Feasibility and Practices of Making Biodiesel Out of Low-Quality Greases

by Qingshi Tu, Jingjing Wang, Mingming Lu, Ming Chai, and Ting Lu

One of the few commercialized alternative energy forms, biodiesel consists mainly of methyl esters derived from a variety of plant oils, animal fats, and recycled cooking oils with the transesterification process.[1,2] Biodiesel is renewable, domestically produced, and generates lower emissions of carbon monoxide (CO) and particulate matter (PM) compared to traditional fuels. For the biodiesel industry, 50–80% of the cost lies in the cost of the feedstock, which has motivated the search for low-cost feedstocks such as various oil-containing wastes.

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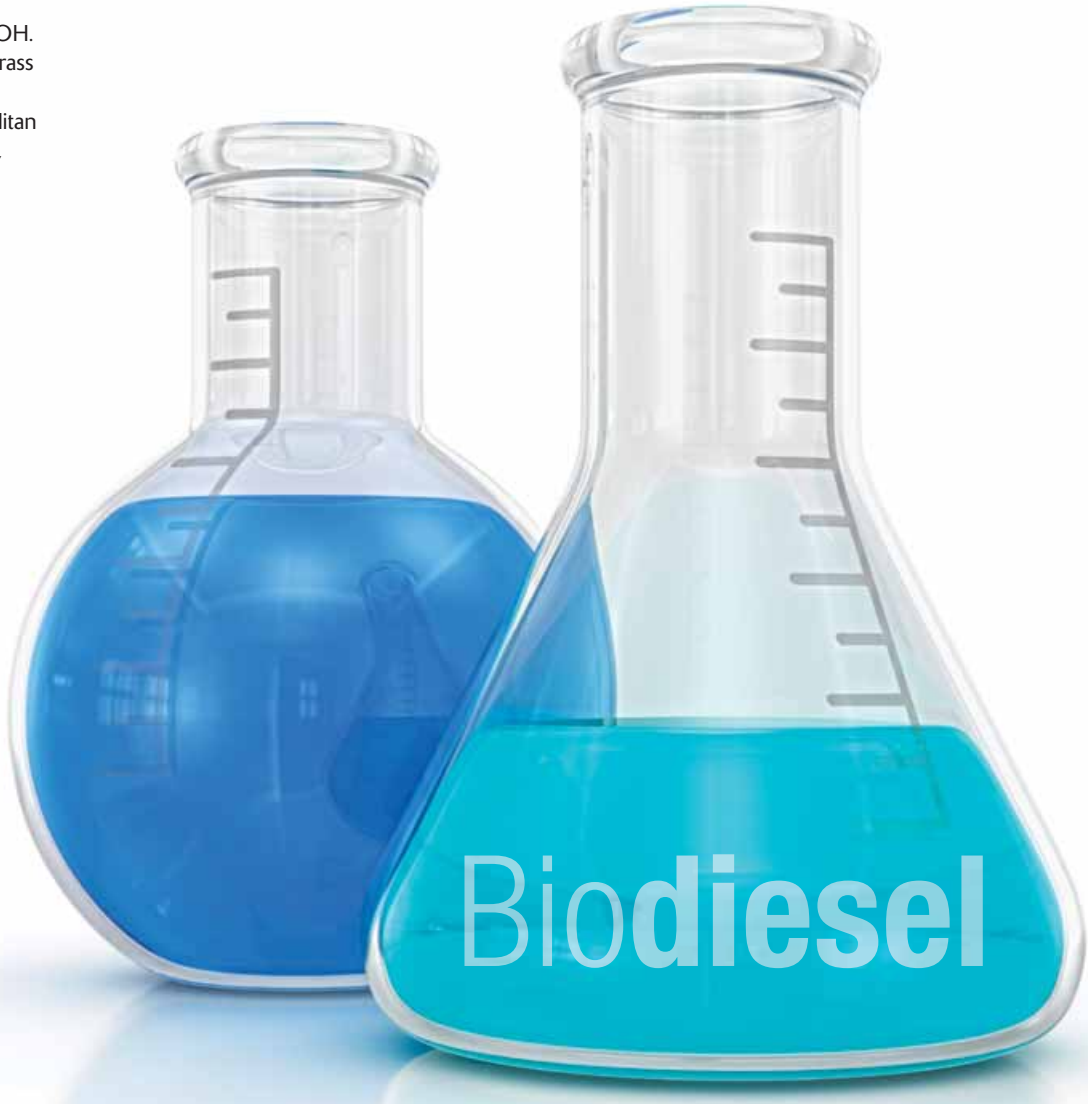

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While waste cooking oil and animal fats have already been accepted as biodiesel feedstocks, trap grease and municipal sewage sludge have yet to be fully exploited. According to a U.S. Department of Energy (DOE) study, the amount of trap grease generated annually in the United States is approximately 13.37 lb/person,[3] or (potentially) 495 million gallons of biodiesel.

Trapping the Grease

The terms trap grease and brown grease are used interchangeably. Brown grease, a term from the waste oil rendering industry, describes waste oil with a free fatty acid (FFA) concentration of 15–50%, while trap grease loosely refers to the mixture of fat, oil, and grease (FOG), water, and solids that comes from the grease trap of commercial food services.

A 2009 report by the U.S. Environmental Protection Agency (EPA) showed that 47% of sewer line blockages are related to FOG.[4] Most municipalities have coordinates that prevent the illegal dumping of FOG from commercial food sources, which is one of the major causes of pipe clogging. Restaurants and other food services should have a grease trap that separates grease from wastewater before discharging to the public sewers (see Figure 1). Periodically, the trapped grease is pumped by a specialized company at a cost to the restaurant and sent to wastewater treatment plants for disposal. Typically, the trapped grease is then incinerated, anaerobically digested, or landfilled. No regulations have been imposed for household cooking. Due to the cost involved in pumping and landfilling, trap grease has long been considered as a burden.

In the Metropolitan Sewer District of Greater Cincinnati (MSDGC), trap grease goes through primary treatment process and stays in the holding tank until it goes to landfill (see Figure 2). MSDGC is a Hamilton County-owned sewer district collecting and treating 192 MGD of wastewater by operating seven major treatment plants and serving a community of more than 800,000 people. There are over 1,000 restaurants throughout the county and MSDGC receives approximately 10,000,000 gallons of grease trap discharge annually. MSDGC's charge of $50 per 1,000 gallon of trap grease is much lower than the cost of treatment and disposal.

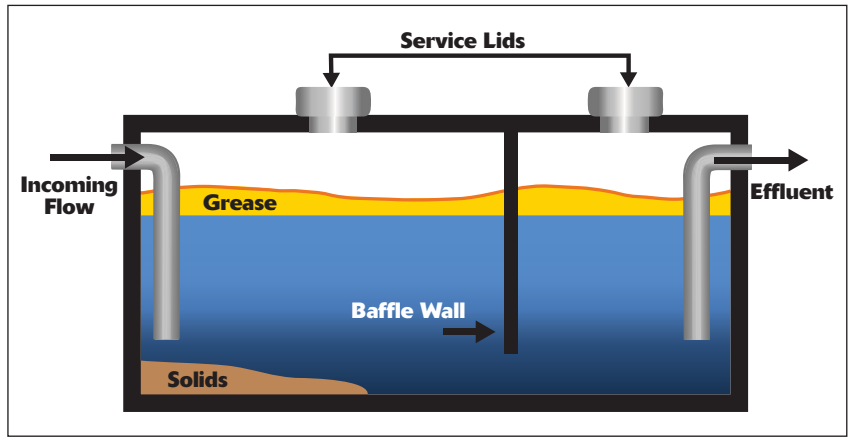

Figure 1. Grease trap demonstration.

There are several technical challenges in making biodiesel from trap grease, including much higher impurity and FFA contents than "traditional" waste cooking oil from commercial kitchens. Heterogeneous in nature, the composition of trap grease varies greatly from case to case. For example, the trap grease from steak houses may have much higher fatty acids than those from french fry operations. Generally, the largest portion of contaminants include water and solid impurities such as food residues, kitchen trash, and other solids.[5] Another practical issue is the quantity of the feedstock: do we have a continuous supply of trap grease?

Current Practices for Converting Trap Grease to Biodiesel

One possibility is to integrate trap grease into the existing biodiesel manufacturing process, since many of the facilities can already handle "multi-feedstock" and have pretreatment capabilities; another possibility is to build a standalone biodiesel facility dedicated for trap grease, such as at the site of a wastewater treatment plant.

The City of San Francisco has taken the lead by using trap grease-generated biodiesel to power diesel equipment.[6] The facility can convert 10,000 gallons of restaurant trap grease daily into biodiesel with a 3% overall conversion rate. Its grease recycle program (SFGreasecycle) was developed in collaboration with commercial biodiesel companies BlackGold Biofuels, URS, and Pacific Biodiesel Inc., under the financial support from DOE.

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This project demonstrated the effectiveness of co-locating a biodiesel conversion facility within a wastewater treatment plant in terms of waste minimization and reduced petroleum fuel consumption. In addition, the economic analysis of this study highlights the monetary benefits of biodiesel production from trap grease (potential revenue of $1,525,000/yr).

Elsewhere, engineering company H2O'C has partnered with BlackGold to conduct a feasibility study of recovering and utilizing FOG from urban sewage for biodiesel production under the grant from Missouri Department of Natural Resources.[7] The study focuses on the FOG collected in the domain of Kansas City and St. Louis and with the expected outcome of a roadmap for the other communities to capture and reuse the FOG wastes.

In addition, biodiesel manufacturers have also started commercializing trap grease biodiesel. For example, Biodiesel International AG (BDI) has built a 100,000 t/yr plant in Hong Kong to convert multiple feedstocks, including trap grease, into biodiesel. While in 2010, Piedmont Biofuels commissioned the first enzymatic biodiesel plant in the United States capable of dealing with up to 100% FFA in oil and tolerating a certain degree of trace moisture in the feedstock.

Making biodiesel from trap grease offers the dual benefits of waste reduction and alternative fuel production.

The Technology in Brief

In order to separate the oil portion from the bulk impurities, pretreatment is necessary. The next step is the extraction of the oil content, which sometimes is done by the rendering companies. To date, there have been very few technical reports on how to make biodiesel from trap grease, especially regarding the feedstock pretreatment.

Called "the enemy in making biodiesel," water content is very undesirable for the conventional alkali transesterification reactions, as it can result in soup formation. However, most trap grease has considerable moisture content. As an example, the moisture content for the trap grease sample the authors received ranged from 47.1 to 74.5%. A quick solvent extraction (e.g., with *n*-hexane) and gas chromatography-mass spectroscopy analysis indicated that the trap grease contained mainly C16 and C18 FFA with minor quantities of triglycerides. We consulted an expert, who confirmed that this content was typical of trap grease.

FFA is considered detrimental to the alkaline-catalyzed biodiesel conversion. FFA can react with the alkaline catalyst, such as (e.g., NaOH) to form soap, which will not only reduce biodiesel yield, but also result in poor separation of biodiesel and glycerine. Typically, an FFA level of less than 0.5–1% is

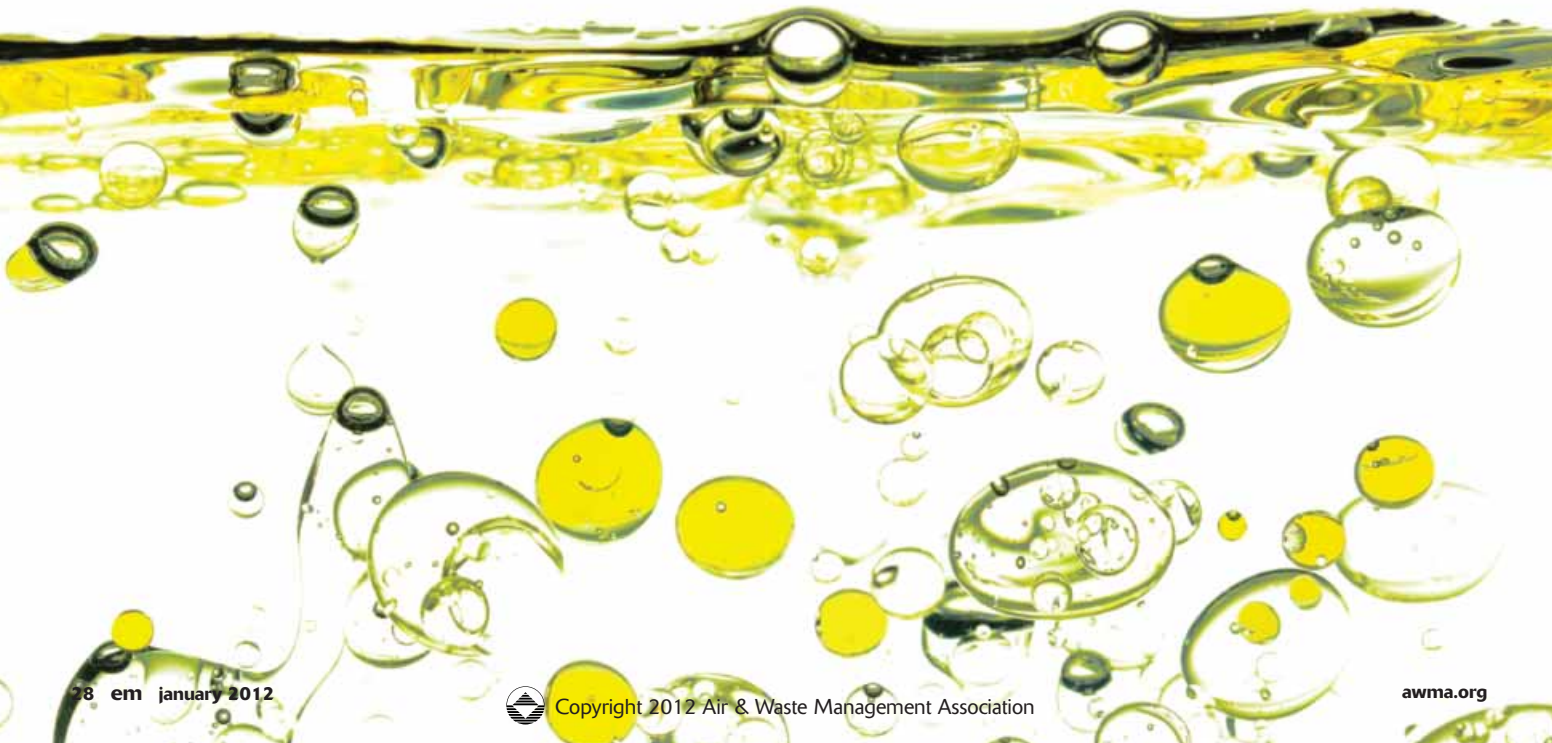

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Figure 2. Trap grease from restaurant grease traps (left) and municipal sewage sludge from the skimmers of the primary settling tanks in Metropolitan Sewer District of Greater Cincinnati (right).

preferred for the alkaline process.[8-10] A pretreatment step is usually required to lower the FFA level to an acceptable range when working with high FFA feedstocks, such as waste cooking oil, animal fats, and palm oil. The most widely adopted method for removing the FFA is to convert it into esters by acid catalytic esterification.[10] Alternatively, the glycerolysis and enzymatic process can also be considered. Glycerolysis converts FFA into monoglycerides and the required high temperature (approximately 200 °C) eliminates the water removal step.

Chakrabarti et al.[11] conducted both bench- and pilot-scale studies on biodiesel production from trap grease. The process successfully produced biodiesel meeting all ASTM specifications, except for the sulfur content.

Summary

Making biodiesel from trap grease offers the dual benefits of waste reduction and alternative fuel production. The awareness and practices of using trap grease to make biodiesel have been steadily increasing. Technical challenges exist, especially since trap grease has been traditionally handled as a waste and a burden without much care, which has affected the feedstock quality. However, with the increased demand on the feedstock market, it is reasonable to expect that trap grease will attract more attention as a less expensive alternative to plant oils and recycled cooking fats. **em**

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