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Recycling of polymer material for fuel cell applications

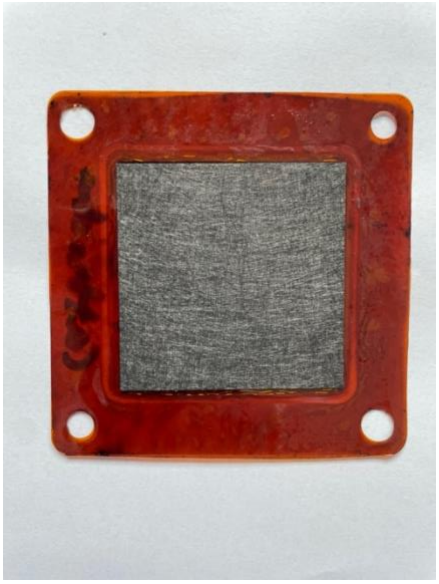
In order to reduce greenhouse gas emissions, there has been an incentive to develop alternatives to the combustion engine that are not dependent on the use of fossil fuels. An interesting option is fuel cell technology as it offers the possibility of using renewable fuels which can effectively decrease carbon dioxide emissions. In this master thesis project a recycling method for a polymer used in the production of fuel cells at Blue World Technologies was successfully developed with the purpose of reducing economic costs and increasing the sustainability of their production process.

The release of greenhouse gases into the atmosphere is continuing to increase the global surface temperature – rapidly changing the climate on our planet. The effects of climate change are already noticeable all around world with an increased frequency of extreme weathers, floodings and food and water scarcity. Carbon dioxide has been identified as the most prominent greenhouse gas and is the cause for roughly three quarters of the global warming. The majority of carbon dioxide emissions come from the combustion of fossil fuels including petroleum, coal and natural gas. Clearly, there is a need for technological development that allows us to not be reliant on the use of fossil fuels in order to save the planet.

In the last decades, Polymer Electrolyte Membrane Fuel Cell (PEMFC) technology has emerged as a potential candidate to replace the combustion engine. A PEMFC is a device that converts chemical energy into electricity through electrochemical reactions. It works like an ordinary battery – with the difference being that a fuel cell can continue to operate as long as a fuel is fed to it. By using renewable fuels it can supply electrical power while providing a significant reduction of carbon dioxide and other particle emissions!

A challenge with developing the fuel cell technology is to make it economically viable in comparison to the combustion engine. One way to achieve this is to reduce the production costs of the components in the fuel cell. The Danish fuel cell company Blue World Technologies has attempted to do exactly this by recycling the material that is used to construct the Polymer Electrolyte Membrane (PEM) – which is an integral component of the fuel cell made from a polymer called polybenzimidazole (PBI). In the production line at Blue World Technologies (BWT), there is a loss of PBI material when cutting out membranes from larger sheets to obtain the correct shapes and sizes to fit in the fuel cell. To prevent this, a method for recycling of the otherwise lost material was developed in this work.

The recycling method recovers the PBI material by dissolving it, followed by casting into new membrane sheets. Evaluation of the recycled membranes was carried out and the results were compared to freshly produced membranes. Interestingly, it was observed that the molecular weight – which in simple terms is a measurement of the size of the polymer molecules - of the PBI was slightly reduced after the recycling step had been applied. However, from additional characterization it was determined that the recycling process did not significantly change the properties of the polymer membranes. The performance of the recycled membranes was also evaluated in a fuel cell test setup and the results proved that it was comparable to what is obtained from BWT’s commercial fuel cells.



The fuel cell component which the recycled polybenzimidazole is part of.

The outcome of the work indicates that the developed recycling method can be used as a viable option for BWT to reduce economic costs and make their fuel cell production more sustainable.