MycoMimic

Business Plan

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H Steel and E Richardson

University of Sydney

CONTENTS

Summary -

The purpose of this report is to provide an analysis of the development and commercial economic viability and likelihood of the *MycoMimic* product. This product was produced by the University of Sydney 2015 international Genetically Engineered Machine (iGEM) team. This report was established by the 2015 Sydney_Australia iGEM team, building on the work of Dr Nicholas Coleman at the University of Sydney.

This work aims to produce ethylene oxide in a more efficient, environmentally friendly, and rapid manner. Ethylene Oxide is a prominent and versatile substance that is found in a lot of the products we use daily. The current production method of ethylene oxide is environmentally detrimental, expensive, and uses non-renewable resources as its reagents. A major focus of governments, industries, companies, and universities over the last few decades is to create a more sustainable future. Indeed, in University of Sydney's Environmental Sustainability Policy, there is an emphasis on encouraging and *"integrating relevant environmental sustainability themes into courses and research"* (15.B). Furthermore, numerous environmental and sustainability organisations including the United Nations Environmental Program have highlighted the need for alternative greener and more sustainable procedures for producing common compounds.

We believe that this product can significantly assist in decreasing carbon emissions and in creating a more sustainable future for all. The future demand for ethylene oxide is only going to increase as the population increases and countries such as China and India expand and increase in wealth. Consequently, in a time where the demand for ethylene oxide is increasing we simply cannot afford to continue using inefficient, environmentally damaging, and expensive methods of chemical synthesis.

Our pitch -

Bacterial production of ethylene oxide is a significantly better alternative to traditional chemical synthesis.

The current situation -

Ethylene oxide is produced from ethylene from the oxidation process. It is one of the most abundantly produced compound. The industries in which this compound is utilised include but are not limited to pharmaceutical, medical, and manufacturing industry. The world production of ethylene oxide is 9.6 x 10^6 metric tons and it is likely to be increasing, due to the expand economies of countries like China and India.[1]

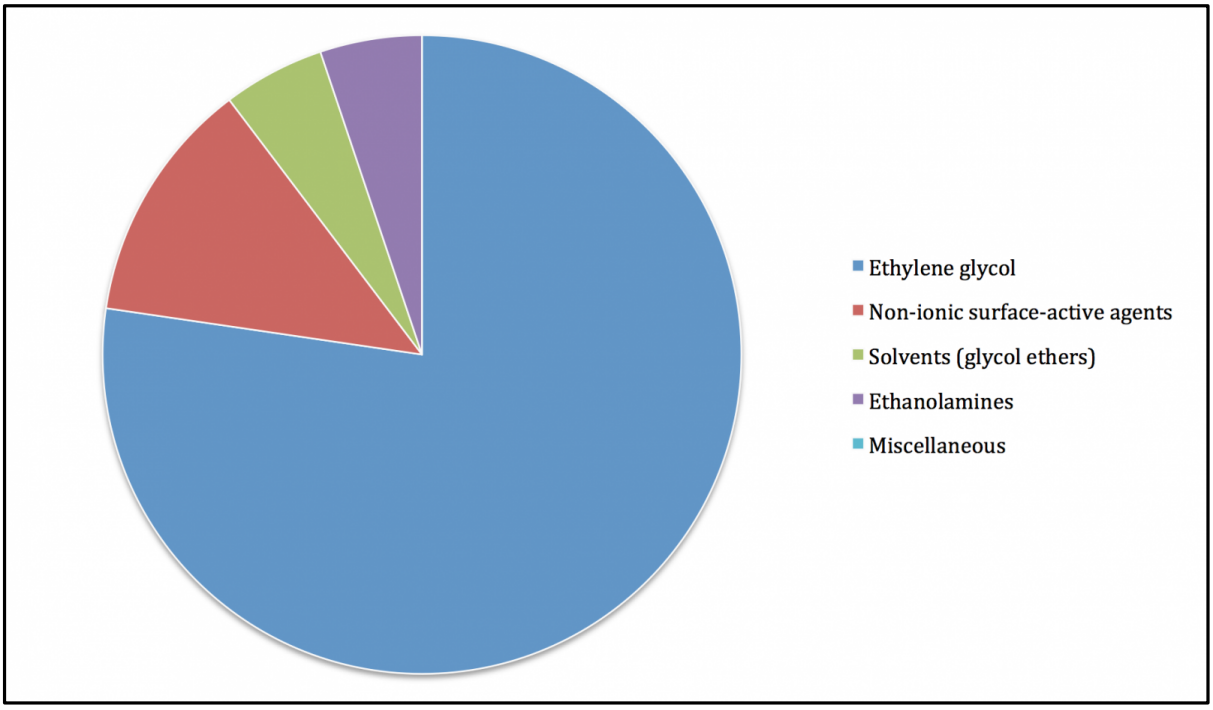

Figure 1: A pie chart showing the uses of ethylene oxide.

Due to the abundant use and versatility of ethylene oxide it is evident this compound is essential to our current society. The use of ethylene oxide is not going to decrease, and thus it is imperative we find a way to produce this critical substance in an environmentally friendly and cost efficient way.

Current production method:

Traditionally, ethylene oxide has been produced through a chlorohydrin process. This process was replaced by the complete oxidation process, pioneered by Theodore Lefort in 1931. Since the production of ethylene oxide, chemists have successfully synthesised other epoxides including propylene oxide. Epoxides are incredibly versatile due to the addition of the oxygen atom on the tetrahedral ring making the compound strained and unstable. Consequently the ring can be easily opened up, releasing abundant amounts of energy that can be used in further reactions, such as nucleophilic addition, hydrolysis and reduction.

Analysis of current production method:

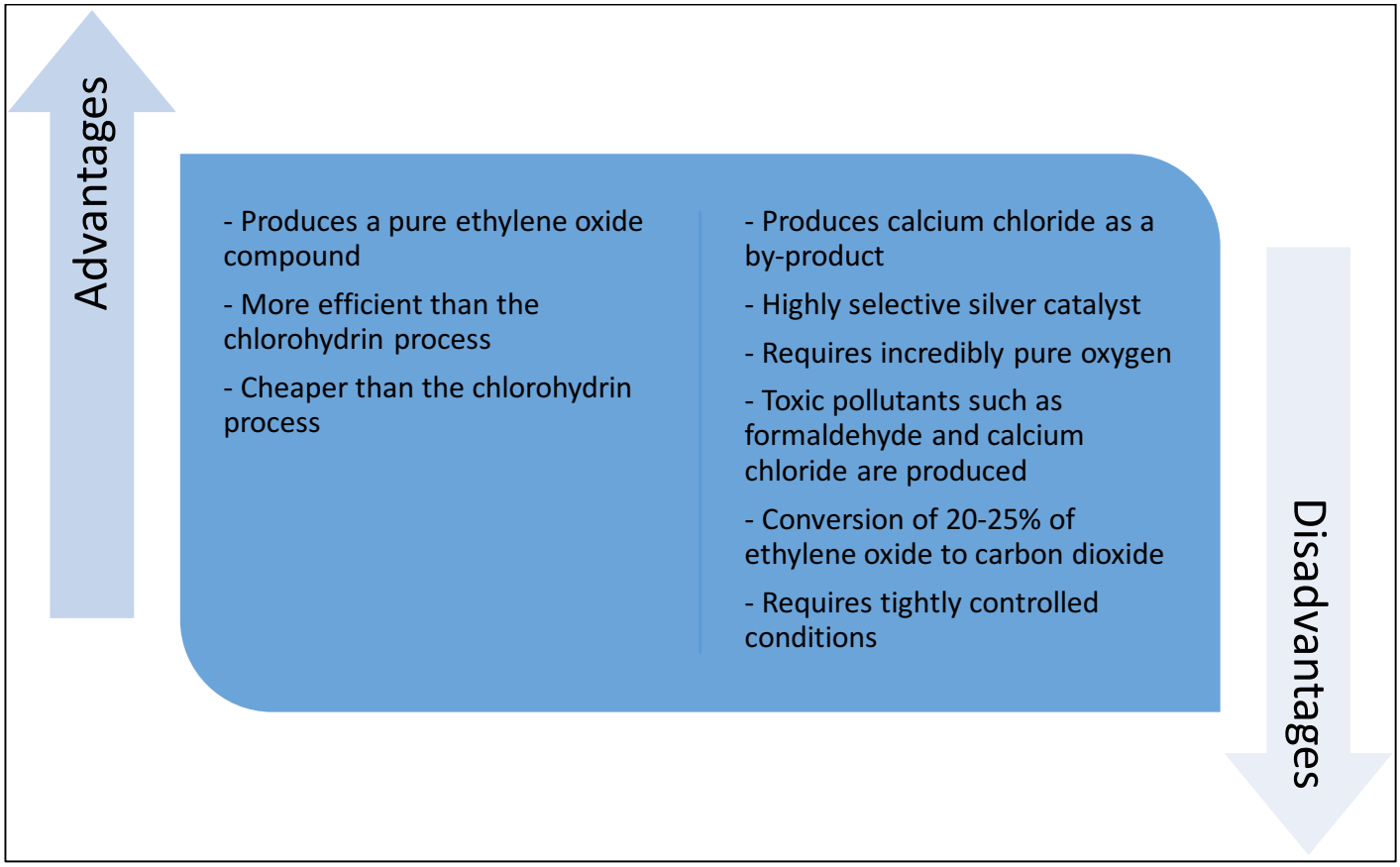

Figure 2: The advantages and disadvantages of production of ethylene oxide through the complete oxidation process

Given these numerous disadvantages of the complete oxidation process, which far outweigh the advantages – it is evident a new, clean, green process needs to be created and implemented on an industrial scale.

Our solution: MycoMimic –

Monooxygenase enzymes are capable of performing this epoxide reaction, thus converting alkenes to epoxides safely and efficiently. These biological catalysts are renewable, non-toxic, biodegradable, and can be scaled up for large-volume production. Our product, *MycoMimic* is a genetically engineered *Pseudomonas Putida* bacterium which contains the enzyme ethene monooxygenase. With the insertion and successful expression of this enzyme, the bacterium can produce ethylene oxide.

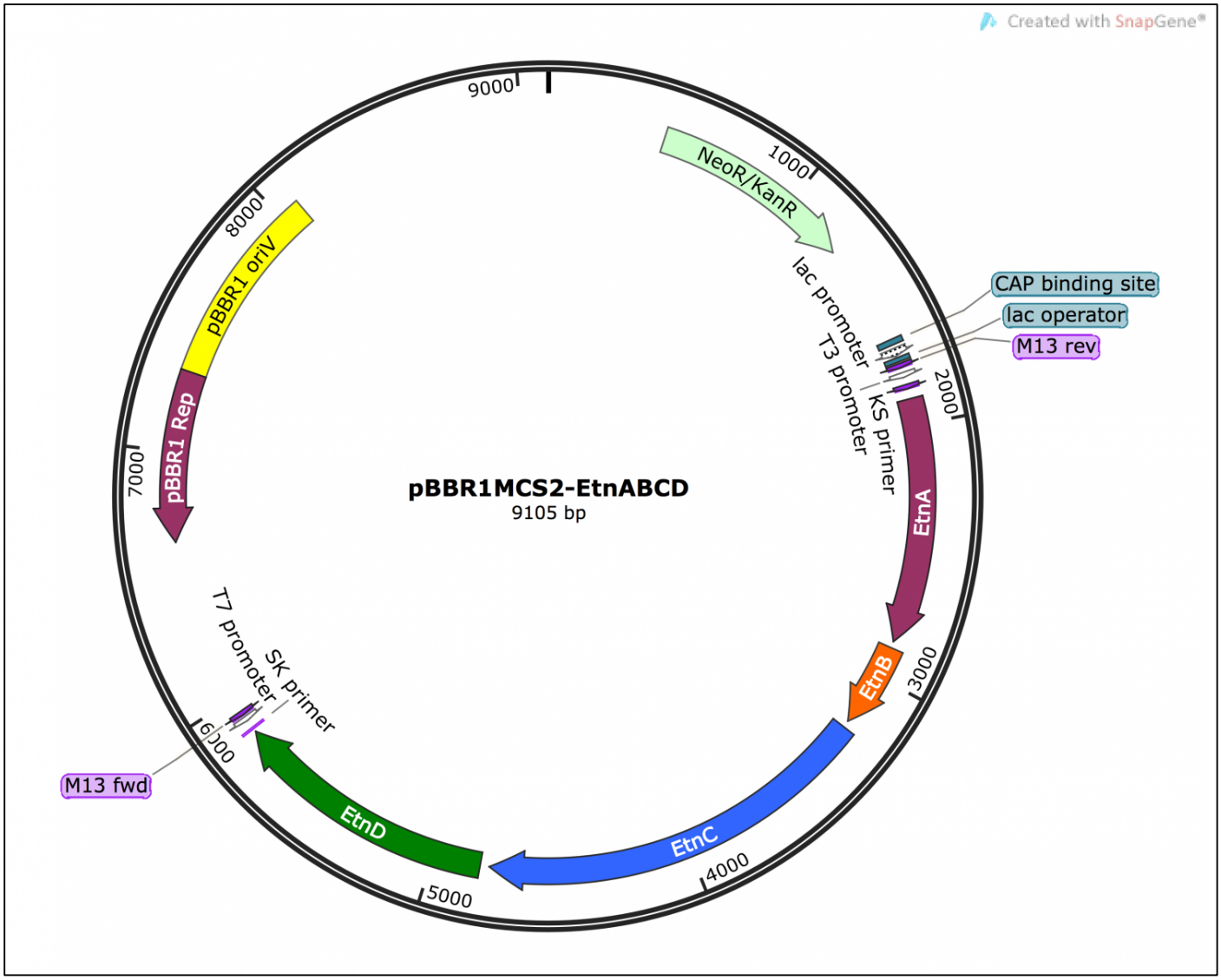

Figure 3: The pBBR1MCS2 plasmid showing the ethene monooxygenase insert. The “EtnA” “EtnB”, “EtnC”, and “EtnD” are the four subunits of the enzyme.

Given *MycoMimic* is an easy product to work with, it can be used on a large and small scale. The only requirements for this product are the bacteria *MycoMimic* itself and a source of ethylene. Thus, both large and small industrial companies can use this product – creating a more accessible, transparent, and open market. We believe this is important as it creates competition in the market, which will lead to a more diverse and fair environment.

Risk analysis -

Technical -

It is imperative *MycoMimic* is closely monitored when it is scaled up to an industry level. Ethylene oxide is a highly flammable and reactive compounds. When working with it on a small scale in the laboratory, it poses minimal and controllable threats. However, when working with it on an industry and commercial scale it has the potential to be dangerous and harmful. Thus, it is imperative it is closely monitored and the producer ensures there are regular safety and security checks to ensure there are no unintentional or deliberate accidents.

Financial –

Financial risks include failing to manage cost restraints and changes. In an unstable market with increasing competition from other countries in the Asia-Pacific region, great effort needs to be taken to ensure the financial aspect of the product is under control, Furthermore, the major rival to this product is the pre-existing method of production form crude oil. In the short term, competition from oil-companies may prove to be a risk. However, in the long-term, the financial advantages of *MycoMimic* are greater. This is because companies are moving away from non-renewable resources (the investment in coal has dropped dramatically over the last 5 years).

Safety and society -

The community reaction to products made from a synthetic and genetically modified organism may prove a risk. In the unlikely (but still possible) event the community does not approve of a product made from a genetically modified organism, then this could be a risk. To combat this potential risk, it will be necessary to firstly establish the different views on this issue and secondly to explain or market the product so that the consumers understand the benefits of *MycoMimic* both to themselves and the environment.

Product analysis and development -

Product analysis –

A “SWOT” analysis is used to assess the strengths, weaknesses, opportunities, and threats of this project. This analysis will be used to proactively plan and effective strategy that will focus on the strengths of this product while catering for weaknesses and possible threats.

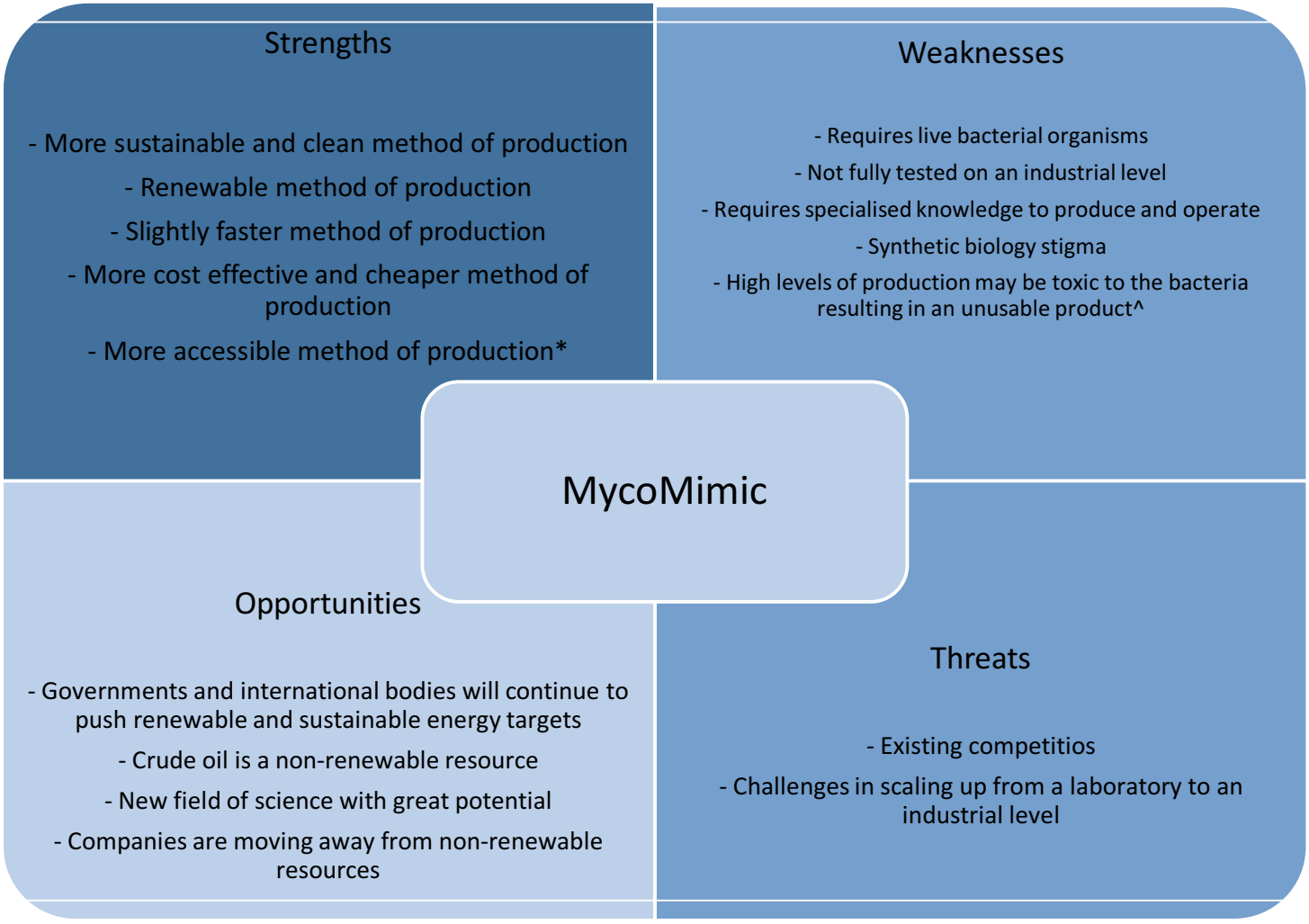

Figure 5: SWOT analysis of *MycoMimic*

* A major advantage of *MycoMimic* (as outline above) is its capacity to be utilised on a large and small scale. Large companies can produce tonnes of ethylene oxide to supply an entire nation. Alternative, smaller companies could produce ethylene oxide to supply only a state or few communities. This is beneficial for a few reasons. Firstly, it can be utilised in a flexible and changing market, a market which suits both large scale corporations and small organisations. This effectively creates a safety net in which *MycoMimic* can be utilised in a changing unstable market. Secondly, this will create a more accessible market allowing the control over this important compound not to fall into the hands of a few.

^ In order to combat this threat. We co-expressed the operon LacI which will stop the production of ethylene oxide when it reaches a toxicity level to the cell.

Conclusion -

As outlined above, *MycoMimic* has the potential to be an incredibly effective, versatile and necessary product in a time where the world is striving to be more environmentally sustainable and friendly.

Disclaimer – This proposal was written by the Sydney_Australia team as part of the International Genetically Engineered Machine competition. Its aim was to demonstrate the capacity and the *MycoMimic* project has to be applied to the real world and developed into a working product. However, it is not indicative of a final proposal that should be considered by businesses.

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[1] United States Environmental Protection Agency, 1986, *Locating and estimating air emission from sources of ethylene oxide*, viewed 20th of July 2015,http://www.epa.gov/ttnchie1/le/ethoxy.pdf (p. 11).