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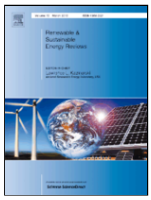

Assessment of diesel engine performance when fueled with biodiesel from algae and microalgae: An overview

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ABSTRACT

Biofuels derived from algae can have lower impact on the environment and the food supply than biofuels produced from crops. The strain selection, cultivation method, culture conditions and the chemical composition strongly influences the production costs but also the engine's performance and the exhaust gas emissions. The scope of this paper is to make a critical review about the impact of the use of biofuels produced from (micro) algae to power diesel engines. There is a huge disparity in the amount of papers published for algae culture, oil extraction, and biodiesel production compared to reporting performance on diesel engines. This paper presents an analysis of the papers published in this specific field. Generally, a reduction of torque and power output is reported. A wide range of blends up to B50 but also pure biodiesel has been tested. The blend showing results closest to diesel fuel appears to be B20. Several pollutants can be reduced if biofuels from different strains are used but an increase in NOx is generally reported, associated to higher temperatures in the combustion chamber. The use of emulsions instead of blends or neat biodiesel reveals a promising alternative with important reductions of CO_2 and NOx. However, the few reports for engine tests present some contradictions, or are lacking important information about the experiments. The assessment of biodiesel produced from algae or microalgae is a field hardly explored and until today some reference papers contain contradictory results or non-well studied behaviors as this survey demonstrates.

1. Introduction

Microalgae offer an attractive way of generating renewable and sustainable biofuels. An alternative to diesel fuel should be liquid, compatible with the engine, economically competitive, and available [1]. Biofuels derived from algae have lower environmental impact compared to biofuels produced from crops and do not compete with food supply [2–5]. Among many advantages, the production and use of biofuels from (micro) algae shows: a high CO_2 sequestration capability [2,6–9]; reduction of the use of freshwater [8–10] for its culture and/or land use [5,11–14], grows in residual wastewaters; it uses areas unsuitable for agricultural purposes; the cultures can be induced to produce a high concentration of feedstock; it can be harvested without the use of fertilizers and pesticides; it produces value-added co-products [15] and represents the only source of renewable fuels with capability for meeting the global demands of energy for transportation [3]. An important advantage of algae and microalgae for biofuels is that different fuels can be produced from it as is observed in Fig. 1. Through fermentation, ethanol can be produced; from anaerobic digestion, methane and hydrogen can be obtained; and bio-oil through pyrolysis [16–18]; fuel gas from gasification, and biodiesel from oil transesterification. The biofuel produced from algae is classified as a third generation biofuel [5,19,20]. The first generation biofuels should not exceed 6% of the final energy consumption in European transport by 2020, as opposed to the current 10% target in the existing legislation [21]. Therefore, compared to other feedstock, biofuels from algae could play an important role in the future.

Algae (macroalgae) are macroscopic photosynthetic organisms while microalgae are microscopic. Both can be found in marine and fresh water environments and also use CO_2 and nutrients for growth. They also can be found in a wide range of available strains. Microalgae are more advantageous because they are the fastest growing photosynthesizing organisms and can complete an entire growing cycle every few days [3].

Biodiesel produced from microalgae compared to rapeseed or soybean crops requires less land, around 100 times. Biodiesel from algae seems to be the only renewable biofuel that has the potential to completely displace petroleum-derived transport fuels without adversely af-

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