**SUMMARY OF FINDINGS : STRIVE Report No. 113**

# The use of novel enzymes for the cleaner, greener production of cellulosic bioethanol

**Authors: Angela Boyce & Gary Walsh**
**Lead Organisation: University of Limerick**

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Cellulosic bioethanol is produced from lignocellulosic feedstocks, for eg. straw, and does not compete with food production. Cellulosic bioethanol can achieve significant greenhouse gas reductions in the transport sector, contribute to energy security and economic growth and assist nations in the practical implementation of relevant national/international global policy documents/agreements. The production of cellulosic bioethanol is however technically challenging and improvements in the production process are desirable to achieve widespread deployment and use of cellulosic bioethanol. The pretreatment step, necessary to disrupt the structure of lignocellulose, is often carried out using acid at high temperature and is considered to be one of the key areas for improvement.
The focus of this project was to develop an alternative greener pretreatment method, based on the use of thermoacidophilic enzymes, which aims to improve the efficiency of the pretreatment step and overcome many of the technical, economical, environmental and health & safety related disadvantages associated with current practice.

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**Key Words:** cellulosic bioethanol, second-generation biofuel, enzymes, pretreatment

## Background:

Climate change is considered as one of the most significant and challenging issues currently facing humanity. The transportation sector currently accounts for approximately 50% of global oil consumption and produces roughly 25% of global energy-related CO2 emissions. In Ireland, transport is the third largest contributor to overall emissions at 18.9% of the total. Developing renewable energy is an integral part of climate change strategy. The UN Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol provide the basis for international action to address climate change. Most global regions have adopted blending targets & mandates requiring increased use of biofuels, for example, the EU Renewable Energy Directive (RED) and the US Renewable Fuels Standard. Meeting the mandatory target of 10% renewable energy in transport by 2020, set by RED for member states, will require a progressive increase in renewable energy use in this sector. Furthermore, The European Commission Roadmap for achieving a low-carbon economy by 2050 indicates further GHG emission reduction requirements by that year. Increasing world population and oil demand, diminishing oil reserves and energy security concerns has also led to calls for diversification of fuel sources. Moreover, biofuels support economic growth by creating green jobs and new sources of income. First generation biofuels, produced primarily from food crops such as grains have come under increasing criticism due to limited GHG reduction benefits, their contribution to rising food prices and impacts of land-use changes.

Attention has therefore shifted to 2nd generation biofuels produced from lignocellulosic biomass feedstocks which overcome these disadvantages. Current biochemical processes for producing cellulosic bioethanol involve an initial pretreatment step to disrupt the lignocellulose structure followed by enzymatic hydrolysis of the cellulose and hemicellulose components to sugars which can then be fermented to ethanol. Improving this process is essential to achieve widespread deployment of cellulosic bioethanol and maximising the efficiency of the pretreatment step is considered a key area for improvement.

## Key Points & Findings

- Significant advances were made towards developing an environmentally-friendly enzymatic pretreatment method, particularly with regard to identifying suitable enzymes. While further optimisation of this method is necessary, the initial results observed are promising with the developed pretreatment method potentially offering several environmental, technical and health and safety-related benefits.
- The project resulted in the identification of several additional enzymes of potential application in the cellulosic bioethanol production process, the use of which may potentially contribute to overall process improvement.
- The project has expanded expertise in this area within the research group and has built capacity for further applied research aimed at improving the cellulosic bioethanol production process using enzymes produced by thermoacidophiles.

## Recommendations

- Further optimisation of the enzymatic pretreatment method developed using higher, more industrially relevant enzyme dosage levels.
- Further research on the additional enzymes identified in terms of their potential to improve the cellulosic bioethanol production process.
- Research which contributes to overcoming the technical, economical and environmental issues associated with the production of cellulosic bioethanol should be continued to facilitate wide-scale deployment of cellulosic bioethanol with subsequent benefits in terms of GHG emissions, energy security and economic growth.

**Further Information:** Prof. Gary Walsh, Department of Chemical and Environmental Sciences, University of Limerick, Limerick. E-mail: gary.walsh@ul.ie

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## Publications associated with this work

- Boyce, A. and Walsh G. (2012) Potential application of *Phanerochaete chrysosporium* enzymes in the dilute-acid pretreatment stage of bioethanol production. Proceedings of The 5th International Conference on Sustainable Energy and Environmental Protection (Part 1), Dublin City University, Olabi, AG and Benyounis, KY (eds), 131-136. (Conference paper and poster)

- Boyce, A. and Walsh G. (2012) Investigation of the potential suitability of the enzymes produced by the fungus *Thermoascus aurantiacus* for the pretreatment of lignocellulose for bioethanol production, Proceedings of EU BC&E 2012, 20th European Biomass Conference and Exhibition, Milan, 1658-1661. (Conference paper and poster)
- Boyce, A. and Walsh G. (2012) Assessment of the potential suitability of the enzymes produced by an environmental isolate for the pretreatment of lignocellulose for bioethanol production, The World Congress on Industrial Biotechnology and Bioprocessing, Florida. (Conference poster)
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