การผลิตไบโอดีเซลจากไขมันในน้ำเสียของโรงงานอุตสาหกรรม ผลิ ตและแปรรู ปอาหารทะเล

Production of Biodiesel from Waste Fat in Waste Water of Marine product Processing Plant

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บทคั ดย่ อ

งานวิจัยนี้ เป็นการศึกษาการผลิตไบโอดีเซลจากไขมันในน้ำเสียของโรงงานอุตสาหกรรมผลิตและแปรรูปอาหารทะเล ที่มีปริมาณกรดไขมันอิสระประกอบอยู่สูง ถึง 70-85 เปอร์เซ็นต์ โดยใช้กระบวนการผลิตไบโอดีเซลแบบสองขั้นตอน ขั้นตอนแรกใช้กระบวนการเอสเทอริฟิเคชั่นโดยใช้กรดซัลฟิวริก เป็นตัวเร่งปฏิกิริยาระหว่างกรดไขมันอิสระ กับเมทานอล จนปริมาณกรดไขมันอิสระมีค่าต่ำกว่า 2 เปอร์เซ็นต์ และขั้นตอนที่สองคือกระบวนการทรานส์เอสเทอริฟิเคชั่น โดยนำผลิตภัณฑ์จากขั้นตอนแรกมาทำปฏิกิริยากับเมทานอลต่อโดยใช้ไพแทสเซียมไฮดรอกไซด์ เป็นตัวเร่งปฏิกิริยา และได้ผลิตภัณฑ์เป็นเมทิลเอสเทอร์ จากการทดลองพบว่า ขั้นตอนแรกของกระบวนการเอสเทอริฟิเคชั่น ใช้อัตราส่วนโดยโมลของ เมทานอลต่อไขมันเท่ากับ 10: 1 ความเข้มข้นของกรดซัลฟิวริกเท่ากับ 3 เปอร์เซ็นต์โดยเทียบกับน้ำหนักไขมัน และเวลาในการทำปฏิกิริยาเท่ากับ 240นาที ส่วนในขั้นตอนที่ 2 ใช้กระบวนการทรานส์เอสเทอริฟิเคชั่น โดยใช้ไพแทสเซียมไฮดรอกไซด์เป็นตัวเร่งปฏิกิริยาที่ความเข้มข้น 1.5 เปอร์เซ็นต์โดยน้ำหนัก อัตราส่วนโดยโมลของเมทานอลต่อผลิตภัณฑ์ที่ได้จากขั้นตอนที่ 1 เท่ากับ 6::1 ระยะเวลาในการทำปฏิกิริยาเท่ากับ 30 นาที สามารถสังเคราะห์ไบโอดีเซลได้บริสุทธิ์ สูงสุด 67.0 เปอร์เซ็นต์ ไบโอดีเซลที่ได้เมื่อทดสอบคุณสมบัติตามมาตรฐานไบโอดีเซลชุมชนพบว่าผ่านเกณฑ์ตามมาตรฐาน ASTM ที่กำหนดไว้

Abstract:

This research was to study the waste fat in waste water from sea food processing plants as the raw material for biodiesel production. Due to high free fatty acid content(about 70-85%), two-step process reaction was required. The first step was esterification using sulfuric acid as a catalyst to reduce free fatty acid from 70-85 percent to lower than 2 percent. In the second step, transesterification, potassium hydroxide was applied as a catalyst in the reaction between the product from the first step and methanol . The optimum conditions for the esterification step were 10:1 molar ratio of methanol to oil, 3 percent of sulfuric acid by weight on fat and 240 minutes of reaction time. The optimum conditions for the transesterification step were 1.5 percent by weight of catalyst, 6:1 molar ratio of methanol to the product from the esterification step and 30 minutes of reaction time. The maximum purity of biodiesel was 67.0 percent. The quality of biodiesel passed the standard community biodiesel follow ASTM standard.

Introduction: Biodiesel is a renewable fuel. It is produced from high quality food grade vegetable oil which makes biodiesel more expensive than diesel fuel. Therefore,a low cost feedstock is needed. The waste fat from a grease tap of a waste water treatment plant for marine production plants is considered as an available feedstock to produce biodiesel in this study. Due to high free fatty acid (FFA) content in waste fat, alkali is used as a catalyst in transesterification to produce biodiesel, which gives low biodiesel yield because FFA reacts with alkali to form soap, resulting emulsification and separation problems. To resolve these problems, acid catalyst has been used as a pretreatment step. Sulfuric acid is the most commonly used catalyst. The optimization of pretreatment reaction was investigated with sulfuric acid dosage to reduce FFA content to below 2%. Alcohol molar ratio and reaction time were also studied. The transesterification reaction is carried out with an alkali catalyst to investigate the optimum dosage of potassium hydroxide, methanol molar ratio and reaction time. Biodiesel quality will be evaluated according to ASTM standard for community biodiesel.

Methodology:

1. Pretreatment

Waste fat from grease tap → Filtration → Dehydration at 110ºC → Extraction with methanol 1:1 (V/V) → Vacuum filtration → Alcohol evaporation → Raw material for biodiesel production

2. Esterification

Raw material from pretreatment step, Methanol mixed with Sulfuric acid → Esterification reactor → Separation → Methanol /water; Methyl ester / oil with free fatty acid<2%

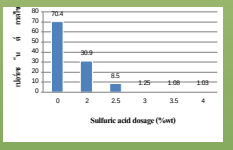
3. Transesterification

Product from esterification step, Methanol mixed with potassiumhydroxide → Transesterification reactor → Separation → Evaporation → washing → Dehydration → Biodiesel

4. Quality Analysis

Results and Discussion :

The initial content of FFA of the waste fat in this study was 70.14% . Esterification process ,the FFA content decreases with increasing sulfuric acid dosage ,as shown in Figure 1. The reaction was controlled at a constant stirring speed of 500 rpm., a constant temperature of 60 ºC, a reaction time of 4 hr. and molar ratio of methanol to fat 10:1.The optimum dosage of sulfuric acid was found at 3.0 % w/w. Different molar ratios, 6:1, 8:1, 10:1 and 12:1 were tried for acid esterification. The FFA got lowered to maximum extent using molar ratio of 10:1 which resulted in maximum %conversion as shown in Figure 2. When varied the reaction time, the optimum reaction time for the waste fat in this study was 4 hr.The FFA was decreased to 1.25% and get maximun %conversion to FAME at 88.44% as shown in Figure 3.The summarized result of optimum conditions of the esterification step for the waste fat in this study were 3.0% w/w of sulfuric acid, 10:1 of molar ration and 4 hr.of .reaction time. This condition can decrease %FFA from 70.14% to 1.25% and get maximum %conversion to FAME at 88.44 % .



Figuer 1 Influence of catalyst dosage during acid esterfication on FFA(%)

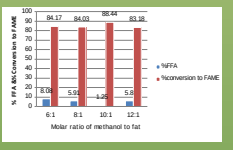


Figure 2 Influence of molar ratio of alcohol to fatty acids during acid esterification on %FFA and %conversion toFAME

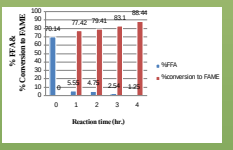


Figure 3 Influence of reaction time during acid esterification on %FFA and %conversion to FAME

Alkaline catalyzed transesterification process was further studied by using a pretreated product from the esterification step that had an FFA content of 1.25%. Potassium hydroxide was used as catalyst at different dosages range 0.5 to 3.0%,molar ratios of methanol to the product from the esterification step of 6:1, 10:1, 15:1, 20:1, 25:1, 35:1 and 40:1. and a different reaction time of 30-120 minutes. The result showed that catalyst dosage of 1.5% w/w gave maximum 67%FAME as shown in Figure 4. The further experiment with molar ratio as shown in Figure 5. It show that the molar ratio was not a significant effect on %FAME (2.6% difference) . The effect of different reaction time of 30-120 min. was also not a significant effect to % FAME as shown in Figure 6. The summary optimum conditions of transesterification process were 1.5 % of catalyst dosage, 6:1 of molar ratio of methanol to the product from the esterification step, reaction time of 30 min at temperature of 60˚C and the reaction stirring speed of 500 rpm. The color of biodiesel turned from dark to brown color after transesterification step.

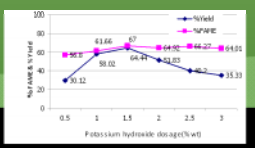


Figure 4 Influence of catalyst dosage During alkaline transesterfication on % FAME and %Yield

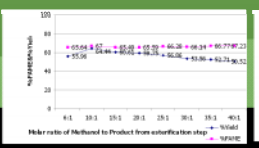


Figure 5 Influence of molar ratio during alkaline transesterfication on % FAME and %Yield.

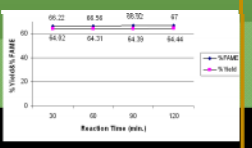


Figure 6 Influence of reaction time during alkaline transesterfication on %FAME and %Yield

Raw material: Waste fat from grease trap

Biodiesel before and after washing

The comparison of biodiesel quality with ASTM standard for community biodiesel passed the criteria of ASTM standard as shown in Table 1

Table 1 Properties of biodiesel from waste fat of marine products processing plant compared to ASTM standard for community biodiesel.

Properties	Unit	Biodiesel from waste fat	ASTM criteria
Kinematic viscosity (40˚C)	mm^2s^{-2}(cst)	5.81	1.9-8.0
Acid number	$mgKOHg^{-1}$	0.80	<0.8
Flash point (closed cup)	˚C	164	<120
Water and sediment	%volume	0.05	<0.2
Total glycerine	%wt	0.08	<1.50

Conclusion :

Waste fat from waste water of marine products processing plant can be a possible feedstock for production of community biodiesel. Acid esterification followed by alkaline transesterification was necessary as the waste fat has been found to possess high free fatty acid content of 70.14%. Molar ratio of alcohol to oil of 10:1, 3% w/w of sulfuric acid, reaction time of 4 hr. at 60˚C and 500 rpm of stirrer speed were optimum conditions to bring down the free fatty acid to below 2 % The optimum conditions of alkaline transesterification process were 1.5% of potassium hydroxide as catalyst, molar ratio of methanol to the product from the esterification step of 6:1, reaction time of 30 min. at 60˚C temperature and 500 rpm of stirrer speed. The final product bears viscosity of 5.81 cst at 40˚C , acid value of 0.8 mg KOH/g , flash point 164˚C and water and sediment 0.05% which conform to ASTM standard of community biodiesel.

Acknowledgement:

This study was financial supported by energy conservation promotion fund, Energy policy and Planning office, Minnistry of Energy, Thailand (2009)

Reference :

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