Environmental Protection Authority
Te Mana Rauhī Taiao

APPLICATION FORM
RELEASE

Application to import for release or to release from containment new organisms

under the Hazardous Substances and New Organisms Act 1996

Send by post to: Environmental Protection Authority, PO Box 131, Wellington 6140 OR email to: noinfo@epa.govt.nz

Application number

ERMA200833

Applicant

Lanzatech New Zealand Limited

24 Balfour Road, Parnell, Auckland 1052, New Zealand

Important

This application form is to seek approval to import for release or release from containment new organisms (including genetically modified organisms).

The application form is also to be used when applying to import for release or release from containment new organisms that are or are contained within a human or veterinary medicine.

Applications may undergo rapid assessment at the Authority's discretion if they fulfil specific criteria.

This application will be publicly notified unless the Authority undertakes a rapid assessment of the application.

This application form will be made publicly available so any confidential information must be collated in a separate labelled appendix.

The fee for this application can be found on our website at www.epa.govt.nz.

If you need help to complete this form, please look at our website (www.epa.govt.nz) or email us at noinfo@epa.govt.nz.

This form was approved on 21 September 2011.

1. Brief application description

LanzaTech wishes to use the anaerobic bacterium ***Clostridium magnum*** to convert carbon-based gases to acetic acid. It has already successfully carried out HSNO Act-approved contained laboratory-scale research. LanzaTech wants to now scale up to a pilot plant to prove commercialization is possible. This development requires the organism to be released.

2. Summary of application

Provide a plain English, non-technical description of what you are applying to do and why you want to do it.

LanzaTech was founded in 2005 to further the research and development of technology that promises to help meet the increasing global demand for affordable, low carbon transport fuels and sustainably produced chemical intermediates (Macfie, 2010).

Today LanzaTech's processes have been proven capable of converting carbon-based waste gases (produced by industries such as steel manufacturing, oil refining and chemical production), as well as other gases (like those generated by gasification of forestry and agricultural residues, municipal waste and coal), into valuable fuels (including ethanol) and chemical products.

The company is acknowledged as a world leader in clean energy technology. It has been identified (at the 2011 Icehouse Ideas Conference) as a potential billion dollar company. LanzaTech's progress toward its commercialization goals have been recognized both in New Zealand and internationally. LanzaTech was NZBIO's 2011 Company of the Year and its cofounder and chief scientist Dr Sean Simpson won the NZBIO 2011 Young Biotechnologist of the Year award. Dr Simpson was also the E&Y Entrepreneur of the Year 2011 technology category winner.

Those accolades joined numerous international awards during the past two years. They include Dr Simpson and CEO Dr Jennifer Holmgren being in the prestigious Biofuels Digest "Top 100 People in Bioenergy" in the world. The company was named in the Red Herring Global 100 and also won the Frost & Sullivan 2011 Global Green Excellence Award for Technology Innovation in "green chemistry", among others.

As well as substantial funding from the New Zealand Government and NZ investors, LanzaTech has attracted funding from US-Based Khosla Ventures and in Asia from Qiming Venture Partners and SoftBank. It is currently in a Series C fund raising round for US$40 million. LanzaTech was also the recipient of up to US$4 million from the United States Department of Energy to develop a cost-effective technology that converts biomass-derived ethanol into jet fuel using catalysts and produce a valuable bio-product called butadiene that could be used to improve the overall economics of the fuel production process.

In January 2011 LanzaTech was mentioned in a White House statement about US-China commercial relations during a visit to the US by China's President Hu Jintao. LanzaTech has joint venture agreements with two of China's largest steel millers and a strong relationship with the Chinese Academy of Sciences.

LanzaTech has taken its technology to the world, but retained and grown its R&D headquarters in New Zealand. This application relates to an extension of that R&D being able to take place in a pilot plant setting in New Zealand.

LanzaTech wishes to use the anaerobic bacterium ***Clostridium magnum*** to convert carbon-based gases to acetic acid. It has already carried out HSNO Act-approved contained laboratory-scale research. In the next stage it wants to scale up to a pilot plant in New Zealand, which necessitates this application for the organism to be released.

Once the larger scale process is proven, LanzaTech intends the technology be commercialised, creating wide ranging employment opportunities - including securing and retaining further international class scientific talent for LanzaTech's R&D facilities in New Zealand - and delivering the country significant foreign exchange earnings.

Acetic acid is an important chemical reagent and industrial chemical used in the production of:

- polyethylene terephthalate (PET) (mainly used in soft drink bottles)
- cellulose acetate (mainly used for photographic film)
- polyvinyl acetate (used in wood glue, as well as synthetic fibres and fabrics)

Acetic acid has a global consumption of over 12 million tonnes annually and is a multi-million dollar product/industry.

Benefits

The initial benefit to be realized from the release of *C. magnum* will be the scientific knowledge gained from the operation of the pilot plant and honing the process for commercialization. The establishment of the pilot plant will require capital investment and create work in the design and building industries as well as those jobs required to operate the plant.

This aspect of LanzaTech's technology could also deliver economic benefit from the sale of the acetic acid produced (see section 6 for further details).

The Māori tradition of kaitiakitanga, or guardianship of the environment, is respected by LanzaTech's technology. In the future, assuming the technology works at an industrial scale and is adopted by industry, the release of this microorganism could result in the reduction of greenhouse gas (CO_2) emissions and a consequential reduction in the environmental impact of industrial processes.

This aspect of LanzaTech's technology – turning "waste into gold" - has already secured it joint ventures with some of the world's largest steel, coal, chemical and oil refineries in China, India, Taiwan and Korea and industrial solutions companies (including Japan's Mitsui and US-based Harsco).

LanzaTech's contribution to beneficial environmental effect, and its attraction to global scale corporations and organizations, further enhances New Zealand's global reputation. NZ was ranked fifth in the Global Reputation when measured for the first time against 50 other countries in 2011.

Risks

We have not identified any risks from this organism. *Clostridium magnum* is unable to survive in air and dies in the presence of oxygen thus is termed a strict anaerobic bacteria. It is also not known to cause any disease in humans, animals or plants (see section 4 for further details).

3. Describe the background and aims of the application

This section is intended to put the new organism(s) in perspective of how they will be used. You may use more technical language but please make sure that any technical words used are included in a glossary.

See section 2.

4. Information about the new organism(s)

- Provide a taxonomic description of the new organism(s) (if the organism is a genetically modified organism, provide a taxonomic description of the host organism(s) and details of the genetic modification).
- Describe the biology and main features of the organism including if it has inseparable organisms.
- Describe if the organism has affinities (e.g. close taxonomic relationships) with other organisms in New Zealand.
- Could the organism form an undesirable self-sustaining population? If not, why not?
- What is the ease with which the organism could be eradicated if it established an undesirable self-sustaining population?

Clostridium magnum

1) Anaerobic, spore forming, gram negative, large motile rod shaped bacterium (1-4 x 4-16 µm). The species is strictly anaerobic.

2) C. magnum prefers a growth temperature of 30-32C, but can live a wider range of temperatures. The strain grows best at neutral pH conditions within a narrow range of 6.0-7.5. Several sugars, 2,3-butanediol or CO_2 + H_2 can serve as carbon source. Several minerals and vitamins must be supplied for any growth. Furthermore it requires a nitrogen (yeast extract or ammonia) and sulfur (cystein or sulfide) source for growth.

While the native form of this bacteria can sporulate, though infrequently (preferentially after growth on sugars),it is important to note the actual bacteria LanzaTech will be using has been "in culture" for many generations. This is important because the ability to sporulate is lost through continuous culturing, Mieneck et al. (1984). Moreover sporulation during growth on CO_2+H_2 (as will be present in the waste industrial gas to be used as substrate) has never been observed for *C. magnum*.

There are no known inseparable organisms associated with *C. magnum.*

3) *C. magnum* does not have any known affinities with other organisms in New Zealand.

This microorganism is not known to cause disease in humans, animals, plants or fungi and belongs to risk group 1. *Clostridium magnum* does not contain any known infectious agents normally able to cause disease in humans, animals, plant or fungi.

Clostridium magnum is a natural isolate of mud, sourced from outside of New Zealand. While *C. magnum* has not been reported in New Zealand, closely related isolates (93% identity of 16s rRNA) are common in the country and there are no known affinities with *Clostridium magnum* or closely related isolates. For example, *C. autoethanogenum*, has been isolated within New Zealand (Isolation of *C. autoethanogenum* within the New Zealand Environment, Report by Biodiscovery NZ Ltd).

4) New Zealand does have many anaerobic and micro aerobic environments, including mud pools, sediments and guts of animals. However for *C. magnum* to reach such environments and form self-sustaining populations, a number of steps must occur:

1) The *C. magnum* must leave the anaerobic environment where it is currently growing. For example, in an industrial setting, this could be a bioreactor.
2) If the environment the *C. magnum* encounters once it leaves the anaerobic environment is aerobic, then the *C. magnum* will die.
3) However, if the environment encountered is suitable for survival (in terms of oxygen level, pH range, temperature range and substrates) and it is free of competing microbial species (which would be similar in nature to *C. magnum)*, then the *C. magnum* may be able to form a self-sustaining population.
   For this *C. magnum* population to be undesirable, it would have to cause adverse effects relative to the microbes that may already inhabit that environment.

5) We consider that it is highly improbable that *C. magnum* could move from an anaerobic environment to a suitable anaerobic environment (as described in point 3) to form a self sustaining population.

Even in the event that a population formed we have not identified any adverse effects. Therefore, we consider that this microorganism will not form an undesirable, self-sustaining population.

Eradication of undesirable self-sustaining population

In the highly improbable event that a self-sustaining population was to form, it is unlikely that it would be able to be eradicated. However, it is also highly unlikely to have adverse effects. Furthermore a self sustaining population

would require anaerobic conditions to be maintained. In nature this happens in the subsoil, in the deep ocean, or again in ocean sub surface layers, the intracellular regions of plants and in the digestive tract of many animals.

LanzaTech's microbes would need to be anaerobicaly transferred (without coming into contact with air) from the reactor to one of these environments. However, given that the strains it uses, which have been cultured for many generations, are compromised in their ability to uptake sugars (evidence from the genome sequencing of LZ1561), their ability is further reduced.

5. Detail of Māori engagement (if any)

Discuss any engagement or consultation with Māori undertaken and summarise the outcomes.

The Māori cultural tradition of kaitiakitanga is respected by the LanzaTech process. The use of waste gases in the process, coupled with the capture of greenhouse gases, has the long-term potential benefit to reduce atmospheric CO_2 and assists in mankind's guardianship of Earth's environment.

Lanzatech is always open discussing the outcomes of this proposal.

6. Identification and assessment of beneficial (positive) and adverse effects of the new organism(s)

Adverse effects include risks and costs. Beneficial or positive effects are benefits.

- Identification involves describing the potential effects that you are aware of (what might happen and how it might happen).
- Assessment involves considering the magnitude of the effect and the likelihood or probability of the effect being realised.

Consider the adverse or positive effects in the context of this application on the environment (e.g. could the organism cause any significant displacement of any native species within its natural habitat, cause any significant deterioration of natural habitats or cause significant adverse effect to New Zealand's inherent genetic diversity, or is the organism likely to cause disease, be parasitic, or become a vector for animal or plant disease?), human health and safety, the relationship of Māori to the environment, the principles of the Treaty of Waitangi, society and the community, the market economy and New Zealand's international obligations.

Environment

Potential benefits

Long-term we speculate that the technology being developed, if scaled up and further developed to utilize other waste streams, could contribute to mitigating the effects of climate change induced by CO_2 emissions.

Potential risks or costs

No adverse effects or risks on the environment, or New Zealand's inherent genetic diversity - including displacement of native species and deterioration of natural habitats - resulting from the release of *C. magnum* have been identified.

As *C. magnum* is strictly anaerobic, this microorganism is unable to survive in the air. *C. magnum* is able to produce spores, a reproductive structure that is adapted for dispersal and with the ability to survive for extended periods in unfavorable conditions. However, industrialised strains, such as those that we intend to use should this application be approved, have undergone an extended period of continuous culture. This occurs through natural selection (not genetic modification) in culture in the laboratory and results in the loss of sporulation ability (Meinecke et al. 1984) and means they are not able to survive in an oxygen-containing environment.

It is important to note that working with the microbes at an industrial scale (as LanzaTech proposes to do) requires that the vessels containing the microbes are sealed to ensure that they are not exposed to air or oxygen during production. Any release of the micro organism from these vessels will result in exposure to oxygen which is mortally toxic within a very short time period.

However, as the *C. magnum* proposed to be released is not limited to only those industrial strains and may be released by persons other than LanzaTech, we have assessed the risks based on the *C. magnum* producing spores and for use outside an industrial setting.

On human health and safety

Potential benefits

The use of waste gases in the process, coupled with the capture of greenhouse gases, has the long-term potential benefit to reduce atmospheric CO_2 and assists in mankind's guardianship of Earth's environment which leads downstream to benefits for human health and safety.

Potential risks or costs

No adverse effects or risks on human health and safety resulting from the release of *C. magnum* have been identified. Although other *Clostridium* species can cause human disease, this microorganism does not colonise or cause disease.

On the relationship of Māori and their culture and traditions with the environment

Potential benefits

The Māori cultural tradition of kaitiakitanga is respected by the LanzaTech process. The use of waste gases in the process, coupled with the capture of greenhouse gases, has the long-term potential benefit to reduce atmospheric CO_2 and assists in mankind's guardianship of Earth's environment.

The release of *C. magnum* to allow this green technology within first a pilot plant, and then an industrial setting, will also enhance knowledge that can be shared across cultures and countries.

Potential risks or costs

No adverse effects or risks on the relationship of Māori and their culture and traditions from the release of *C. magnum* have been identified

On society and communities

Potential benefits

The initial benefit to be realized from the release of *C. magnum* will be the scientific knowledge gained from the operation of the pilot plant and honing the process for commercialization. The establishment of the pilot plant will require capital investment and create work in the design and building industries as well as those jobs required to operate the plant.

Commercialised and taken up by industry, wider beneficial effect on society and community will be possible through the use of green technology and greenhouse gas capturing technology in New Zealand.

Commercialized, regardless of project location, a typical commercial project would demand 10-20 early phase design and engineering jobs, 500-1000 jobs for extended duration engineering, procurement and construction jobs and more than 1000 plant operation, service, operation, feedstock and indirect jobs.)

Potential risks or costs

No adverse effects or risks on society and communities from the release of *C. magnum* have been identified.

On the market economy

Potential benefits

LanzaTech contends that if the pilot plant is successful then the subsequent international media coverage will have a flow on effect for New Zealand's bioscience sector in terms of international investment in R&D in New Zealand. International media already closely monitor LanzaTech's progress (see awards and media examples appendix)

There is also a potential to offset New Zealand's requirement to import acetic acid and create an opportunity to become an exporter of this valuable platform chemical. Acetic acid is an important chemical reagent and industrial chemical, it is used in the production of polyethylene terephthalate mainly used in soft drink bottles; cellulose acetate, mainly for photographic film; and polyvinyl acetate used in wood glue, as well as synthetic fibres and fabrics.

For reference, in 2011 New Zealand imported NZD$4,842,000 of acetic acid from eight trading partners, predominantly, USA (32%), China (28%), and Taiwan (22%). In 2011 New Zealand exported NZD$54,000 of Acetic acid to one trading partner, Fiji. (Source: The 2011 Import and Export Market for Acetic Acid and Its Salts in New Zealand - ICON Group Ltd.)

Potential risks or costs

No adverse effects or risks on the market economy from the release of *C. magnum* have been identified**.**

7. Could your organism(s) undergo rapid assessment?

7.1. **If your application involves a new organism that is or is contained within a veterinary or human medicine, could your organism undergo rapid assessment (s38I of the HSNO Act)?**

Describe the controls you propose to mitigate potential risks (if any). Discuss what controls may be imposed under the ACVM Act (for veterinary medicines) or the Medicines Act (for human medicines).

Discuss if it is highly improbable (after taking into account controls if any):

- the doses and routes of administration of the medicine would have significant adverse effects on the health of the public or any valued species; and
- the organism could form an undesirable self-sustaining population and have significant adverse effects on the health and safety of the public, any valued species, natural habitats or the environment.

Do not include effects of the medicine or new organism on the person or animal being treated with the medicine.

Clostridium magnum is not contained within a veterinary or human medicine.

LanzaTech is not seeking for its application to undergo rapid assessment under s38I of the HSNO Act.

7.2. If your application involves a new organism (excluding genetically modified organisms), could your organism undergo rapid assessment (s35 of the HSNO Act)?

Discuss if your organism is an unwanted organism as defined in the Biosecurity Act 1993.

Discuss if it is highly improbable that the organism after release:

- could form self-sustaining populations anywhere in New Zealand (taking into account the ease of eradication)
- could displace or reduce a valued species
- could cause deterioration of natural habitats,
- will be disease-causing or be a parasite, or be a vector or reservoir for human, animal, or plant disease
- will have adverse effects on human health and safety or the environment.

MAF has a list of organisms it deems detrimental to NZ - http://www.biosecurity.govt.nz/pests/registers/uor *Clostridium magnum* is not in the register- thus is not an unwanted organism.

No *C. magnum* should not be assessed under the rapid pathway (s35).

8. Other information

Add here any further information you wish to include in this application including if there are any ethical considerations that you are aware of in relation to your application.

We are not aware of any ethical considerations that relate to this application form.

This is an application for a release without controls. LanzaTech has calculated that this project would not be enconomically viable or cost effective if it was subjected to containment measures.

9. Appendices(s) and referenced material (if any) and glossary (if required)

Macfie R 2010. The environmental bug. New Zealand Listener 222 (3638, 30 January – 5 February): 54.

BioDiscovery NZ Ltd. Reasearch and Development Report – Identification of *Clostridium autoethanogenum* in the New Zealand environment.

Bomar M, Hippe H, Schink B 1991. Lithotrophic growth and hydrogen metabolism by *Clostridium magnum*. FEMS Microbiology Letters 83: 347-350.

ICON Group Ltd. The 2011 import and export market for acetic acid and its salts in New Zealand.

Patel BKC, Monk C, Littleworth H, Morgan HW, Daniel R M 1987. *Clostridium fervidus sp. nov.,* a new chemoorganotrophic acetogenic thermophile. International Journal of Systematic Bacteriology 37: 123-126.

Schink B 1984. *Clostridium magnum* sp. nov., a non-autotrophic homoacetogenic bacterium. Archives of Microbiology 137: 250-255.

Widdel F, Pfennig N 1981. Studies on dissimilatory sulfate-reducing bacteria that decompose fatty acids. I. Isolation of new sulfate-reducing bacteria enriched with acetate from saline environments. Description of *Desulfobacter postgatei* gen. nov., sp. nov. of Microbiology 129: 395-400.

Wolin EA, Wolin MJ, Wolfe RS 1963. Formation of methane by bacterial extracts. Journal of Biological. Chemistry 238: 2882-2886.

Meinecke B., Bahl H, Gottschalk G 1984. Selection of an asporogenous strain of *Clostridium acetobutylicum* in continuous culture under phosphate limitation. Applied and Environmental Microbiology 48: 1064-1065.

10. Signature of applicant or person authorised to sign on behalf of applicant

☒ I request the Authority to waive any legislative information requirements (i.e. concerning the information that shall be supplied in my application) that my application does not meet (tick if applicable).

I have completed this application to the best of my ability and, as far as I am aware, the information I have provided in this application form is correct.

Signature **Date**