Gas Fermentation at Calysta

Intro for REMEDY workshop
October 20, 2020
Gas Fermentation is the Next Step in Industrial Biotech

• Lower cost feedstocks are needed for biological products to compete with petroleum derivatives

• C1 feedstocks (CH$_4$, CO, CO$_2$) are accepted to be among the cheapest sources of carbon

• C1 feedstocks are generally pollutants, with significant safety and solubility issues compared to traditional biofeedstocks

• Calysta owns the world’s only commercially-validated gas fermentation technology allowing use of C1 feedstocks
**Calysta’s Methanotroph Platform**

*Methylococcus capsulatus* Bath

- Gammaproteobacteria, type I methanotroph
- Relatively fast growth rate (methane:oxygen mix)
- Genome sequence available
- Amenable to genetic manipulation
- Only methanotroph proven at commercial scale
- Variety of formats for strain testing: well plates, pressure bottles, 2L fermenters
- Amended media and optimized feeding strategies produce high cell densities in small scale.
Calysta’s Platform: Strain Engineering

Calysta has developed a set of novel engineering tools for methanotrophs:

- Reporter genes

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- Plasmids that replicate both in methanotrophs and in *E. coli*
- Constitutive and inducible (low/med/high) promoters
- Techniques for chromosomal knockin and knockouts
Calysta Performs Methanotrophic Fermentation at All Scales

High Throughput

Fermentors

NorFerm Commercial Plant

China Plant

TPP

Nanjing Demo Lab

Calysta
Calysta FeedKind Production Process

**Fermentation**

- Gases are mixed in a proprietary fermenter where they are consumed by Calysta's natural microorganisms, which form the basis of *FeedKind* protein.

**Separation**

- *FeedKind* protein is separated from the aqueous media in which it is grown, with water and nutrients returned back to the fermenter.

**Drying and Packaging**

- *FeedKind* protein is dried and packaged per customer specifications.

**Distribution**

- Products are shipped to be fed to fish and livestock worldwide.

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*FeedKind*
FeedKind Protein Commercial Samples Shipping Worldwide from Teesside UK Plant

- Production of ~50 tons/year
- Shipping commercial samples to customer and partners worldwide
- Facility is a “scale-down” of the original Tjeldbergodden, Norway reactor, demonstrated to produce at a rate of 10,000 mtpa
- Successful maintenance of 12+ weeks of continuous fermentation, exceeding design parameters for key commercial metrics such as yield and productivity
- Partnered with Center for Process Innovation (“CPI”) to provide on site services and well trained staff
FeedKind® is a Natural, Non-GMO Protein Source

FeedKind Protein is composed of naturally occurring microorganisms that metabolize methane as their sole source of carbon and energy, producing a nutritious, high-protein biomass.

✓ **FeedKind is a non-GMO source of protein obtained by natural fermentation**

**EU Register of Feed Ingredients, 2017**

| 12.1.2 | Product from *Methylococcus capsulatus* (Bath), *Alcaligenes eutrophus* and *Bacillus firmus* rich in protein (1) (2) | Fermentation product obtained by culture of *Methylococcus capsulatus* (Bath) (NCIMB strain 11132), *Alcaligenes eutrophus* (NCIMB strain 13287), *Bacillus brevis* (NCIMB strain 13288) and *Bacillus firmus* (NCIMB strain 13289) on natural gas (approx. 91 % methane, 5 % ethane, 2 % propane, 0.5 % isobutane, 0.5 % n-butane), ammonia, and mineral salts, the crude protein is at least 65 %. | Crude protein | Crude ash | Crude fat | Propionic acid if > 0.5 % |

✓ **Approved in the EU, Japan and Australia**
✓ **Can be used in Canada and in the Philippines**
✓ **On-going regulatory process in the USA**
✓ **Additional countries in process**
Calysta Commands a Leading IP Position, Creating Significant Barriers-to-entry

- >50 granted patents with over 100 pending applications covering more than 22 patent families
- Strong claims covering proprietary reactor design that have already invalidated one potential competitor’s patent
- Broad claims granted in 2016 covering biological production of any chemical from natural gas
- Aggressively filing on new gas fermentation reactor designs and improvements with 4 new issued patents and 15 applications in the area
- 38 pending applications in the area of animal feed