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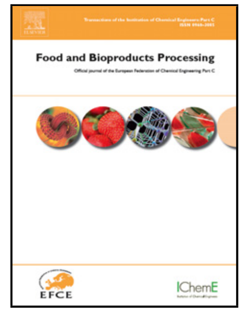

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Environmental Impact Assessment of Lignocellulosic Lactic Acid Production: Integrated with Existing Sugar Mills

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Abstract

Lactic acid (LA) is considered for the diversification and value addition to sugar industry in South Africa, through a bioconversion of sugarcane bagasse and leaves. A bioconversion process was modeled in Aspen Plus® V8.6 and its environmental impacts were evaluated using the Life Cycle Assessment method using SimaPro® considering its integration into existing South African Sugar mills. The life cycle approach took into account the whole sugar production chain, including sugarcane cultivation stage, harvesting and transportation of sugarcane, sugar mill, and LA production. The life cycle inventories of the sugarcane cultivation and sugar mill were obtained from literature while Aspen Plus® simulation data were used for the LA production. The ecoinvent database of SimaPro® was used for all external inputs and fossil-based LA production. Environmental impacts of the biobased and fossil based LA productions were assessed and compared. The total environmental savings of the major impact categories obtained upon replacing a tonne of fossil-based LA with biobased LA are: 3925.65 kg of CO_2 eq. of global warming potential; 1742.05 kg of *fossil fuel* eq. of abiotic depletion potential; 1296.16 kg of 1,4-DB eq. of human toxicity potential; 397.79 kBq U_{235} eq. of ionizing radiation potential; 253.97 kg Fe eq. of metal depletion potential; 43.48 kg of 1,4-DB eq. of marine aquatic ecotoxicity potential; 42.97 kg of 1,4-DB eq. of fresh water aquatic ecotoxicity potential and 18.23 kg of SO_2 eq. of acidification potential. Auxiliary chemicals used in the biobased LA production are most relevant to the total environmental impacts. Thus, biobased LA production has significantly reduced the impact on the environment, giving 80 – 99% environmental savings compared to fossil-derived LA.

Keywords: lactic acid, environmental impacts, lignocellulose, sugarcane bagasse, gypsum free

1. Introduction

The ongoing depletion of petroleum reserves and the associated environmental impacts are driving research to investigate the potential substitution of the current petrochemically derived building blocks with equivalent molecules from renewable resources.[1] Substitution of the existing fossil based economy with a green economy within the framework of sustainable development is one of the challenges of our time. The environmental impacts of the growing demand for petroleum-derived chemicals and fuels can be mitigated by the use of lignocellulosic biochemicals and biofuels. Significant research efforts have been directed to the conversion of such bio-derived feedstocks into chemicals as a means to replace fossil-derived products, mitigate global warming and meet the societal needs for greener products[1]. In this context, lactic acid (LA) has gained significant interest[2]. LA, the simplest hydroxy carboxylic acid is a bulk chemical with two optically active enantiomers (D(-) and L(+)). LA is a platform chemical with wide industrial applications, in the food, chemical, pharmaceutical and health care industries[3,4]. It is primarily used for food and pharmaceutical applications, preferentially the L(+) isomer since it is the only LA isomer produced in the human body[5]. LA can be used as feedstock to generate multiple commodity and intermediate chemicals[2,3,6], such as acrylic acid, 1,2-propanediol, pyruvic acid, acetaldehyde, and 2,3-pentanedione. These LA-based products and

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