

**SUSTAINABLE PROCESS DESIGN OF BIOFUELS: BIOETHANOL
PRODUCTION FROM CELLULOSIC MULTI-FEEDSTOCKS**

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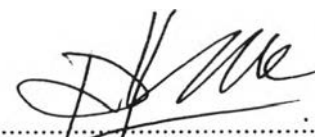
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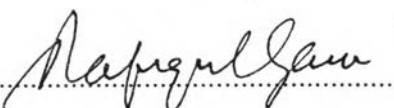
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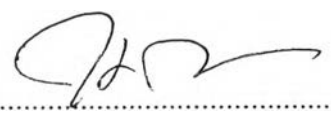

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ABSTRACT

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This research focuses on sustainable process design of ethanol from lignocellulosic biomass in Thailand. Feedstocks used to produce bioethanol are cassava rhizome, corn stover and sugarcane bagasse as they are agricultural residues that are abundantly available, avoid competition with food industries, reduce CO₂ emission because of open burning, and independent of fossil fuel resources. For each feedstock, process design alternative cases were first established. Each case was investigated through a four-part method. The first part dealt with simulation to evaluate different process design alternatives. The second part dealt with economic evaluation in term of, total capital investment, total operating cost, net revenue and so on. The third part dealt with sustainability analysis to analyze three main factors (mass, energy and water usage) in the process and through the analysis identify the process bottleneck. The fourth part dealt with life cycle assessment (LCA) to analyze environmental impacts of the process such as acidification, eutrophication, global warming potential, and else. A sustainability metrics was generated after finishing the four main parts. Results from the studies were divided into two sections, one where each feedstock was considered separately and another where the feedstocks were combined into an optimal mixed feed. Attention was given to the second combined feed option because it enhances long-term security of feedstocks supply for sustainable bio-ethanol production, which is a critical factor for sustainability of biofuels. Finally, alternatives for the combined cases were generated and improved to determine the best sustainable process design.

บทคัดย่อ

คิวนัฐ ชัยรักษ่วงศา : การออกแบบกระบวนการผลิตเชื้อเพลิงชีวภาพอย่างยั่งยืน : การผลิตไบโอเอทานอลจากสารตั้งต้นเซลลูโลซิกหลายชนิด (Sustainable Process Design of Biofuel: Bioethanol Production from Cellulosic Multi-Feedstocks) อาจารย์ที่ปรึกษา : ผศ. ดร. ปมทอง มาลากุล ณ อยุธยา และ ศ. ดร. ราฟีก กานี 214 หน้า

งานวิจัยนี้มุ่งเน้นศึกษาการออกแบบกระบวนการผลิตไบโอเอทานอลจากลิกโนเซลลูโลสในประเทศไทย สารตั้งต้นที่ใช้ในการผลิตไบโอเอทานอล ได้แก่ เหม้ามันสำปะหลัง ต้นข้าวโพด และชานอ้อย เพราะสิ่งเหล่านี้เป็นเศษวัสดุที่เหลือใช้ทางการเกษตรซึ่งมีจำนวนมาก หลีกเลี่ยงการแข่งขันกับอุตสาหกรรมอาหาร ช่วยลดการปลดปล่อยคาร์บอนไดออกไซด์ในการเผาทิ้งสู่บรรยากาศ และช่วยลดการใช้ทรัพยากรจากเชื้อเพลิงซากดึกดำบรรพ์ สำหรับแต่ละสารตั้งต้นจะถูกนำมาใช้ในการสร้างแบบจำลองพื้นฐานสำหรับกระบวนการผลิตไบโอเอทานอล โดยแต่ละกระบวนการจะถูกวิเคราะห์ด้วย 4 วิธีหลัก โดยวิธีแรกเป็นการสร้างแบบจำลองกระบวนการผลิตไบโอเอทานอลเพื่อประเมินรายละเอียดและศักยภาพของกระบวนการผลิตที่แตกต่างกัน วิธีที่สองเป็นการวิเคราะห์เชิงเศรษฐศาสตร์ในส่วนของเงินลงทุนทั้งหมดในกระบวนการผลิต ต้นทุนดำเนินการผลิต รายได้สุทธิ และอื่นๆ วิธีที่สามเป็นการวิเคราะห์ความยั่งยืนโดยประกอบด้วย 3 ปัจจัยหลัก ได้แก่ มวล พลังงาน และน้ำในกระบวนการผลิต และวิเคราะห์ระบุหากระบวนการคอกขวด วิธีที่สี่เป็นการประเมินวัฏจักรชีวิตของผลิตภัณฑ์ เช่น การเกิดฝนกรด การเจริญเติบโตอย่างรวดเร็วของจุลินทรีย์ในแหล่งน้ำ การเกิดภาวะโลกร้อน และอื่นๆ ตารางวิเคราะห์ความยั่งยืนจะถูกสร้างขึ้นเมื่อผ่านกระบวนการวิเคราะห์เหล่านี้ ผลของการศึกษาจะถูกแบ่งออกเป็น 2 ส่วน โดยในส่วนแรกเป็นการวิเคราะห์สารตั้งต้นชนิดเดียว และในส่วนที่สองเป็นการวิเคราะห์สารตั้งต้นหลายชนิดรวมกัน ซึ่งในงานนี้ให้ความสำคัญในส่วนนี้ เพราะการใช้สารตั้งต้นหลายชนิดช่วยเพิ่มความยั่งยืนในกระบวนการผลิตระยะยาว ซึ่งเป็นปัจจัยที่สำคัญสำหรับความยั่งยืนของการผลิตเชื้อเพลิงชีวภาพ โดยการศึกษาจะวิเคราะห์และพัฒนากระบวนการผลิตของสารตั้งต้นหลายชนิดรวมกันเพื่อวิเคราะห์หาความยั่งยืนของกระบวนการผลิตไบโอเอทานอลที่ดีที่สุด

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