

2014

Research Brief: Applying Green Chemistry Principles Towards the Sustainable Synthesis of Biodiesel from Waste Vegetable Oil

Brandon Ackley

Follow this and additional works at: http://vc.bridgew.edu/undergrad_rev



Part of the [Chemistry Commons](#)

Recommended Citation

Ackley, Brandon (2014). Research Brief: Applying Green Chemistry Principles Towards the Sustainable Synthesis of Biodiesel from Waste Vegetable Oil. *Undergraduate Review*, 10, 9-11.

Available at: http://vc.bridgew.edu/undergrad_rev/vol10/iss1/7

Research Brief: Applying Green Chemistry Principles Towards the Sustainable Synthesis of Biodiesel from Waste Vegetable Oil

BRANDON ACKLEY

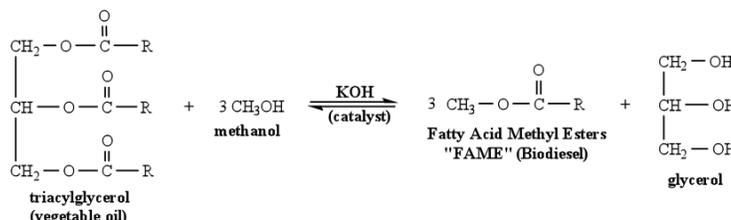


Brandon Ackley is a junior Chemistry major with a concentration in professional chemistry.

Brandon began doing research in the summer of 2011 as part of the STREAMS (STudent REtention Across Mathematics and Science) Summer Bridge program. STREAMS invites 16 incoming freshman in the STEM field to participate in 3 weeks of intensive class and research work. Brandon conducted this research under the mentorship of Dr. Edward Brush (Chemistry) with funding from a 2013 Adrian Tinsley Program summer research grant. Brandon presented this research at the 247th American Chemical Society National Convention in Dallas, TX.

In 2011, the U.S. consumed over 18 million barrels per day of refined petroleum products and biofuels; almost 22% of global petroleum consumption.¹ This includes oil used for transportation, electricity, and production of consumer products. More than half of this oil was imported from foreign countries, and in his 2006 State of the Union Address President Bush warned that, “We have a serious problem, America is addicted to oil, which is often imported from unstable parts of the world.”² With the need for new energy sources more apparent than ever, serious research is needed to further the advancement of alternative fuels, so that they may become a more practical source of energy. Biodiesel is an alternative fuel to petroleum diesel, and is produced from renewable and/or recycled resources. Biodiesel’s benefits include reduced emissions of unburned hydrocarbons, carbon monoxide, particulate matter and nitrogen oxides, plus reduction of greenhouse gas emissions.³ The process of making biodiesel involves transesterification of triacyl-glycerides in Waste Vegetable Oil (WVO) with methanol, using potassium hydroxide (KOH) as a catalyst, Figure 1.^{4,5,6}

Figure 1. Traditional Transesterification Reaction of Vegetable Oil into Biodiesel.



Research in Dr. Brush’s group has focused on developing an efficient and cost-effective process for converting 50 liter (13 gallon) batches of Waste Vegetable Oil (WVO) from BSU cafeterias into biodiesel fuel for campus use. However, in a detailed analysis of our efficiency in producing biodiesel by this traditional process, we found that this “simple” transesterification reaction is only one small part of a complex, inter-related, and inefficient overall production process.

dium borate as transesterification catalysts, and analyzed these reactions using Nuclear Magnetic Resonance spectrometry (NMR). Figure 3 illustrates the NMR from our traditional synthesis and purification of biodiesel (Figure 1), and our general reaction conditions are given in the legend.

Although NMR analysis of our small scale reactions using either boric acid or sodium borate did show the biodiesel signals seen in Figure 3, we also observed a substantial amount of unreacted WVO, suggesting that neither of these compounds were effective catalysts for transesterification with methanol, either on their own or when added in combination with KOH catalyst. Sodium borate gave the most encouraging results as NMR analysis suggested a very slow, continuous formation of biodiesel product; however, the reaction did not go to completion. Our conclusion from this preliminary work is that neither boric acid or sodium borate would be suitable catalysts for WVO transesterification.

We did notice that the NMR spectra from these experiments indicated very little contaminating glycerol, implying that boric acid and sodium borate might have potential for purifying biodiesel. Boric acid in particular may improve the efficiency of the water wash by: (1) KOH neutralization, and (2) glycerol extraction. We are following up on this idea by evaluating the effect of KOH-borate additives on the reaction equilibrium, and the effectiveness of acidic washing using aqueous boric acid.

Future Work:

In order to complete our evaluation of the effects of boron compounds on biodiesel production efficiency, we are conducting a more detailed assessment of sodium borate as a chemical additive (with KOH) to help push the equilibrium reaction to completion by removing the glycerol byproduct. We will also follow up on our preliminary results suggesting that boric acid increases the efficiency of the water wash of crude biodiesel by both neutralizing the KOH catalyst and binding the glycerol byproduct.

Acknowledgements:

I would like to thank Dr. Edward Brush for helping me through every step of this project, and the Adrian Tinsley Program and Center for Sustainability for funding this research.

Literature Cited:

¹Independant Statistics and Analysis, *The U.S. Energy Information Administration* (EIA), <http://www.eia.gov/> (accessed March 2014).

²President Bush's State of the Union Address, *The Washington Post*, January 31, 2006, <http://www.washingtonpost.com/wp-dyn/content/article/2006/01/31/AR2006013101468.html> (accessed March 2014).

³Kemp, W.H., *Biodiesel Basics and Beyond: A Comprehensive Guide to Production and Use for the Home and Farm*, Aztext Press, 2006.

⁴Behnia, M.S., Emerson, D.W., Steinberg, S.M., Alwis, R.M., Dueñas, J.A. and Serafino, J.O. (2011), "A Simple, Safe Method for Preparation of Biodiesel," *J. Chem. Educ.*, 88(9):1290–92.

⁵Kulkarni, M.G. and Dalai, A.K. (2006), "Waste Cooking Oils-An Economical Source for Biodiesel: A Review," *Industrial and Engineering Chemistry Research*. 45: 2901-13.

⁶Agnew, R., Chai, M., Lu, M. and Dendramis, N. (2009), "Making Biodiesel from Recycled Cooking Oil Generated in Campus Dining Facilities," *Sustainability: The Journal of Record*, 2(5): 303-7.

⁷Anastas, P. T.; Warner, J. C. *Green Chemistry: Theory and Practice*; Oxford University Press: Oxford [England]; New York, 1998.

⁸Kondaiaha, G.C.M., Reddy, L.A., Babu, K.S., Gurav, V.M., Hige, K.G., Bandichhor, R., Reddy, P.P., Bhattacharya, A. and Anand, R.V. (2008), "Boric Acid: An Efficient and Environmentally Benign Catalyst for Transesterification of Ethyl Acetoacetate," *Tetrahedron Letters*, 49: 106-9.