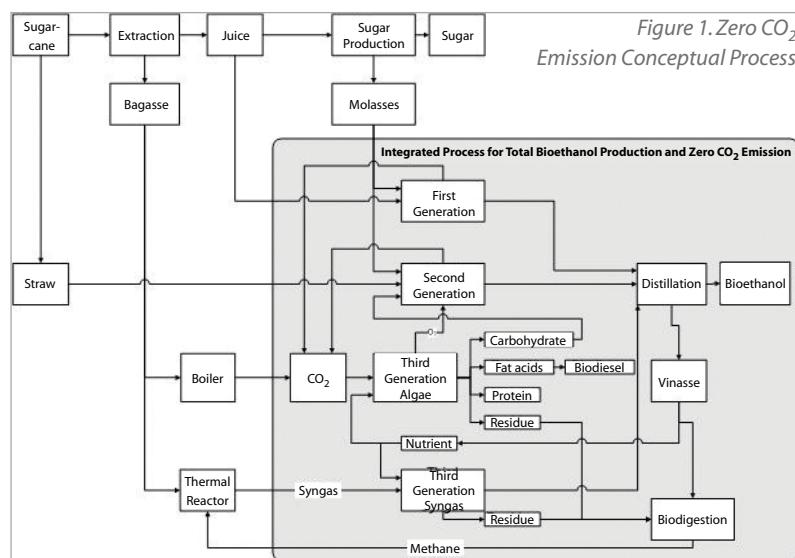


Figure 1. Zero CO₂ Emission Conceptual Process

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

The project proposed concept

This research project aims a totally integrated bioethanol production process, in order to improve the productivity of existing ethanol generation (sugarcane molasse fermentation), the so-called First Generation Bioethanol, to develop suitable processes for improving the Second Generation Bioethanol (from biomasses) and to investigate the viability of the Third Generation Bioethanol, which is produced from algal/bagasse biomass or from catalytical or biological fermentation of synthesis gas. The Third Generation Bioethanol has a major appeal of consuming carbon dioxide produced in the First and Second Generation processes, causing the great impact of almost zero CO₂ emission within the whole integrated process. The improvement of the energy intensive processes that constitute the distillation units are also objective of study in the present project and the proposal of alternatives procedures will be evaluated, including the hybrid configurations. *Figure 1* depicts a schematic diagram of the integrated process for bioethanol production.

Justification expected results

The interest in biotechnology-based production of fuels tends to increase with the concern about exhaustion of fossil fuels and the increase in their price. The world meetings make clear that policies for renewable energy are essential to achieve sustainable development in a broad sense. Environmental protection, job creation, alleviation of external debts in developing countries and security of supply are some of the key issues to mention. In Brazil, the sugarcane industry keeps the greatest commercial energy production in the world with bioethanol and the almost complete use of sugarcane bagasse as fuel. In addition to growing sugarcane and processing it to produce bioethanol and electricity, new biorefineries in Brazil should focus on marketing conventional bioethanol, its associated agricultural assets and co-generation plants, as well as making use of the acquired data and experience to contribute to research aimed at developing next generation biofuels. Thus, it is essential to implement a research program for the integrated production of bioethanol, where studies will be focused on improving the first generation bioethanol, the bioethanol from lignocellulosic feedstocks (second generation bioethanol) and mixed alcohols produced from synthesis gas, Substitute Natural Gas (SNG), and H₂ (third generation bioethanol). Although first-generation biofuels have the potential to replace fossil fuels as the main source of energy supply, its production is surrounded by issues like effects on global food supply and tropical forests destruction. Instead, second and third generation bioethanol offers the advantage of disconnecting the biomass from the food supply. These approaches have a better lifecycle and carbon footprint than sugarcane bioethanol. However, there are challenges and obstacles such as cost, technology and environmental issues that need to be overcome. Hence, the introduction of new processing integrated technologies is crucial in promoting and implementing bioethanol effectively and subsequently turning it in an environmentally, as well as economically, feasible source of energy.

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