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Life cycle assessment of dewatering routes for algae derived biodiesel processes

Daniel O'Connell · Mariano Savelski · C. Stewart Slater

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Abstract Biodiesel derived from algae is considered as a sustainable fuel, but proper downstream processing is necessary to minimize the environmental footprint of this process. Algae is grown in dilute liquid cultures, and achieving the low water contents required for extraction represents one of the greatest challenges for the production of algae derived biodiesel. An analysis of the life cycle emissions associated with harvesting, dewatering, extraction, reaction, and product purification stages for algae biodiesel were performed. This "base case" found 10,500 kg of total emissions per t of biodiesel with 96 % of those attributed to the spray dryer used for dewatering. Alternative cases were evaluated for various sequences of mechanical and thermal dewatering techniques. The best case, consisted of a disk-stack centrifuge, followed by the chamber filter press, and a heat integrated dryer. This resulted in 875 kg emissions/t of biodiesel, a 91 % reduction from the base case. Significant reductions in life cycle emissions were achieved for all mechanical dewatering alternatives compared to the base case, but further improvements using these existing technologies were limited. Additional improvements will require the development of new techniques for water removal or wet extractions.

Keywords Microalgae · Dewatering · Biodiesel · Life cycle assessment · Algal biofuel

D. O'Connell (✉) · M. Savelski · C. S. Slater
Rowan University, Glassboro, NJ 08028, USA
e-mail: oconne55@gmail.com

Introduction

The manufacture of biodiesel from algae feedstock has become an important issue due to the increased demand for alternative fuels. Algae have several advantages over other renewable feed stocks. They can naturally mitigate CO_2 and unlike sourcing biofuels from crops, algae do not compete for the use of arable land (Chisti 2007). Algae can also be used as a feedstock to produce other fuels such as ethanol, hydrogen, and methane (Wang et al. 2008, Sialve et al. 2009, Collet et al. 2011). They are adaptable, have the ability to multiply rapidly, and contain a high oil content making it a feasible feedstock in the production of biodiesel (Chisti 2007). Species, such as *Schizochytrium* sp. and *Botryococcus braunii,* can have high lipid contents of up to 70 wt% oil (Chisti 2007, Mata et al. 2010). This oil is composed mostly of triacylglycerides (TAGs), which can be processed into biodiesel and further blended into conventional diesel fuel, lessening the burden on petroleum derived liquid fuels. (U.S. DOE 2010).

The algae biodiesel process begins with algae cultivation, followed by harvesting to separate the algae from the water. The TAGs are then extracted from the biomass and reacted to break down into fatty acid methyl esters (FAMEs), which are high energy content carbon chains with properties similar to those of diesel fuel. Converting an algae feedstock into biodiesel is energy intensive, which in turn contributes to the carbon footprint and emission of greenhouse gases. As a result, it is unknown whether algae derived biodiesel is environmentally efficient from an energy usage viewpoint. Life cycle assessments (LCAs) provide information which goes into the decision-making process of determining the most environmentally effective production route for algae derived biodiesel.