



DECISION

Date	26 April 2012
Application code	ERMA200833
Application type	To release from containment any new organism under section 34 of the Hazardous Substances and New Organisms Act 1996
Applicant	LanzaTech New Zealand Limited (LanzaTech)
Date application received	3 November 2011
Hearing and consideration date	23 March 2012
Considered by	The Environmental Protection Authority (EPA)
Purpose of the application	To release the anaerobic microorganism <i>Clostridium magnum</i>
The new organism approved for release	<i>Clostridium magnum</i>

1. Summary of decision

- 1.1 The application to release from containment *Clostridium magnum* (*C. magnum*), an anaerobic bacterium that can convert carbon-based gases to acetic acid, was lodged under section 34 of the Hazardous Substances and New Organisms Act 1996 (the Act).
- 1.2 The EPA has **approved** the application for the release of *Clostridium magnum* without controls in accordance with section 38(1)(a) of the Act.

2. Application process

Application Receipt

- 2.1 The application was formally received for processing on 3 November 2011.

Public notification

- 2.2 Section 53(1)(c) of the Act provides that an application under section 34 of the Act must be publicly notified by the EPA.
- 2.3 The EPA notified the application by placing a notice on its website on 7 November 2011.
- 2.4 In accordance with section 53(4) of the Act, the EPA also sent letters or emails notifying the Minister for the Environment, the Ministry of Agriculture and Forestry (MAF), the Department of Conservation (DOC), and other government departments, crown entities, local authorities, Māori organisations, non-government organisations and stakeholders who had expressed an interest in being notified about applications for non-genetically modified new organisms. The EPA provided those parties with an opportunity to comment on the application as per section 58(1)(c) of the Act and clause 5 of the Hazardous Substances and New Organisms (Methodology) Order 1998 (Methodology).
- 2.5 Section 59(1)(c) of the Act requires an application to be open for the receipt of submissions for 30 working days from the date of public notification. The application was open for submissions for a period of 30 working days from 7 November 2011 until 19 December 2011.
- 2.6 Three submissions were received - from NZBIO, Dr Cliff Mason and Clean Earth. NZBIO and Dr Cliff Mason requested to be heard.

Comments from MAF and DOC

- 2.7 MAF stated that they did not have any risk concerns with the proposed release and that *C. magnum* does not appear to possess any characteristics that present a risk to biosecurity.
- 2.8 DOC did not raise any concerns with this application.

Reports sought

- 2.9 The EPA requested a report (referred to as the “internal EPA advice”) from staff of the EPA, under section 58(1)(a) of the Act.
- 2.10 On 9 March 2012, the EPA published the internal EPA advice on its website and informed the applicant and submitters of its availability.
- 2.11 The EPA also requested advice from Ngā Kaihautū Tikanga Taiao.



Hearing and consideration

- 2.12 The applicant requested a delay of the date for commencement of the hearing to enable expert witnesses to appear on its behalf. The EPA is required by section 59(1)(d) of the Act to fix a date for the commencement of the hearing that is not more than 30 working days after the closing date for submissions. The EPA treated the applicant's request as an application under section 59(3) of the Act for the EPA to waive that requirement and granted the application under section 59(5).
- 2.13 The hearing took place in Auckland on 23 March 2012.
- 2.14 Two submitters presented their submissions at the hearing. The submissions received and heard expressed support for and opposition to the release of *C. magnum*. These submissions are discussed in more detail below. The EPA found the information supplied to be valuable and informative in assisting them to make a decision, and were very grateful for these contributions and for submitters' participation in the process.

Information available for the consideration

- 2.15 The information available for the consideration comprised:
- The application
 - Internal EPA advice
 - Comments received from MAF and DOC
 - The Ngā Kaihautū Tikanga Taiao report
 - Submissions
 - Information obtained during the hearing.

Legislative criteria for application

- 2.16 The application was determined in accordance with section 38 of the Act, taking into account the matters specified in sections 36 and 37, relevant matters in Part 2 of the Act, and the Methodology.

3. Minimum Standards

- 3.1 The EPA considered whether *C. magnum* meets the five minimum standards as specified in section 36 of the Act.

Consideration of sections 36(a), 36(b) and 36(d) of the Act

- 3.2 The EPA considered the following three minimum standards together:
- Is *C. magnum* likely to cause any significant displacement of any native species within its natural habitat (section 36(a) of the Act)?



- Is *C. magnum* likely to cause any significant deterioration of natural habitats (section 36(b) of the Act)?
- Is *C. magnum* likely to cause any significant adverse effect to New Zealand's inherent genetic diversity (section 36(d) of the Act)?

- 3.3 The EPA firstly considered the evidence presented regarding the biological characteristics of *C. magnum*.
- 3.4 The EPA noted the information provided by the applicant that *C. magnum*, originally obtained from the American Type Culture Collection, only grows in environments where there is no oxygen and dies at even low oxygen concentrations (1-2%). Therefore it would not survive in air which has 21% oxygen content (Karnholz *et al*, 2002). The applicant also noted that there are only a limited number of environmental conditions that allow *C. magnum* to grow e.g. it has a limited substrate range, it needs a reduced anaerobic environment, a temperature range between 15-45°C (optimum 30-32°C), a narrow pH range 6.0-7.5 (optimum 7.0) and low salt concentrations (less than 1%, cf. sea water is 3.5%) (Schink, 1984; Bomar *et al*, 1991).
- 3.5 The EPA considered whether *C. magnum* is likely to be ubiquitous in the environment where conditions are favourable.
- 3.6 The applicant provided evidence at the hearing that *C. magnum* is well characterised and has been found in a wide range of environments overseas for example freshwater creek sediments in Germany, soil of harvested potato plots in the USA and whey permeate wastewater in Korea (Schink, 1984; Luo *et al*, 2008; Kim *et al*, 2011). The applicant also provided evidence that acetogens (such as *C. magnum*) are widely distributed in the environment, including in New Zealand. The applicant noted in their application that closely related *Clostridium* species, such as *C. autoethanogenum*, are present in New Zealand.
- 3.7 The applicant considered that *C. magnum* is likely to be present in New Zealand. This opinion was shared by a witness for the applicant Professor Ian Maddox who considered *C. magnum* to be ubiquitous in the environment and therefore he would be able to isolate it from the New Zealand environment. However the applicant stated that they had not attempted to isolate *C. magnum* from the New Zealand environment as microbial ecology is not their core capability and would be a distraction.
- 3.8 Submitter Cliff Mason considers that the purposes of the Act and these three minimum standards have not been adequately addressed. He stated that "*we know very little about bacteria in New Zealand and in fact we know very little about microbial ecology in any event, but this issue is crucial in the consideration of an application such as this under the HSNO Act*". He believes that "*as far as the*



evidence exists that Clostridium magnum appears to be a prime example that biogeography does exist. That bacteria are limited in their distribution and it happens that Clostridium magnum is not found in New Zealand.” He did “not believe that this application can be approved without any knowledge, significant knowledge of microbial ecology”.

- 3.9 The EPA considered the concern related to a potential lack of information regarding anaerobic environments and microbial diversity in New Zealand and if this may result in uncertainty about the potential impacts of *C. magnum* in the environment.
- 3.10 The EPA noted the ubiquitous nature of many environmental microorganisms and after assessing all the information, the EPA decided that *C. magnum* was likely to be ubiquitous; however, because it has not been isolated in New Zealand it must be treated as a new organism under the Act. Therefore, they did not consider that this uncertainty is material.
- 3.11 The EPA then considered whether *C. magnum* could cause any significant displacement of any native species within its natural habitat, cause any significant deterioration of natural habitats or cause any significant adverse effect to New Zealand's inherent genetic diversity.
- 3.12 The applicant provided evidence that *C. magnum* would be unable to dominate bacterial communities or environments due to simple energetic reasons and self inhibition. The applicant referred to publications by Lee *et al.* (2008) and Kim *et al.* (2011) which showed that *C. magnum* did not dominate a complex population.
- 3.13 Submitter Cliff Mason noted that an organism does not need to be predominant for it to have significant ecological effect.
- 3.14 The EPA noted that *C. magnum* would only be “metabolically active” when the appropriate conditions were present and essentially inert when the conditions were not appropriate.
- 3.15 After assessing all the information, the EPA decided that *C. magnum* was not likely to cause significant displacement of any native species within its natural habitat, cause any significant deterioration of natural habitats or cause any significant adverse effect to New Zealand's inherent genetic diversity.

Consideration of sections 36(c) and 36(e) of the Act

- 3.16 The EPA considered the final two minimum standards together:
- Is *C. magnum* likely to cause any significant adverse effects on human health and safety (section 36(c) of the Act)?



- Is *C. magnum* likely to cause disease, be parasitic, or become a vector for human, animal, or plant disease (section 36(e) of the Act)?

3.17 The applicant provided evidence at the hearing that *C. magnum* is a WHO Risk Group 1 organism (no or low individual and community risk) and has the same rating as baker's yeast (DSMZ, no date; ATCC, no date). The applicant stated that *C. magnum* is unlikely to cause disease in humans, animals or plants.

3.18 No further information regarding this was provided by submitters.

3.19 The EPA considered that after reviewing the known biological characteristics of *C. magnum*, there is no evidence that it will cause disease, be parasitic or become a vector for human, animal or plant disease.

3.20 After assessing all the information, the EPA decided that *C. magnum* is not likely to cause any significant adverse effects on human health and safety, or cause disease, be parasitic or become a vector for human, animal, or plant disease.

Conclusion on compliance with the minimum standards

3.21 The EPA decided that *C. magnum* meets the minimum standards as stated in section 36 of the Act.

4. The ability to establish an undesirable self-sustaining population and the ease of eradication

4.1 Section 37 of the Act requires the decision-maker to have regard to the ability of the organism to establish an undesirable self-sustaining population and the ease with which the organism could be eradicated if it established such a population.

4.2 The EPA noted that *C. magnum* could establish a self-sustaining population and that the eradication of such a population may be very difficult. However, as no adverse effects were identified, the EPA considers that a self-sustaining population would not be undesirable.

5. Effects of any inseparable organism

5.1 No inseparable organisms were identified.



6. Assessment of adverse effects¹

6.1 The EPA considered the potential adverse effects of the organism on human health and safety, the environment, society and communities, Māori culture and traditions, the principles of the Treaty of Waitangi (Te Tiriti o Waitangi) and the market economy.

Effects on the environment

6.2 As discussed in sections 3.2-3.20, the EPA did not consider that it was likely that *C. magnum* would cause any significant displacement of any native species within its natural habitat, cause any significant deterioration of natural habitats, cause any significant adverse effect to New Zealand's inherent genetic diversity or cause disease, be parasitic or become a vector for animal or plant disease.

6.3 The EPA did not identify any other adverse effects.

6.4 After assessing all the information, the EPA did not identify adverse effects on the environment from the release of *C. magnum*.

Effects on human health and safety

6.5 As discussed in sections 3.16-3.20, the EPA did not consider that *C. magnum* is likely to cause any significant adverse effects on human health and safety.

6.6 After assessing all the information, the EPA did not identify any other adverse effects on human health and safety from the release of *C. magnum*.

Effects on Māori and their culture and traditions and the principles of the Treaty of Waitangi (Te Tiriti o Waitangi)

6.7 The EPA took into account the effects on the relationship of Māori and their culture and traditions with their ancestral lands, water, sites, waahi tapu, valued flora and fauna, and other taonga, and the principles of the Treaty of Waitangi (Te Tiriti o Waitangi).

6.8 The applicant did not identify any adverse effects on the relationship of Māori to the matters identified above but stated that they would be open to discussing their proposal with local iwi/hapū.

6.9 The applicant stated that they intend to consult with local iwi. They are currently in discussions with several Māori groups to gain understanding of how to consult and engage properly.

¹ Adverse effects can include any risks and costs associated with the release of the organism



- 6.10 Submitter Clean Earth requested that the EPA assist the applicant to identify the groups to consult with at the sites of the proposed processing plant(s). The EPA stated that they are open to providing the applicant with assistance to establish relationships with the tangata whenua at the site(s) of any proposed processing plant(s).
- 6.11 After assessing all the information, the EPA did not identify adverse effects on the relationship of Māori and their culture and traditions with their ancestral lands, water, sites, waahi tapu, valued flora and fauna, and other taonga.
- 6.12 Given the absence of identified effects to the outcomes of significance to iwi/Māori (as outlined in the Protocol 'Incorporating Māori perspectives in HSNO Act decision making') the EPA considers the application to be broadly consistent with the principles of the Treaty of Waitangi (Te Tiriti o Waitangi). As noted previously, the EPA encourages the applicant to consult widely with iwi in the proposed region/s of the activity.

Effects on the market economy

- 6.13 Neither the applicant nor submitters identified potential adverse effects on the market economy.
- 6.14 After assessing all the information, the EPA did not identify adverse effects on the market economy from the release of *C. magnum*.

Effects on society and community

- 6.15 Neither the applicant nor submitters identified potential adverse effects on society and community.
- 6.16 After assessing all the information, the EPA did not identify adverse effects on society and community from the release of *C. magnum*.

Conclusion

- 6.17 After considering the information, the EPA did not identify adverse effects from the release of *C. magnum*. Therefore the EPA considered that any adverse effects from the release of *C. magnum* would be negligible. As the EPA did not identify adverse effects from the release of *C. magnum*, the EPA was not required to take into account the probability of occurrence and magnitude of any adverse effects.



7. Assessment of positive effects²

7.1 The EPA considered the potential positive effects (benefits) of the organism on human health and safety, the environment, society and community, Māori culture and traditions, and the market economy.

Potential long term positive effects

7.2 The applicant and submitters NZBIO and Clean Earth identified that there may be potential long term positive effects from technologies that use waste gases and capture CO₂ emissions for the environment, human health and safety, Māori culture and traditions, and the market economy. The applicant also identified the production of acetic acid as a potential positive effect.

7.3 Other long term positive effects that were identified include those related to the international clean tech market e.g. high paying jobs and high margin products, and services for export.

7.4 The EPA noted that such long term positive effects (which would require the commercial adoption in New Zealand and overseas) would depend upon which facilities adopt the technology, their current level of carbon-based gas emissions and the level of reduction in carbon-based gas emissions and production of acetic acid production seen after the use of this technology.

7.5 The EPA considered that it would be too speculative for an assessment to be made of the potential long term positive effects, and therefore considered the potential shorter term positive effects.

Potential shorter term positive effects

7.6 The applicant, submitters NZBIO and Clean Earth, and the EPA identified a range of shorter term positive effects (e.g. related to the development of a pilot plant).

7.7 The EPA identified the following value propositions:

- Securing intellectual property for New Zealand.
- Innovation in gas fermentation and reactor technologies.
- Innovation in using microorganisms to convert waste products to valuable products and as a consequence reducing carbon emissions.

7.8 The EPA considered the significant funding and investments obtained by the applicant to be evidence of these value propositions. For example:

- a US \$55.8 million investment publicised in January 2012 (LanzaTech, 2012).

² Positive effects can include any benefits associated with the release of the organism



- a US\$3 million contract publicised in December 2011 (LanzaTech, 2011a).
- a US\$18 million investment publicised in July 2011 (LanzaTech, 2011b).

7.9 The EPA sees these value propositions as appropriate as they capture value for New Zealand from the development of clean technologies. The EPA noted the statements by submitter NZBIO that they support a strong regulatory system because New Zealand's ability to produce safe products is crucial to our reputation as a trading partner, and because there is a 'halo effect' from being known as a clean, green, transparent, and safe location that will deliver safe products and be a safe country to live in and do business in.

7.10 After assessing all the information, the EPA identified the following significant positive effects that will be created from the approval of this application:

- Gaining scientific knowledge from the operation of the plant(s), honing the process for commercialisation and intellectual property generation.
- Retaining international class scientific talent in New Zealand.
- Society and community beneficial effects from the development and use of sustainable 'green' technologies and greenhouse gas-capturing technologies.
- Providing growth and support opportunities for associated companies including enhancing the ability to form partnerships with carbon gas emitters and promoting increased international investment into research and development.

7.11 After considering the information, the EPA considered the magnitude of these positive effects to be **major** based on their significance to New Zealand and New Zealanders. The EPA assessed the likelihood of these positive effects as **very likely** given the applicant's previous successes. The EPA therefore considered the positive effects were **high**.

7.12 The EPA noted that a Māori submission indicated an alignment between Māori principles of environmental sustainability, and the proposed method of converting waste materials into usable products. This is an instance where science can support cultural aspirations and the EPA therefore recommended that the applicant initiate ongoing relationships with the local iwi-hapū, to report back progress to the HSNO Committee, and support their development of future activities that align with environmental sustainability.

8. Other issues raised by submitters

Requests to limit the approval to non-sporulating strains of *C. magnum*

8.1 Submitter Cliff Mason requested that *C. magnum* be limited to non-sporulating laboratory strains.



- 8.2 The EPA noted that endospores could be formed by *C. magnum*.
- 8.3 The applicant stated that they have been working with laboratory isolates since 2007 and they have not observed spore formation (*C. magnum* is grown in dissolved gaseous substrates). The applicant noted that their fermentation process selects for bacteria that are non-sporulating and therefore the formation of endospores will be a very rare event. The applicant noted that in one published paper, *C. magnum* was observed to produce endospores when grown on certain sugars (Schink, 1984) and these nutrients are not used in the fermentation process.
- 8.4 The applicant stated that the endospores will not increase the ability of *C. magnum* to impact the environment. Cliff Mason stated that endospore production will give *C. magnum* the capability of surviving and being transported to distant anaerobic habitats.
- 8.5 The EPA acknowledges that limiting the approval to non-sporulating strains is a mechanism to reduce the persistence of certain microorganisms in the environment, and that imposing controls is a mechanism of controlling the adverse effects of an organism to people or the environment.
- 8.6 The EPA considered that as no adverse effects have been identified from the release of *C. magnum*, restrictions on approving the release of only non-spore forming strains of *C. magnum* will not be imposed.

Requests to impose controls to contain *C. magnum*

- 8.7 Controls are restrictions imposed for the purposes of controlling the adverse effects of a new organism on people or the environment. Submitter Cliff Mason requested that *C. magnum* that controls be imposed so that *C. magnum* is contained.
- 8.8 The EPA noted that in regards to the applicant's proposed activities, although the nature of the *C. magnum* requires oxygen to be excluded from the bioreactor during the fermentation process, this is not 'containment'. Under the Act, 'containment' means restricting an organism to a secure location or facility to prevent escape.
- 8.9 The EPA noted that the cost of containment would be prohibitive and that overseas only microorganisms with adverse human health effects require containment.
- 8.10 The EPA considered all the information presented but decided that as no adverse effects have been identified from the release of *C. magnum*, controls to contain the microorganism will not be imposed.



9. Achieving the purpose of the Act

- 9.1 The purpose of the Act is to protect the environment, and the health and safety of people and communities, by preventing or managing the adverse effects of hazardous substances and new organisms (section 4 of the Act).
- 9.2 In order to achieve the purpose of the Act, when considering the application the EPA recognised and provided for the following principles:
- a) the safeguarding of the life-supporting capacity of air, water, soil and ecosystems; and
 - b) the maintenance and enhancement of the capacity of people and communities to provide for their own economic, social and cultural well-being and for the reasonable foreseeable needs of future generations.
- 9.3 The EPA took into account the following matters when considering the application in order to achieve the purpose of the Act:
- the sustainability of all native and valued introduced flora and fauna;
 - the intrinsic value of ecosystems;
 - public health;
 - the relationship of Māori and their culture and traditions with their ancestral lands, water, sites, waahi tapu, valued flora and fauna, and other taonga;
 - the economic and related benefits and costs of using a particular hazardous substance or new organism;
 - New Zealand's international obligations;
 - the need for caution in managing adverse effects where there is scientific and technical uncertainty about those effects; and
 - the principles of the Treaty of Waitangi (Te Tiriti o Waitangi).
- 9.4 The EPA is satisfied that this decision is consistent with the purpose of the Act and the above principles and matters. Any substantive issues arising from the legislative criteria and issues raised by submitters have been discussed in the preceding sections of this decision.



10. Evaluation and weighing of positive and adverse effects

- 10.1 Given that there were no adverse effects, consideration of whether the adverse effects may aggregate in order to assess any cumulative effects was not relevant.
- 10.2 Overall, the EPA did not identify adverse effects from the release of *C. magnum*.
- 10.3 The EPA concluded that the positive effects accruing from the release of *C. magnum* are **high**.
- 10.4 Therefore, given the organism meets the minimum standards set out in section 36 of the Act, the EPA took into account all the effects of the organism, the effects of any inseparable organism, and the matters in section 37, and concluded that the positive effects of releasing the organism outweigh the adverse effects.

11. Decision

- 11.1 After reviewing all of the information contained in the application, the EPA was satisfied that the application met the requirements of section 34 of the Act. In any event, in accordance with section 59(3)(a)(ii), the EPA waives any information requirement that has not been met as requested by the applicant in its application.
- 11.2 The EPA considered that the threshold for approval under section 38 of the Act had been met, as it concluded that the organism met the minimum standards set out in section 36 of the Act and that the positive effects of the organism outweighed the adverse effects of the organism, taking into account all of the following:
- all the effects of the organism;
 - the matters in section 37 of the Act;
 - the relevant matters in Part 2 of the Act; and
 - the Methodology.
- 11.3 The EPA decided to exercise its discretion and approve the release of *C. magnum* under section 38(1)(a) of the Act. The EPA noted that in accordance with section 38(2) of the Act, the approval has been granted without controls.
- 11.4 The EPA noted that under section 38(3) of the Act, if *C. magnum* has not been released within five years of the date of this decision, the approval will lapse. However, any person may apply before the expiry of the time limit for an extension of that time limit for a further period of up to five years.
- 11.5 The EPA noted that section 38(4) of the Act requires that every person that releases the organism



within five years of the date of this decision, notify the EPA within one month after the date of release.

- 11.6 The EPA would like to thank all people who submitted information that has been used by the EPA in making this decision.

Dr Val Orchard
Chair, Decision Making Committee
Environmental Protection Authority

3 May 2012

Approval code: NOR100063



Approval number for organism on application ERMA200833

Approval number	Organism
NOR100063	Clostridium magnum



References:

ATCC no date. <http://www.straininfo.net/strains/113907/browser> - retrieved April 2012.

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

DSMZ no date.

<http://www.straininfo.net/strains/113908/browser;jsessionid=5FD2583CA21EF67F8C43BD26B2A4061C> - retrieved April 2012.

Karnholz , A, Küsel, K, Gößner, A, Schramm, A, Drake, HL 2002. Tolerance and metabolic response of acetogenic bacteria toward oxygen. *Applied and Environmental Microbiology* 68: 1005-1009.

Kim, J, Shin, SG, Han, G, O'Flaherty, V, Lee, C, Hwang, S 2011. Common key acidogen populations in anaerobic reactors treating different wastewaters: Molecular identification and quantitative monitoring. *Water Research* 45: 2539-2549.

LanzaTech 2011a. Press release - LanzaTech Gets US\$3 Million Contract From FAA For Alcohol To Jet Project.

http://www.lanzatech.co.nz/sites/default/files/imce_uploads/dec_1_2011_lanzatech_receives_faa_contract_for_alcohol_to_jet_project_0.pdf - retrieved April 2012.

LanzaTech 2011b. Press release - Global investment in CleanTech sees LanzaTech riding high.

http://www.lanzatech.com/sites/default/files/imce_uploads/series_b_funding.pdf - retrieved April 2012.

LanzaTech 2012. Press release - LanzaTech Closes US \$55.8 Million Series C Round.

http://www.lanzatech.co.nz/sites/default/files/imce_uploads/seriesc_lanzatech_final_for_release.pdf - retrieved April 2012

Lee, C, Kim, J, Shin, SG, Hwang, S 2008. Monitoring bacterial and archeal community shifts in a mesophilic anaerobic batch reactor treating a high strength organic waste water. *FEMS Microbiology Ecology* 65: 544-554.

Luo, Y, Zhang, H, Salerno, M, Logan, BE, Bruns, MA 2008. Organic loading rates affect composition of soil-derived bacterial communities during continuous, fermentative biohydrogen production. *International Journal of Hydrogen Energy* 33: 6566-6576.

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

