BBSRC NIBB AD Network
Seeding Catalyst Awards: Title and publically available summary

2017 Seeding Catalyst Awards

SC2017002
In-situ bio-methanisation for small-scale biogas upgrading
A translational demonstration from academic research to industrial application is planned by operating a pilot-scale hybrid technology, developed to combine renewables-driven electrolytic H2 production with anaerobic digestion (AD). This allows biogas produced in AD to be upgraded to around 95% CH4 by biochemical reduction of its CO2 content. The process uses direct injection of H2 into the digester and, through continuous monitoring and control, matches this to the available carbon in its oxidised form of CO2. By adaptive evolution the system biology of the digester promotes carbon flow predominantly through hydrogenotrophic methanogenesis, thus maximising the conversion of the carbon present in waste biomass into a useful fuel product, and increasing the CH4 yield by 40% or more. This approach opens up possibilities for using untapped waste biomass resources, by making better use of the digester's working volume to produce the more energy-dense gaseous biofuel known as biomethane. Although the process could be used at any scale, with potential commercial markets as an energy storage solution for balancing supply and demand in the electricity grid network, the current proposal focuses on smaller-scale applications. This approach has greater potential for integration with on-farm use of digestion and in meeting the sustainability challenges faced in developing countries. In both cases it offers the possibility of supplying local energy needs by producing a storable product for use in low-pressure gas distribution systems, as compressed bottled gas supplies or as a low-pollution vehicle fuel.
PI: Dr Sonia Heaven Water and Enviromental Engineering Group, Faculty of Engineering and the Environment, University of Southampton, Southampton, SO17 1BJ. Also: Prof. Charles Banks, University of Southampton **Partner:** LUTRA LTD.

SC2017003
Evaluation on thermal pre-treatment to enhance digestibility of an emerging type of sludge-aerobic granular sludge
Aerobic granule sludge (AGS) is a novel and promising technology for wastewater treatment in the context of circular economy. Compared with conventional activated sludge, AGS features with 75% less footprint, 50% less energy consumption, much more simplified process for carbonaceous pollutant, nitrogen and phosphorus removal and better effluent quality. Because of these advantages, AGS technology has been commercialized very quickly with more than 30 full scale facilities constructed worldwide and 3 in the UK. It is expected that with much less energy consumption, the energy recovery via digestion could move AGS plant towards energy self-efficiency or even net energy output. However, due to distinctive characteristics of AGS such as big size, compact structure, high content of extracellular polymeric substances, and high ash content in the sludge, AGS from some conditions has 58% less digestibility compared with activated sludge although a comparable digestibility was also reported. These contradictory results indicate an uncertainty of AGS digestibility as well as the possible dependence of digestibility of AGS on the characteristics of sludge. To enhance AGS digestibility from different conditions and to reduce the final residual solid disposal, sludge pre-treatment is necessary. Among different sludge pre-treatment approaches, thermal pre-treatment is one of the most commonly used methods. This project will thus evaluate the thermal pre-treatment of AGS to enhance digestibility of AGS and establish the correlation between characteristics of AGS and thermal pre-treatment conditions for digestion enhancement.
PI: Dr Yongqiang Liu Faculty of Engineering and the Environment University of Southampton Southampton, SO17 1BJ. **Partner:** CAMBI GROUP AS.

SC2017004
Biogas methane as a feedstock for a sustainable bioprocessing
The Aim: To explore the feasibility of use biogas methane as a feedstock to produce chemical commodities using methane consuming bacteria as a process organism in gas fermentation. **The Need:** Biogas methane, the main product of anaerobic digestion (AD), is an energy-rich feedstock with an energy density of 55.7 MJ/kg at 1.013 bar, 15 ºC. Raw AD biogas is roughly 60% methane and 29% CO2 with trace elements of H2S. The methane concentration is insufficient for direct use as fuel gas for machinery and the H2S is highly corrosive to the mechanical components. Considerable money and effort has to be expended in the purification of methane and for its combustion to generate electricity. Consequently, in many cases, it is not cost-effective to use raw biogas as a fuel for electricity production and is flared at the site, causing Green House Gas emission and environmental damage. **The Solution:** We shall convert biogas methane through a biological process to the polymer, polyhydroxybutyrate (PHB), which can be easily converted into a wide variety of different plastics. From a business standpoint, it makes more sense to use methane as a feedstock than to burn it for power production. PHB sells for $3 to $4 a kilogram on today's market, while methane burned for electricity production would return as little as 40 to 80 cents a kilo. **The Delivery:** The successful completion of this project would represent the essential initial step in the development of a potential future sustainable bioprocess at industrial scale.
PI: Dr Ying Zhang (Biological Engineering) Nottingham BBSRC/EPSRC Synthetic Biology Research Centre (SBRC), B11, Centre for Biomolecular Sciences Building, The University of Nottingham, University Park, Nottingham, NG7 2RD Also: Prof. Nigel Minton (Applied Microbiology & SBRC Director) Dr Helen West (Environmental Biology/AD specialist)

SC2017005
Determining the influence of feedstocks on the analysis and suitability of separated anaerobic digestate fibre for commercial-scale mushroom substrate production
G's Fresh is a major producer of fresh vegetables and mushrooms. It has a 3 MW, two-stage mesophilic AD plant at Littleport, Cambridgeshire which processes over 50,000 tonnes of maize and rye, 8,500 tonnes of vegetable wastes and 2,000 tonnes of chicken manure annually. This produces over 6,000 tonnes of mechanically separated digestate fibre, accredited to PAS 110, and currently disposed of to land. Adjacent, it has the UK's largest and most advanced mushroom farm, which utilizes 25,000 tonnes of imported substrate to produce 8,000 tonnes of button mushrooms annually. An AD Network BIV project (2016007) has shown that the digestate fibre can be converted into a mushroom cropping substrate, potentially saving up to £1.5M annually on imported mushroom substrate. G's have invested in the construction of bulk processing containers for this purpose. This project will determine the influence of AD feedstocks and the additions of gypsum and different straw types on the analysis and suitability of the separated fibre for producing a mushroom substrate component. The UK mushroom industry currently uses around 300,000 tonnes of mushroom substrate annually. In Europe, more than 4M tonnes of substrate are produced annually. This project has the potential to develop a new, high value market for separated digestate fibre, thus improving the economic viability of AD and separation of the liquid digestate which is easier to apply to crops than whole digestate.
PI: Prof Ralph Noble, NIAB EMR, East Malling, Kent, ME19 6BJ **Partner:** G'S FRESH LTD.

SC2017007
Characterising marine-based microbial communities for commercial anaerobic digestion
A major consideration prior to increasing the scale of production at Algal Omega-3 (AO3) is disposal of produced waste. From a proprietary saline-based fermentation c.a. 85% of the volume is discharged as waste rich in nutrients and solid cellular material. Discharge or treatment of this waste has an associated cost, both fiscal and environmental. Anaerobic digestion of this waste has the potential to (i) reduce costs, (ii) recover value (to offset production costs) and (iii) reduce environmental impact. This project will explore whether a marine-tolerant microbial community can carry out effective anaerobic digestion of this high salt waste stream. We propose to carry out a lab scale (30L) study to identify a suitable salt tolerant microbial community for AD of AO3's waste material. We will also quantify the ability of that community to remove 'billable' content from AO3's production waste with the aim of rapidly implementing a viable solution at their production site in Liverpool.
PI: Dr James Chong Department of Biology, University of York, YO10 5DD **Partner:** ALGAL OMEGA-3 LTD.