Advancing Gas Fermentation Technologies: A multi-disciplinary challenge

Summary of key R&D priorities

The overall goal is to develop our understanding of gas fermentation systems to allow optimisation of operational strategies and conversion efficiencies. Key areas for R&D to achieve this are:

Microbial

- Exploration of more diverse (i.e. non-model) microbial species and communities, including those able to produce novel products, deal better with contaminants, or work under more extreme environmental conditions
- Development of new tools for genetic characterisation and manipulation of non-model organisms
- Systems biology of unique microbes and microbial communities, and metabolic responses to their environment
- Gas-liquid-biomass interactions and microbial inhibition mechanisms during gas fermentation
- Data collection for development of multi-scale mechanistic and predictive modelling tools

Engineering Envelope

- Rheological properties of complex multi-phase liquids and their influence on gas and mass transfer
- Hydrodynamics of bioreactor mixing and mass transfer for process intensification
- Process monitoring tools (e.g. for measurement of dissolved gases and concentration gradients) as a basis for control and optimisation
- Multi-scale mechanistic models, incorporating metabolic and hydrodynamic aspects, to de-risk scale up
- Effective designs for bioreactor manufacture and operation

Other

- Scale-up studies, including the influence of scale effects and the development of reliable scale-down models
- Feedstock mapping and characterisation of production facilities
- Product selection and diversification
- Process integration and optimisation with upstream, downstream and sidestream components, including coordinating supply and demand
- Predictive modelling tools leveraging AI, machine learning and big data
- Support for economic and business models to improve investor confidence

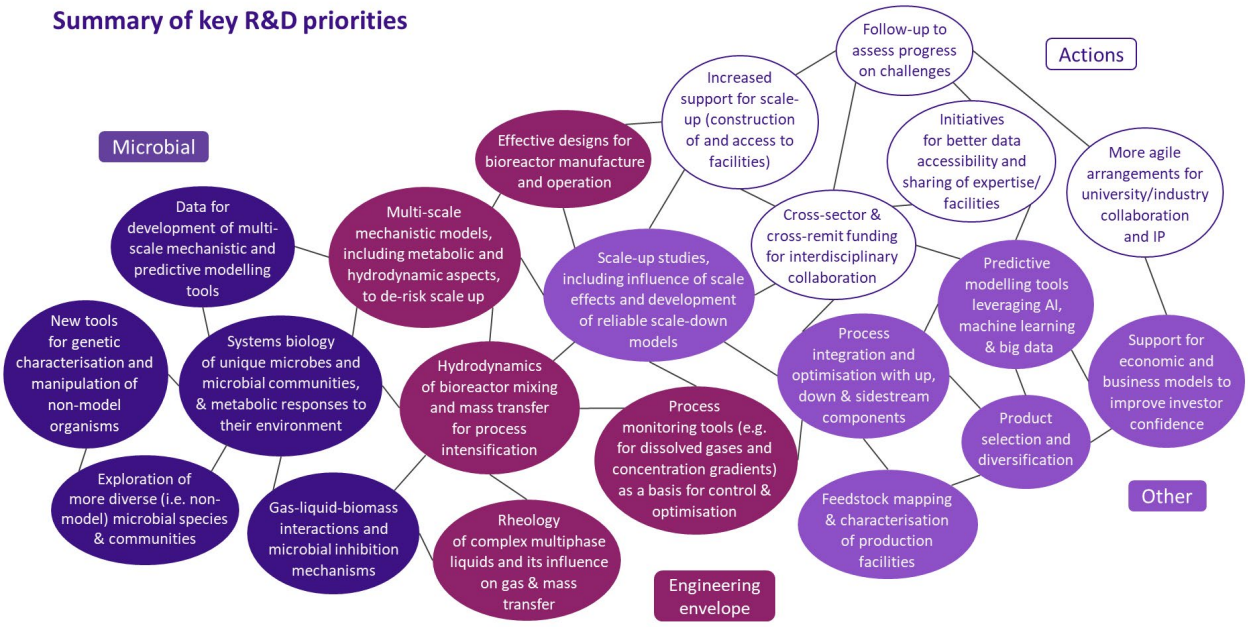
Actions needed include:

- Cross-sector and cross-remit funding enabling collaboration between disciplines
- Sharing infrastructure, knowledge, facilities, data. 'Fair' data practices and methods for sharing anonymised data. Improved discoverability (e.g. searchable databases). Enable inter-institutional access to facilities, lab equipment, etc.
- Increased support for scale-up (construction of and access to facilities) to allow quicker iteration between research and pilot-scale implementation
- More agile university/industry collaboration arrangements (including resolution of tensions between academic publication and IP protection).

Gaseous feedstocks can present safety and operational challenges, and two-stage processes based on pre-conversion to liquid substrates (e.g. methanol, formate) also warrant attention. Many of the R&D

issues identified here also apply to these processes, and addressing them would benefit a much wider range of industrial biotechnologies.

Follow-up is needed on the challenges and gaps identified: these should be re-assessed after 2 years to determine progress and further actions needed.



Workshop participants

Reuben Carr, Ingenza
James Chong, University of York
Sandra Esteves, University of South Wales
Christian Fink, Arkeon Ltd
Klaas Hellingwerf, University of Amsterdam
Raul Muñoz, Universidad de Valladolid
Sophie Nixon, University of Manchester
Bart Pander, University of Edinburgh
Marilene Pavan, Lanzatech
Kristi Potter, Centre for Process Innovation
Simon Rittmann, University of Vienna
Savvas Savvas, University of South Wales
Orkun Soyer, University of Warwick
Adrie Straathof, Delft University of Technology
Mark Walker, University of Hull
Joe Weaver, Newcastle University
Yue Zhang, University of Southampton
Will Zimmermann, University of Sheffield

Also contributing

Claudio Avignone Rossa, University of Surrey
Yadira Bajon-Fernandez, Cranfield University
John Bridgemann, University of Liverpool
Davide Dapelo, University of Liverpool
Antonio Grimalt-Alemany, Technical University of Denmark
Cees Haringa, Delft University of Technology
Ahsan Islam, Loughborough University
Michael Vedel Wegener Kofoed, Aarhus University
Ioannis Skiadas, Technical University of Denmark
William Sloan, University of Glasgow

Supported by

Sonia Heaven, Louise Byfield, Angela Bywater - ebnet@ebnet.ac.uk
Charles Banks, CJC Labs Ltd
Nigel Minton, Alan Burbidge - carbonrecycling@nibb.nottingham.ac.uk

This document was produced as part of a workshop on microbial systems with gaseous feedstocks, run jointly by the Environmental Biotechnology Network (EBNet, www.ebnet.ac.uk) and the Carbon Recycling Network (https://carbonrecycling.net) on 27-28 March2024. For further information contact: Prof Sonia Heaven, University of Southampton, S.Heaven@soton.ac.uk