NZ pilot plant processes BOF gas to ethanol

The use of ethanol as a fuel in road transport has been advocated as a means of mitigating CO_2 emissions but has led to escalating food costs as maize and land is given over to its industrial production by fermentation. Microbial fermentation of the converter gas from steelmaking offers an alternative source of bulk supply.

THE MICROBIAL fermentation of converter waste gases to produce ethanol and other chemicals has been successfully demonstrated for over a year at a pilot plant in New Zealand.

Such a process has never been attempted before because of the concerns that contaminants in the flue gas would inhibit the conversion of the CO in the gas to ethanol. The proprietary microbe developed and owned by LanzaTech was selected based on its ability to produce ethanol from carbon monoxide without being adversely affected by the N_2 and CO_2 also present in the gas. Only dust and any remaining O_2 need be removed.

Dr Sean Simpson, cofounder of LanzaTech says the pilot plant at New Zealand Steel, Glenbrook, near Auckland has operated for over 2500 hours and continuously for over 500 hours. This demonstrates the potential for processing converter-off gas into commercial quantities of ethanol.

The NZ Steel flue gas pilot plant, commissioned in 2008, is demonstrating the potential for processing the industrial waste gas stream. With a 1000 litre fermenter capacity, the Glenbrook plant draws gas directly from the steelmaking converter off-gas stream and, with minimal cleanup to remove particulates and oxygen, processes the gas to ethanol.

Through the production of ethanol LanzaTech are able to not only sequester carbon in fuels and chemicals, which displace equivalent products produced from fossil resources, but also generate more than twice the revenue per volume of steel mill gas processed.

Practical concerns

The process copes well with the varying concentration of CO in converter gas which fluctuates as steelmaking proceeds. The pilot plant has been running for 12 months using such a mixed output from steelmaking without the variability of this gas stream posing any issue for the process in terms of productivity per unit energy in gas (eg per Giga Joule of gas processed).

The process can work with gas streams that contain as little as 15% CO, therefore even blast furnace gas presents a viable feedstock for the process. Converter gas typically averages 40-50% CO with 1-2% H_2, the remainder being N_2 and CO_2.

The N_2 and CO_2 components in the gas create no problems, only the removal of dust form the gas stream is necessary. The microbes are tolerant of all gas components of the converter stream.

The 'Why Ethanol' section is taken from publications by the late Dr John Stubbles

In the total absence of hydrogen as is (effectively) the case with converter off-gas, the microbes generate their own hydrogen via a biological water gas shift reaction. This reaction releases some CO_2. However, with increasing levels of hydrogen in the gas the CO_2 emission is eliminated, and all input carbon is captured in the product stream.

LanzaTech's continuous fermentation of raw steel mill gas has shown no impact on microbial viability, growth or productivity when compared to a synthetic gas equivalent. This virtually eliminates capital cost associated with gas conditioning which is a major advantage over existing gas-to-liquid conversion technologies.

Alternative gas sources

In addition to blast furnace gas, biomass syngas is an alternative supply source. This is generally a mixture of CO and H_2 at various ratios depending on the gasification technology used. However LanzaTech is able to reform the methane component of biogas produced in high volumes such as from the bacterial digestion of land-fill and other organic waste material. In this case a reformer is necessary to produce a stream of CO and H_2 from the methane component in the biogas.

Why Ethanol?

The Bush administration set a goal of 35bn US gallons of ethanol production per year by 2022. The Obama administration has reduced this to 21bn gallons. Most of this is from corn (maize) and has already led to escalating costs for food from this crop particularly in countries relying on export of maize from USA.

In 2008, the US production figure for ethanol was over 8bn US gallons as many farmers took advantage of a \$0.54/gallon subsidy and a tariff protection from Brazilian ethanol of \$0.51. As ethanol has 35% less energy than gasoline, 8bn gallons has the equivalent energy of about 0.4 million barrels of oil a day (MMB/D) but requires a land area of about 34000 square miles to grow the corn.

The microbes developed for the fermentation of CO to ethanol in converter waste gas are tolerant to variable concentrations of CO and the presence of N_2 and H_2

Over 100 plants now produce ethanol in the US and another 75 were planned or under construction in 2008.

Brazil adopted a programme of bio ethanol production in the 1970s when the first oil embargoes occurred; all their vehicles can now use either gasoline or ethanol. They have the advantage that the conversion of sugar cane to alcohol is much cheaper than the use of corn as a feedstock, where the starch to sugar step must first occur.

Today, most gasoline contains about 3% ethanol now that lead compounds have been removed, and this is the current primary market for ethanol.

An 85% blend of ethanol and gasoline (E85) is also marketed on a limited scale but since the energy from ethanol (35% oxygen by weight) is only 66% that of gasoline the miles per gallon for E85 falls by around 25%.

E85 can only be used in vehicles designed for that fuel, although such vehicles can use regular gasoline. In USA, there are only a limited number of service stations dispensing E85 ($<1\%$) and this, coupled with the higher cost per mile, deters motorists from using E85.

In addition, ethanol is corrosive and must be transported by truck. In the US, since the Midwest is the primary producer, ethanol in the South and West is expensive.

Finally, for ethanol produced from corn, the net CO_2 savings per gallon of ethanol (fertilising, harvesting, producing, transporting) may be marginal relative to the use of hydrocarbon oils. ■

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LanzaTech Ltd

The potential of the LanzaTech process was identified in 2005 and 'angel' investors were found to finance the commercialisation of its proprietary low-cost fuel synthesis process in an industrial facility.

A 'Series A' investment by a consortium led by Vinod Khosla (founding CEO of Sun Microsystems and who is now a venture capitalist with an eye for world leading clean technology) expanded the development to include biomass-derived syngas.

LanzaTech has collected the 'Green Technology Innovator of the Year' award at the annual Frost and Sullivan Asia Pacific Industrial Technologies Awards in Singapore. These awards are considered a measure not only of the current market, but also of emerging technology trends in chemicals, materials and foods, measurement and instrumentation, industrial process control, environment and building technologies and electronics and security as well as energy and power systems.