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Photofermentation of crude glycerol from biodiesel using *Rhodopseudomonas palustris*: Comparison with organic acids and the identification of inhibitory compounds

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HIGHLIGHTS

- ▶ Growth and H_2 production by *R. palustris* on various carbon sources investigated.
- ▶ Saponified fatty acids identified as the inhibitory component of crude glycerol.
- ▶ Investigations into inhibition by glycerol, alcohols and salts conducted.
- ▶ Normal growth and H_2 production on crude glycerol after treatment shown.
- ▶ Significant results in photofermenting crude glycerol to high purity H_2.

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ABSTRACT

The growth of the biodiesel industry, and its concurrent production of glycerol, has lowered the price of glycerol 20-fold. While many options for using this glycerol have been proposed, the size of the waste stream means that generation of fuels is likely to be the only viable route. One such fuel is hydrogen, production of which can be achieved biologically. The photofermentation of glycerol to hydrogen using *Rhodopseudomonas palustris* was investigated by exploring the growth rate, hydrogen production rate and hydrogen yield. *R. palustris* grows on glycerol at a rate of 0.074 h^{-1}, and photoferments glycerol into 97 mol% hydrogen at a conversion efficiency nearing 90% of the 7 mol H_2 theoretical maximum at a rate of 34 ml $H_2/g_{dw}/h$. Some inhibition of growth by crude glycerol was seen. This was determined to be caused by saponified fatty acids, removal of which yielded a treated crude glycerol which showed no inhibition.

1. Introduction

The international impacts and repercussions of global climate change resulting from greenhouse gas emissions are increasingly a concern for policy makers. The political pressure this has exerted, as well as the market pressures of increasing crude oil price and decreasing oil reserves, has led to a surge in research into the production of alternative fuels, which, on substitution for fossil fuels, have the potential to reduce the rate of anthropogenic emission of CO_2. Many alternative fuels are made from biological feedstocks, and so are called biofuels. One such fuel, biodiesel, has seen a large and continuing increase in production (Bozbas, 2008). Biodiesel is manufactured from plant or animal oils by trans-esterification of triacyl glycerides with an alcohol, usually methanol or ethanol, to make biodiesel from the fatty acid portion, leaving glycerol as a by-product. The inherent production of glycerol from the biodiesel process is substantial: about 0.1 m^3 of glycerol is produced per 1 m^3 of biodiesel (Thompson and He, 2006).

Owing to the increase in glycerol production associated with an expansion in the manufacture of biodiesel, the price of glycerol has plummeted from about $2/kg in 2002 to about $0.10/kg currently, so that many manufacturers of biodiesel now merely discard it (Johnson and Taconi, 2009). This has opened up an opportunity for finding a suitable use for this waste glycerol.

One option is to produce hydrogen from the glycerol using a photosynthetic bacterium. This has a number of advantages. Firstly, biological production of hydrogen circumvents the problem of producing a dilute aqueous product stream, likely to be obtained

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