

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:

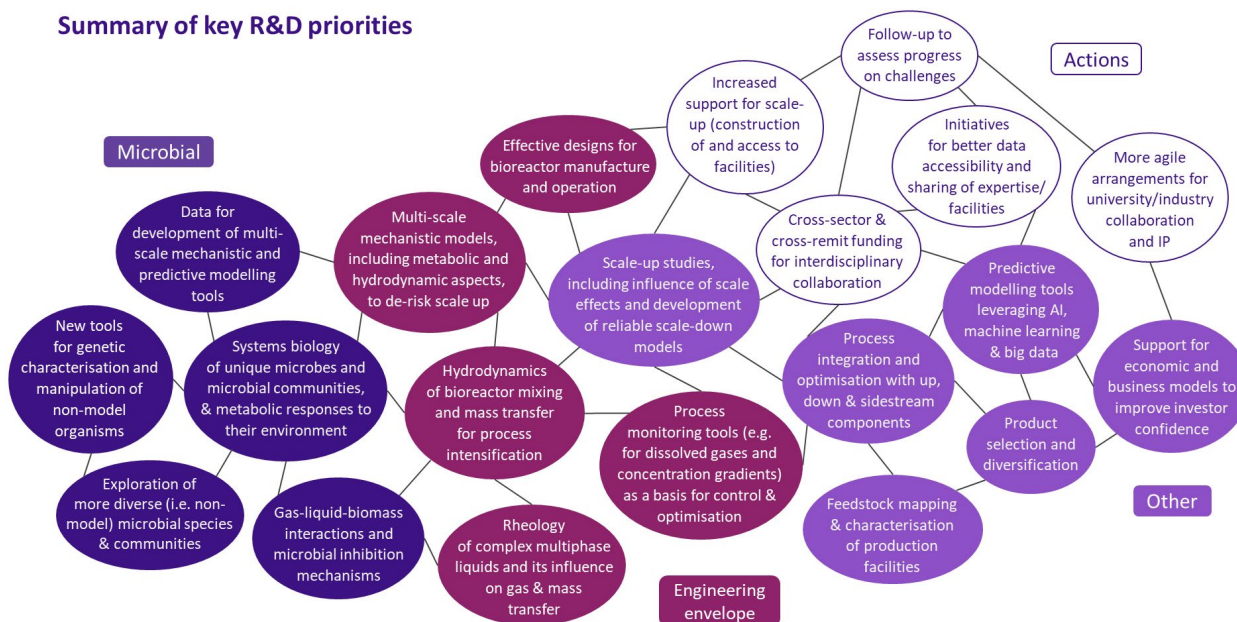
- Cross-sector and cross-remit funding enabling collaboration between disciplines
- Sharing infrastructure, knowledge, facilities, data. 'Fair' data practices and methods for sharing anonymised data. Improved discoverability (e.g. searchable databases). Enable inter-institutional access to facilities, 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.

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