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Procedia Engineering 42 (2012) 634 – 643

Procedia Engineering

www.elsevier.com/locate/procedia

20th International Congress of Chemical and Process Engineering CHISA 2012
25 – 29 August 2012, Prague, Czech Republic

Evaluation of different sludges from WWTP as a potential source for biodiesel production

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Abstract

Biodiesel expansion is currently limited due to high raw material costs for its production. The potential of using sludge from municipal wastewater treatment plants as an alternative lipid feedstock for biodiesel production was investigated. Experiments were conducted to evaluate the suitability of four different types of wastewater sludges for biodiesel production. Lipids were extracted from primary, secondary, blended and stabilized sludge in a Soxhlet extractor, using hexane as a solvent. Finally, the lipids were converted by acid catalysis transesterification into their corresponding fatty acid methyl esters (FAMEs) - biodiesel. Results indicated that among four sludge tested, primary sludge achieved the greatest lipids and biodiesel yields. The amount of extracted lipids for primary sludge was 25.3% compared to 21.9%, 10.1% and 9.1% (dry wt) for blended, stabilized and secondary sludge, respectively. The FAMEs yields obtained in this study were 13.9%, 10.9%, 2.9% and 1% (dry wt) for primary, blended, secondary and stabilized sludge, respectively. The estimation of annual biodiesel production based on the sludge generated in WWTP of Reus was evaluated, showing that primary sludge consists of 87% of the total biodiesel among the wastewater sludges. Gas chromatography analysis of the FAMEs revealed a similar fatty acids composition for all sludge tested with a predominance of palmitic acid, stearic acid, oleic acid and linoleic acid. Comparison of sludge fatty acid profile with common biodiesel feedstocks showed their suitability for the production of biodiesel.

Keywords: Sewage sludge; lipid extraction; biodiesel

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doi:10.1016/j.proeng.2012.07.456

1. Introduction

Nowadays, there is an urgent need for alternative cheap and renewable energy resources with no environmental impact like a biodiesel, bioethanol and biogas derived from renewable biomass. Among them, the greatest demand is currently observed for biodiesel. In 2009, biodiesel represented about 75% of total biofuels produced in The European Union (EU) [1]. Biodiesel is generally produced by the base or acid catalyzed transesterification of vegetable oils and animal fats, which yields the fatty acids methyl esters (FAMEs) of the lipid fraction. Biodiesel represents an excellent alternative to conventional diesel because is renewable, biodegradable, less toxic, and has low emission profiles. It has excellent lubricity and could provide similar energy density to diesel. It can be used directly without any engine modification and does not require new refueling station [2-4]. Due to the advantages of biodiesel mentioned above, the production of this biofuel in the EU and in the world is increasing. For example, the production of biodiesel in the EU has increased from 3.6 billion liters in 2005 to 10.7 billion liters in 2010 [5]. However, the increasing demand for biodiesel has done that the demand for lipid feedstocks such as soybean, canola, rapeseed, sunflower, palm, and coconut oils have also increased, and constitute between 70-85% of the overall biodiesel production cost [6,7]. Therefore, the biodiesel production is currently limited due to high raw material costs. In addition, lack of agricultural lands for growing biodiesel feedstocks limits it expansion and has impacted on the food price increases over the past few years. This fact can provoke that providing enough feedstock to cater to the increasing demands for biodiesel in the next few years will be at the expense of the food manufacturing industry. Thus, it is needed to find a cheap alternative feedstock, uncompetitive with food market, readily available and in large quantities. The search for cheaper feedstocks for the production of biodiesel has turned attention to various forms of waste alternative raw materials, including waste animal fats [8], waste cooking oil [9] and now lipids in sewage sludge [10,11].

Sewage sludge is a waste formed during treatment of wastewater. As shown in Fig. 1, wastewater treatment plant (WWTP) produces primary and secondary sludges, generally after primary and secondary treatment with significant differences between their compositions. The primary sludge is a combination of floating grease and solids collected at the bottom of the primary settler after screening and grit removal. The secondary or activated sludge is composed mainly of microbial cells and suspended solids produced during the aerobic biological treatment and collected in the secondary settler. A portion of the collected secondary sludge is recycled back to the aeration basins to maintain a sufficient concentration of microorganisms [7]. The remainder of secondary sludge, after thickening is mixed with thickened primary sludge and blend of them is the by-product after wastewater treatment. The sludge produced after wastewater treatment needs to be processing to facilitate its handling or disposal [12]. The blended sludge feeds aerobic or anaerobic digester (WWTP, Reus), and after this process stabilized sludge is obtained.

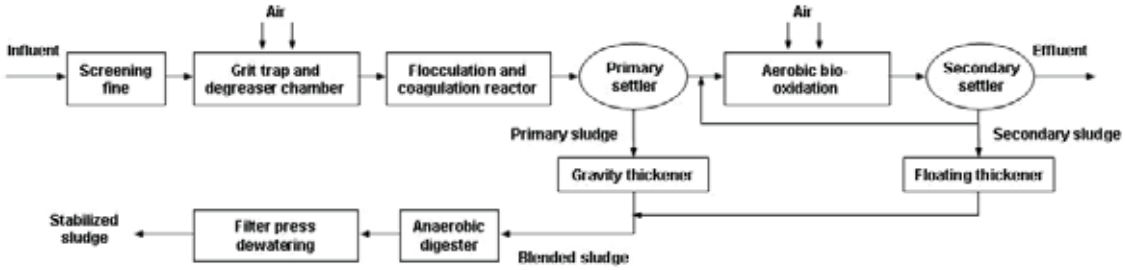

Fig. 1. Schematic diagram of municipal wastewater treatment plant in Reus, Spain.