

**SUSTAINABLE PROCESS DESIGN FOR BIOMASS-BASED BIOFUEL:
BIOETHANOL PRODUCTION FROM MOLASSES**



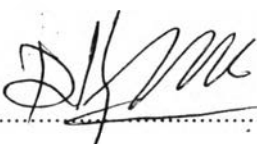
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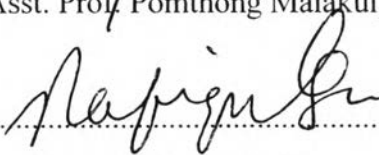
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บทคัดย่อ

นฤพร นารอด : การออกแบบกระบวนการผลิตเชื้อเพลิงชีวภาพจากวัสดุประเภทชีวมวลอย่างยั่งยืน: การผลิตไบโอเอทานอลจากกากน้ำตาล (Sustainable Process Design for Biomass-based Biofuel: Bioethanol Production from Molasses) อ. ที่ปรึกษา: ผศ. ดร. ปมทอง มาลากุล ณ อยุธยา และ ศ. ดร. ราฟีก กานี่ 142 หน้า

งานวิจัยนี้เป็นการพัฒนาสำหรับกระบวนการผลิตเอทานอลจากกากน้ำตาลอย่างยั่งยืน โดยใช้เครื่องมือหลายประเภท ได้แก่ การจำลองกระบวนการผลิต การวิเคราะห์ความยั่งยืน และการประเมินวัฏจักรชีวิต (LCA) โปรแกรม PRO/II 8.2 ได้ถูกนำมาใช้ในการสร้างแบบจำลองพื้นฐานสำหรับกระบวนการผลิตเอทานอลโดยใช้กากน้ำตาลเป็นวัตถุดิบ และใช้โปรแกรมวิเคราะห์ความยั่งยืน SustainPro ในการวิเคราะห์ตัวชี้วัดด้านความยั่งยืน เพื่อนำมาหาแนวทางปรับปรุงแบบจำลอง จากนั้น จึงใช้เทคนิคการประเมินวัฏจักรชีวิตเพื่อประเมินผลกระทบต่อสิ่งแวดล้อมด้วยโปรแกรม SimaPro 7.0 และวิธี CML 2 baseline 2000 โดยมุ่งเน้นที่ผลกระทบด้านภาวะโลกร้อน จากผลการวิเคราะห์ของโปรแกรม SustainPro แบบจำลองทางเลือกใหม่จำนวนสี่แบบได้ถูกสร้างขึ้นทั้งในเชิงกระบวนการและเชิงประสิทธิภาพการใช้พลังงาน ในทางเลือกที่หนึ่งคือ การสร้างสายรีไซเคิลเพื่อพยายามเพิ่มการผลิตเอทานอลให้มากขึ้น ทางเลือกที่สองคือ การนำเซลลูโลสที่ยังไม่ถูกแปรรูปมาใช้เป็นเชื้อเพลิง ส่วนทางเลือกที่สาม ได้นำเซลลูโลสที่ยังไม่ถูกแปรรูปมาใช้เป็นวัตถุดิบในการผลิตไบโอเอทานอลด้วยกระบวนการไพโรไลซิส และทางเลือกสุดท้ายคือการนำเซลลูโลสที่ยังไม่ถูกแปรรูปมาใช้เป็นวัตถุดิบในการผลิตไฮดรอกซิลเมทิลเฟออร์ฟูรัล สำหรับการผลิตพลาสติก โดยทำการเปรียบเทียบระหว่างแบบจำลองพื้นฐานกับแบบจำลองทางเลือกต่างๆ เพื่อแสดงให้เห็นว่าการปรับปรุงกระบวนการให้ยั่งยืนขึ้นเพียงใด ผลการศึกษาแสดงให้เห็นว่าแบบจำลองทางเลือกที่หนึ่งมีอัตราผลตอบแทนมูลค่าเพิ่มทางเศรษฐกิจสูงที่สุด แต่ก็มีการปลดปล่อยก๊าซเรือนกระจกเพิ่มขึ้นเช่นกัน ในทางตรงกันข้าม ทางเลือกที่สองไม่เพียงแต่จะช่วยเพิ่มมูลค่าทางเศรษฐกิจ แต่ยังช่วยลดผลกระทบต่อสิ่งแวดล้อมได้มากที่สุดอีกด้วย เนื่องจากสามารถช่วยลดการใช้พลังงานโดยรวมของระบบลงได้อย่างมาก

ABSTRACT

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This work developed a sustainable process of bio-ethanol production from molasses by using various tools including process simulation, sustainability analysis, and life cycle assessment (LCA). The process simulator, PRO/II 8.2, was used to generate the base case design of the bio-ethanol conversion process using molasses as a feedstock. The sustainability analysis software, SustainPro, was then used to analyze relevant indicators in the sustainability metrics, which were further employed to provide directions for improvements. Lastly, evaluation of the life cycle environmental burdens associated with the bio-ethanol production was performed by using LCA software, SimaPro 7.0 with CML 2 baseline 2000, focusing on GWP. Based on SustainPro results, four design alternatives had been generated for possible improvement in term of energy efficiency. In Alternative 1, the ethanol production was enhanced by using recycle process stream. In Alternative 2, unconverted cellulose in molasses was used as a fuel in the process. In Alternative 3, unconverted cellulose was used to produce bio-oil via pyrolysis. Lastly, Alternative 4, unconverted cellulose was used to produce hydroxymethyl furfural (HMF). Comparing to the base case design, the results show that Alternative 1 yields the highest economic value added but the environmental impact also increases. In contrast, Alternative 2 not only helps increase the economic value added but also lowers the environmental impact due to the overall reduction in energy used in the process.

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