Waste Flue Gas CO to Innovative Biofuel Production

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ABSTRACT

As the world's population and fossil derived fuels and chemicals consumption increases, there is a growing need to use renewable feed stocks as an energy source.

LanzaTech, founded in 2005 in New Zealand, offers a fully integrated sustainable fuels and chemicals platform that uses local, abundant waste and low cost resources to produce fuels such as ethanol[Error! Bookmark not defined.1] and chemicals such as 2,3Butanediol (2,3BD)[2] at high selectivity and yields.

The patented process uses a robust, feedstock agnostic microbe to convert gas rich in CO into fuels and chemicals. These gases are readily available resources. Industrial flue gases from steel mills and processing plants, typically flared or used as a source of fuel; syngas generated from any biomass resource (such as municipal biowaste, organic industrial waste, and agricultural waste); coal derived syngas; and steam reformed methane are good examples. The LanzaTech technology has enjoyed rapid uptake and is in advanced stage of commercialization.

1 THE LANZATECH PROCESS

The process progresses as follows. First, waste gas feedstock are fed to a bioreactor with added fresh media that contains the microbes and consists mostly of water with a specific mixture of nutrients, salts, and metals.

In the bioreactor, fermentation now takes place. (Figure 1) LanzaTech's proprietary microbe, the company's unique bioreactor design, and novel gas introduction methods allow the process to maximize the gas to liquid mass transfer and enhance the gas dissolution.

LanzaTech's gas fermentation process can use gas streams with flexible CO /and H2 input gas ratios. While both CO and H2 are utilized in the LanzaTech process, LanzaTech's proprietary microbes are also able to consume hydrogen-free CO-only gas streams, due to the operation of a highly efficient biological water gas shift reaction[3] within its proprietary bacteria.

The use of waste gases in a microbial fermentation has never been attempted before because of concerns that contaminants in the waste would inhibit conversion to ethanol. LanzaTech's patented microbes were selected based on their ability to use these gases as a nutrient source with minimal clean up[4].

LanzaTech is consequently able to eliminate virtually all capital costs associated with gas conditioning and cleaning at a commercial scale, a significant advantage over conventional thermo chemical processes.

Next, vent gases are relased. The vent gas from the bioreactors contains all inert components such as N_2, CH_4, and CO_2 that were present in the feed stream, as well as unconverted carbon monoxide and hydrogen.

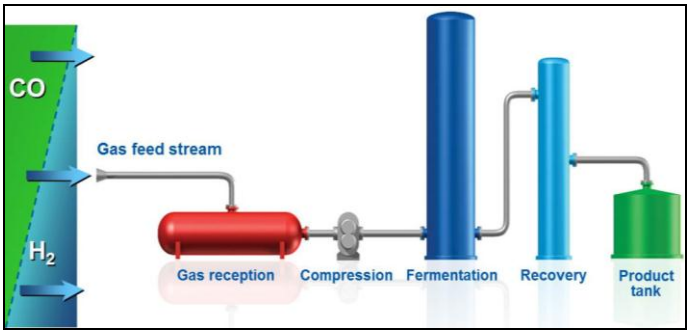

Figure 1: Schematic of the LanzaTech process

The process also contains additional carbon dioxide generated by the fermentation. The gas is scrubbed to remove any additional ethanol and water, then cleaned before venting to remove any potential pollutants, such as H_2S.

If the vent gas contains sufficient heating value, it can be used as a fuel gas to supplement the process heat balance.

Carbon capture can also be employed at this stage to mitigate carbon emissions.

Finally, the fermentation broth is sent to the product recovery section to concentrate the ethanol to fuel grade at >99.5 wt%.

The microbes are separated from the liquid mixture and sent to an anaerobic digestion system, generating biogas that can also be used as a fuel gas.

2 PRODUCT APPLICATIONS

LanzaTech is working with a partner to develop a novel system for recovery of 2,3BD, a C4 dialcohol that can be converted into conventional chemicals (such as methyl ethyl ketone and butadiene), as well as drop-in fuels (such as gasoline, jet, or diesel fuel), from the fermentation broth.

Results indicate it is possible to recover both the ethanol and the 2,3BD, with both products meeting purification specification, at a utility consumption less than recovery of ethanol alone by distillation.

While additional capital is required for this recovery system, the recovery of the higher value 2,3BD leads to a payback of less than one year for the incremental capital.

LanzaTech is also using synthetic biology to enable production of other chemical products such as propanol, n-butanol, and acetone. LanzaTech is actively working with partners for the conversion of these products into downstream petrochemicals and drop-in fuels.

3 FLEXIBLE, GREEN PRODUCT

The low temperature, low pressure gas fermentation route benefits from tolerance to several impurities, and the ability to utilize a flexible H_2/CO ratio feed gas eliminates the need for extensive gas clean-up or conditioning.

The microbes used in the gas fermentation process can convert nearly all of the carbon to fuels or chemicals at high selectivity compared to the conventional chemical syntheses routes. The result is higher overall fuel and thermal efficiency.

Life cycle analysis demonstrates due to higher carbon to fuel conversion efficiency, the gas fermentation route produces less carbon emissions making it an overall 'greener' process with lower CCS requirements compared with producing conventional petroleum products.

Of critical importance, the LanzaTech process' products can be produced at the scale needed to satisfy energy demands, using feed stocks that do not compete with the food value chain.

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4 GAME CHANGING TECHNOLOGY

LanzaTech estimates that 65% of steel mills worldwide use technology that could be retrofitted with the LanzaTech Process. In the ethanol market, LanzaTech's waste gas to ethanol process could potentially be utilized to produce nearly 11 billion gallons of ethanol from steel mill off gases in China alone. Worldwide nearly 30 billion gallons of ethanol could be produced annually through steel mill waste gases using LanzaTech's process, which has the potential to significantly impact, the global fuel pool. The technology has been proven at pilot scale since 2008 at the NZ steel mill in Glenbrook, New Zealand.

5 THE ROAD FORWARD

Lanzatech is now building two demonstration facilities at steel mills in China. One of these facilities will be in partnership with BaoSteel (the world's second largest steel producer), in Shanghai. It will produce 100,000 gallons per annum.

The first full scale commercial production facility in Shanghai will produce 30 million gallons per annum by the end of 2013. China produces 50% of the world's steel and consumes 90% of that domestically. It also has ethanol mandates across many provinces, and so is an ideal first market for LanzaTech's technology.

Additional demonstration plants across a variety of geographies are scheduled for 2012. These include a second steel waste gas plant with Capital Steel in China, a facility using municipal solid waste derived syngas with Concord Enviro in India and in the USA, and a plant using biomass syngas derived from forestry waste.

REFERENCES

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