Biodiesel Production in Fixed-Bed Catalytic Reactors

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Introduction to biodiesel

Biodiesel is a potentially renewable fuel made by the transesterification of vegetable oils or animal fats with a primary alcohol; in this case methanol is used to make fatty acid methyl esters, or FAME. This can be performed with an acid or base catalyst. As a fuel, biodiesel can be interchanged directly with conventional diesel, and so can be used with the existing in-vehicle equipment. Environmental advantages include biodegradability and reduced emissions of volatile organic compounds, carbon monoxide, and particulates\(^1\). This project aims to develop a continuous reactor with a catalyst supported on a monolith structure.

Why heterogeneous catalysis?

Ideally, if a robust and impurity tolerant heterogeneous catalyst can be developed, this will reduce:

- Plant equipment and footprint
- Feedstocks used (catalysts, neutralising agents)
- Waste water and salts
- Production costs

Why heterogeneous catalysis?

Monoliths

Monoliths are catalyst support structures forming a continuous series of regular channels. These may be coated with additional support material, such as alumina, along with a catalyst. The monoliths used in this project are thin walled cordierite with parallel channels.

Slurry coating

The main catalyst of interest is strontium oxide. This has been shown to be a very effective heterogeneous catalyst for transesterification. The monoliths are cut to size and then being coated. A slurry is made by ball-milling strontium hydroxide in water, with some additives to aid adhesion introduced before coating. The monoliths are dipped in the slurry, then dried and calcined at 720°C to form a layer of SrO. SEM images of the catalyst are shown below.

Testing the catalysts

Monolithic catalysts are tested at 120°C in a stainless steel autoclave, with a 6:1 molar ratio of methanol:oil. Samples are taken regularly and analysed by gas chromatography. The results from the most promising candidate are shown in the chart to the right.

Continuous reactor for testing monolithic catalysts.

After a successful catalyst has been identified, it is loaded into the continuous reactor. The reactor can reach temperatures of up to 200°C, at pressures up to 20 bar. It has an available bed length of 400 mm.

Catalyst lifetime

The coated monoliths were tested over the course of three weeks in the continuous reactor. At the end of the test, the catalyst still retained activity.

Conclusions and future work

- Strontium oxide is a powerful heterogeneous catalyst
- A coating method has been developed to deposit SrO on a monolithic support
- Catalyst candidates have been tested in a batch reactor
- Reaction in a continuous setting looks promising
- Further development of slurry coat, to improve mechanical stability and catalyst lifetime
- Continuous reaction data will be used to test a set of reaction modelling equations that have been developed
- Investigate doped La\(_2\)O\(_3\) as a catalyst (see figure on right)


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*General reaction scheme for the transesterification of triglyceride with methanol. Monoacylglycerides and diacylglycerides are produced as intermediate products.*

*SEM images of the tap layer of a slurry coated monolith. In the lower image, mechanical defects can be seen. These lead to structural instability, which will be addressed in future work.*