Survey to assess the Use and Awareness of Industrial Biotechnology in the Chemicals and Chemistry-using Industries in the UK

Survey results, analysis and recommendations

Survey conducted for the

Industrial Biotechnology Innovation and Growth Team (IB-IGT)

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Executive Summary

The results of the survey confirm that there is a strong and diverse base of activity in industrial biotechnology (IB) operating throughout the chemicals and chemistry-using industries. One third of the respondents were current users of IB with a further 13% of companies considering take-up of IB in the future. The higher levels of take-up were concentrated in the renewable energy (mainly biofuels), biotechnology, water and effluent treatment, brewing and chemicals processing market segments. Technologies underpinning the IB-based activity identified by the survey tended to centre on the action of enzymes as biocatalysts (e.g. fermentation processes).

Lack of awareness, knowledge, expertise and experience plus the high risk and investment costs associated with implementing a new technology were all perceived as significant barriers to IB take-up. A significant proportion of the group with no plans to use IB (about half) did not view IB as being relevant to their markets. This was a diverse group not only characterized by companies operating in the downstream part of the supply chain (e.g. formulators and polymer processors) but also included companies producing chemicals and polymers from base feedstocks.

The survey indicates that the benefits to business of adopting IB, particularly in terms of economic gain and sustainability, are not apparent for many potential users. As a consequence, the case for adopting IB is not persuasive. The added value, technical feasibility and improved sustainability of IB must be clearly defined and convincingly communicated to the industry to help overcome these negative perceptions.

Integration of industrial biotechnology into the chemistry-using sector must be viewed as a targeted and prioritized activity. Not all areas will benefit and strategies for better integration of IB into the chemistry-using sector should focus on those industry segments and parts of the supply chain that have the most to gain.

Key recommendations from the survey are:

- Raise awareness throughout the chemistry-using sector through the work and outputs of the IB-IGT.
- Demonstrate a strong economic case for innovation using IB.
- Demonstrate how IB can help to achieve sustainability goals.
- Prioritize which parts of the supply chain and segment industries in the chemistry-using sector would gain most benefit from adopting IB.
- Recognize and encourage the role of the supply chain in promoting innovation in IB.
- Find mechanisms for providing technical and business support to reduce barriers to take-up, particularly for small and medium-sized companies.
- Utilize the Devolved Administrations, RDAs and RCIs to connect companies to IB expertise.
- Utilize the knowledge transfer networks (KTNs) to increase access of companies to IB expertise and to connect expertise along supply chains.
- Conduct a scan of IB research activity and capability covering universities, RTOs and industry, at both UK and international level, and use this information to identify strengths

within the UK's IB sector and to identify where effort should be focused to nurture new and emerging technologies.

- Encourage research and development in IB through collaborative projects and industry-academic links and ensure that this R&D effort demonstrates good alignment with the market-based and societal drivers underpinning this sector.

- Develop mechanisms for promoting interdisciplinary research in IB, particularly at the chemistry-bioscience and bioscience-process engineering interfaces.

- Recognize the importance of biocatalysis and enzyme technology in developing new IB applications and ensure expertise is maintained and cultivated in these subject areas.

Purpose of the Survey

This survey has been performed to provide an evidence base for the use of industrial biotechnology in the chemicals and chemistry-using sectors in the United Kingdom, to assist industry and Government frame the conditions to develop competitive, IB-based chemicals production throughout the UK economy.

Objectives

The objectives of the IB-IGT survey are to collect data on the use and awareness of Industrial Biotechnology (IB) in the UK and provide an analysis of these data to:

- illustrate the extent of current utilisation of industrial biotechnology within the chemicals and chemistry-using industries in the UK.

- identify the barriers to take-up of industrial biotechnology in these sectors either now or in the future

From the analysis of data collected from the survey, conclusions are drawn as to whether further work is required in the IB area and recommendations are made to define the scope of such work.

1. Introduction

The Secretary of State for Business, Enterprise and Regulatory Reform (BERR) announced the formation of an Innovation and Growth Team in Industrial Biotechnology (IB-IGT) in November 2007. The principal aim of the IB-IGT is to facilitate the creation of a strategic view collectively from the chemicals and chemistry-using and bioscience industries in how to best integrate industrial biotechnology into this sector to increase future competitiveness and move towards more sustainable manufacturing.

As part of the work of the Innovation and Growth Team, BERR commissioned a survey in February 2008 to examine the use and awareness of industrial biotechnology across the UK. The results, analysis and recommendations of this survey are described in this report.

2. Survey scope and methods

For the purpose of this survey, BERR have proposed a definition of Industrial Biotechnology as follows:

'The application of biotechnology for the processing and production of chemicals, materials and energy'

This survey project covers primarily 'white' biotechnology (the use of microorganisms, biochemistry, biocatalysts, biochemical engineering and fermentation) but also includes some elements of 'green' (discovery and use of novel genes, processes and materials in plants, crops and forestry) and 'blue' (discovery and use of novel genes, processes and materials in freshwater and marine organisms) biotechnology.

The survey was conducted by the Regional Chemical Initiatives (RCIs) located in the Northeast (NEPIC), Northwest (Chemicals Northwest), Yorkshire and Humber (YCF and HCF) regions, by Chemical Sciences Scotland (CSS) and by the Chemistry Innovation Knowledge Transfer Network. The survey for the Yorkshire and Humber regions was conducted jointly and will be presented for the purpose of this survey in a consolidated format. Each RCI surveyed their respective region; CSS surveyed Scotland and Chemistry Innovation surveyed the East Midlands, West Midlands, East, South East, South West and London regions of England. The region surveyed by Chemistry Innovation will be referred to as Midlands and South for the purpose of this report.

The survey was designed to address a wide range of sectors within the overall chemistry-using sector and to include the views of a broad range of company sizes including SMEs and university spin-outs.

Key elements of the survey questionnaire investigated the following:

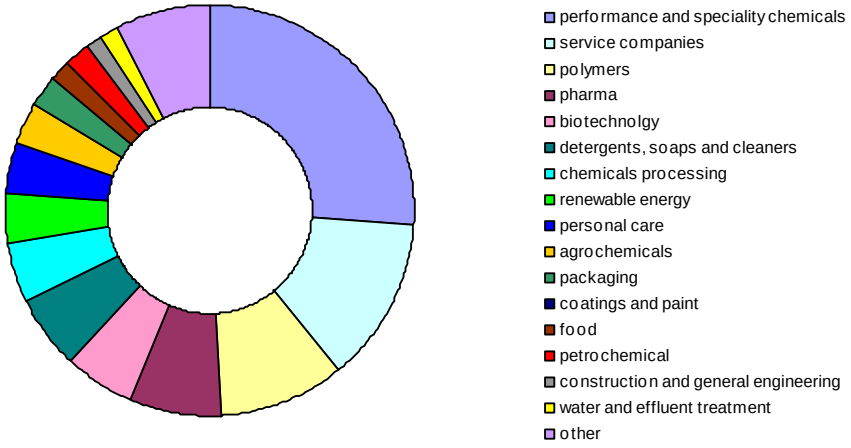
- Extent of current IB take-up.
- Likely extent of future IB take-up.
- Proportion of companies with no plans for using IB and associated reasons.
- Segment breakdown of the chemistry-using industries surveyed in each region.
- Relationship between size of company and IB take-up.
- Extent of collaborative activity for companies currently using IB.

- Assessment of degree of importance of IB for companies currently using or intending to use IB.
- Key technologies for current and potential IB users

The survey was conducted between 15 February 2008 and 19 March 2008. Respondents completed the questionnaire directly or were interviewed by telephone. The general format of the survey questionnaire is attached in Appendix A.

The survey covered a wide range of segment industries operating within the chemistry-using sector with Performance and Speciality Chemicals accounting for just over a quarter of companies participating in the survey. The service company sector, which includes companies providing analytical services, consultancy, training and education, marketing and business support, was the next most represented sector followed by polymers (manufacture and processing). A breakdown of various segments contributing to the survey is shown in Figure 1.

Figure 1: Segment analysis of survey respondents



Appendix B shows the segment analysis for each of the regions covered by the survey. As would be expected there was some variation in segment representation between the regions reflecting differing patterns of historical industrial development and regional focus. In all the regions, however, there was a strong representation from the performance and speciality chemicals, pharma, polymer and service company segments.

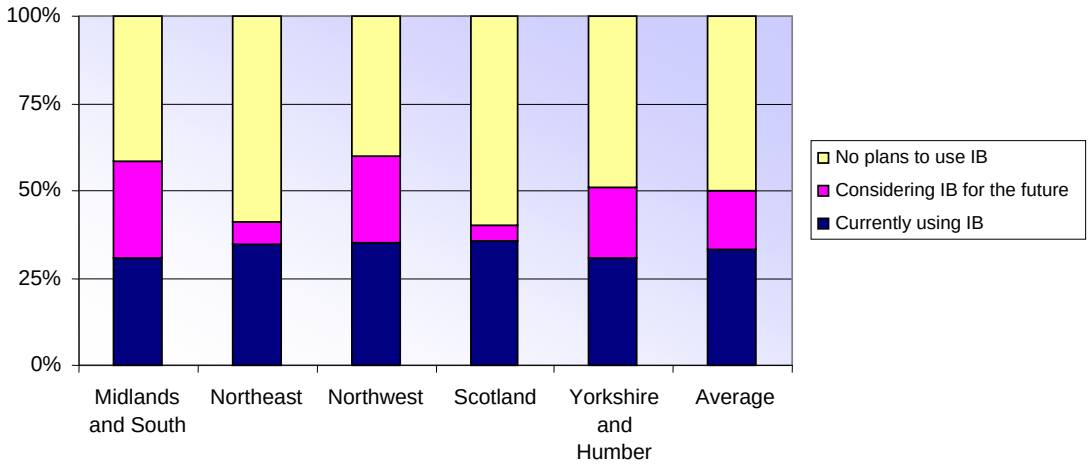
3. Survey results

A total of 279 survey responses were received during the survey. Of these, 95 companies expressed an interest in receiving follow-up questions at a later stage of the IB-IGT project, equivalent to 34% of survey respondents.

3.1 Current and projected IB take-up

The proportions of respondents currently using IB, those considering using IB in the future and those that have no future plans for IB take-up are represented graphically in Figure 2. The proportion of companies currently using IB is remarkably consistent across the regions varying from 30% to 36% and averaging at 33% nationwide (this group is represented by 93 companies). A further 13% of companies (37) expressed an interest in future use of IB whereas the remaining 54% companies (149) had no plans for future take-up.

Figure 2: Current and potential IB take-up



The indications for future IB take-up are more variable when compared across the regions and two groupings may be identified. In the Midlands and South, Northwest and Yorkshire and Humber regions about a quarter of companies indicated future plans involving IB. This figure was lower in the Northeast and Scotland with less than 10% indicating plans for possible take-up in the future.

3.2 Relationship between IB take-up and company size

For the purpose of this analysis, company size has been defined in terms of number of employees based on the EU definition and is as follows:

Company size	Number of employees
Large	> 249
Medium	50 – 249
Small	10 – 49
Micro	1 – 9

Figure 3 shows the size distribution of all companies involved in the survey. From Figure 3, it can be seen that there is a roughly equal representation of small, medium and large sized companies (25-32%) with a lower contribution (14%) coming from micro-sized companies (often these are recent start-ups or university spin-outs). On a qualitative basis, this pattern is fairly consistent across the regions.

Figure 4 shows how company size distribution varied between the regions. Although there were some definite variations, the overall pattern reflects the national picture by showing a roughly equal mix of large, medium and small companies with a smaller proportion of micro-sized companies. Scotland and the Midlands and South region had a higher proportion of large and medium sized companies although the extent of IB take-up was proportionately higher in the Midland and South. In the latter case, this probably reflects the presence of some large

pharmaceutical companies and infers that IB take-up is more influenced by segment profile in large companies.

Figure 3: Size distribution of companies included in the survey.

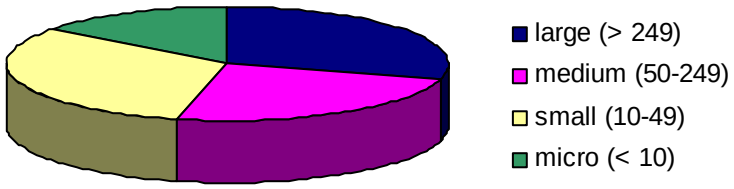
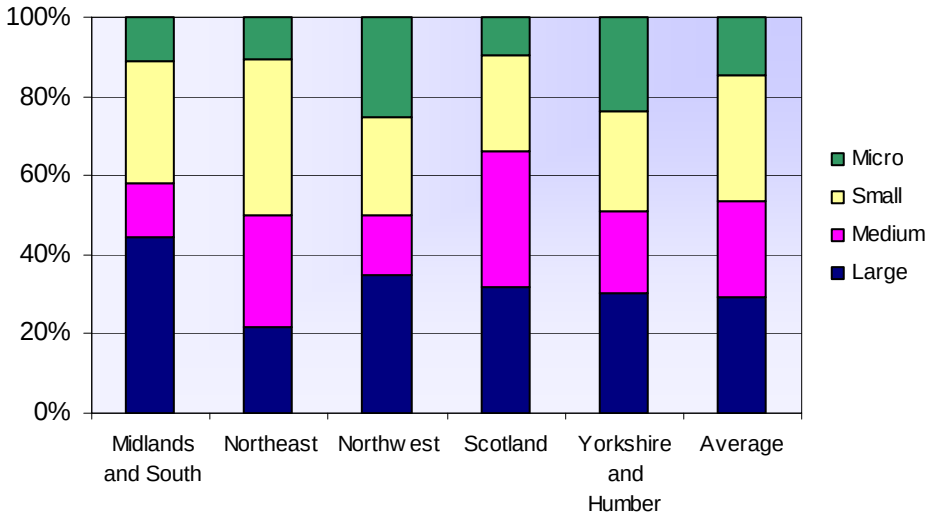


Figure 4: Regional variations in company size distribution

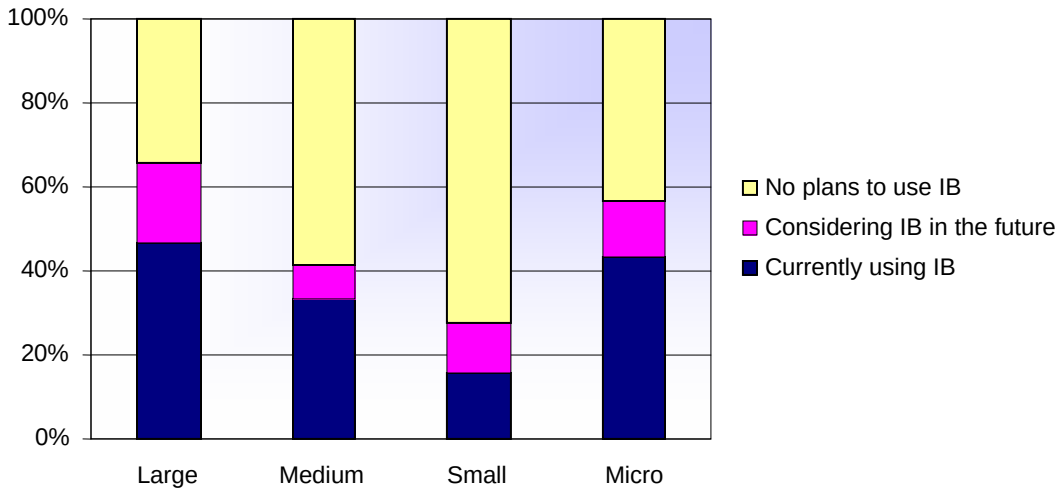


The relationship between current use and future take-up of IB with company size is shown in Figure 5. In all categories of company size, there was a significant representation from current IB users. Large companies showed the strongest level of activity (47%) followed by medium (34%) and small (16%) size companies. The micro companies also showed a high level of current usage (43%). This observation should be treated cautiously and may not be statistically significant due to an element of bias in company selection as well as there being a smaller number of companies (37) populating this size category compared with the larger companies. The situation with potential take-up does not reveal any strong systematic trends with company size, although it is worth noting that the large companies showed a greater tendency towards future take-up (17%) than the smaller companies (5-10%).

Very few companies across the survey volunteered information on whether they were university spin-outs. Two university spin-outs were identified in the Northwest and two in the Midlands and

South region. Due to the smallness of this dataset, it is difficult to draw any firm conclusions about degree of current or intended take-up by these companies. Only one of these four companies was using IB with none of the other three companies having any plans for future take-up. This may be an area that requires further investigation as part of the activities of the IB-IGT.

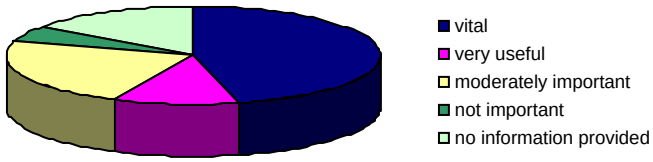
Figure 5: Relationship between IB take-up and company size



3.3 Degree of importance of IB to current and potential users

Figure 6 shows how companies who were current users viewed the importance of IB to their business. Note that 16% of IB users, corresponding to 14 companies, declined to answer this question. Of those companies that responded, over half (54%) viewed IB as vital to their company function and performance.

Figure 6: Importance of IB to current users

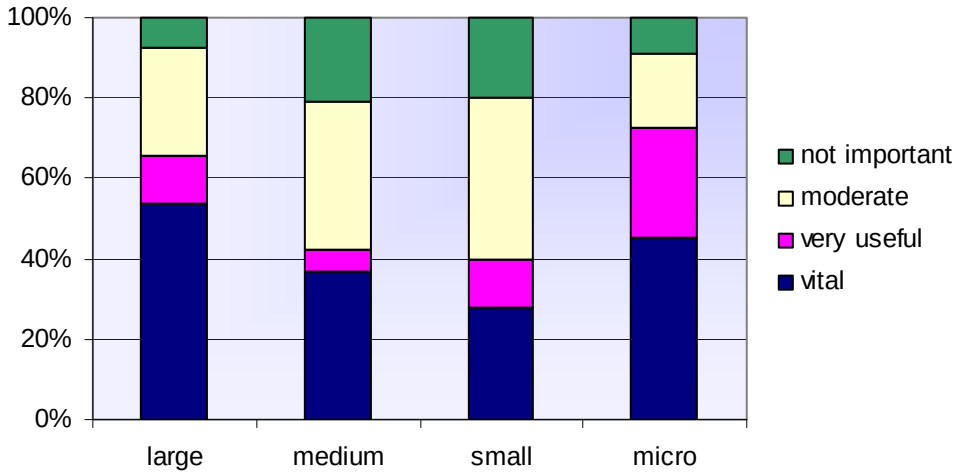


For potential IB users, there is a lower perception of importance (see Figure 7). Of those that responded (25 companies), only 12% viewed IB take-up as vital to their future business. About a quarter of these companies viewed IB as being of low or no importance but often qualified this position by stating that this perception could change as technology and knowledge develops or the cost base becomes more attractive. Hence, the data represented in Figure 7 may overstate the negative position taken by some companies in this potential users group.

Figure 7: Importance of IB to potential users

Perceptions of importance of IB as a function of company size for the current and potential users groups roughly mirrored the relationship seen between take-up of IB (actual or intended) with company size (see Figure 8). Over half of large companies viewed IB as vital as did 45% of micro-sized companies. The trend was less pronounced for medium (37%) and small (28%) sized companies although these are still significant proportions presenting a positive view of the importance of IB.

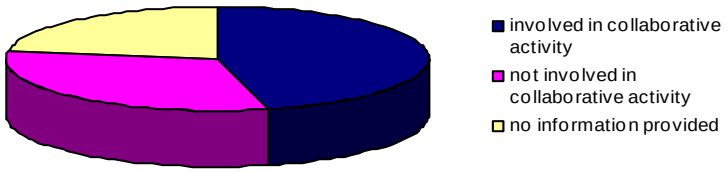
Figure 8: Relationship between importance of IB and company size (current and potential users)



3.4 Collaborative Activity

Figure 9 shows the extent of collaborative activity amongst current IB users. Note that 23% of survey respondents in the current IB users' category, representing 21 companies, did not respond to this question. Of those companies that did respond, approximately 60% were found to be involved in some form of collaborative activity or project. The nature of the collaboration varied considerably and included university interactions, collaborations with other parts of the supply chain and participation in international company-based consortia. The collaborations with universities included both UK and international academic partners. Of note, however, was the significance of the supply chain in influencing the decision to adopt industrial biotechnology. Influence and, in some cases, commercial pressure from the supply chain was revealed to have provided the stimulus for innovation in IB for a number of companies.

Figure 9: Involvement in collaborative activity for current IB users



4. Interpretation of survey findings

In this section, some discussion is given on the general outcomes of the survey in terms of the perceptions and attitudes of the respondents, particularly with regard to perceived advantages of IB or barriers to take-up. Note that opinions given for IB take-up within defined market segments must be viewed as qualitative since they are based on the responses of only those companies who gave a clear indication of their market positioning (equivalent to about 60% of respondents to the survey).

4.1 Reasons for using IB now

Companies currently using IB (93 companies) were found to be engaging in a broad range of activities across the chemistry-using sector including:

- Water treatment
- Effluent treatment
- Chemicals manufacture
- Biosensors
- Resin manufacture
- Biocide manufacture
- Polymer manufacture
- Biofuels production
- Cosmetics
- Food production
- Renewable chemicals
- Cleaning products
- Oil recovery
- Products with low carbon emissions
- Waste product treatment
- Fermentation products

In terms of IB activity within defined chemistry-using segments, the renewable energy (mainly biofuels), biotechnology, water and effluent treatment, brewing and chemicals processing segments were the most active IB users. IB activity within these segments was above the average 'one third' activity level found for current IB users as determined by this survey. The level of IB use for the performance and speciality chemicals segment, the largest segment represented in the survey, was comparable with the survey average.

Within those segments that indicated an above average level of IB activity, examples of products derived from enzyme-catalyzed conversions are numerous. Enzymes are being used as catalysts for the manufacture of flavours and fragrances, personal care products, cleaning agents

and surfactants, polymers, agroproducts and biofuels. Some of these may be characterized as 'crop to chemical' conversions in case of platform chemicals (e.g. acetic acid) and biofuels. IB is also being integrated into extraction and separation technologies via the use of enzymes and novel ionic fluids. Many of the biocatalytic conversions being employed in the active IB users group are fermentation processes. Examples include the fermentation of wheat and starch to manufacture biofuels, the fermentation of sugars to produce vitamin supplements and the use of fermentation in brewing and food manufacture.

Whole cells/microorganisms are also being used to catalyze conversions, a trend that is set to grow as the biotechnology sector develops. One important use of microorganisms is in water and effluent treatment where selected microorganisms release enzymes (as well as organic acids and antioxidants) that digest soil particles present in partially treated water or effluent. In a similar way, microorganisms are being used to digest waste organic matter, fats and greases. Some companies are focusing on the development of bioreactors for anaerobic digestion. Other IB technologies identified by the survey include specialized protein and peptide manufacture, the production of chiral molecules for use in agrochemicals and drugs, the development for biocides for water storage and use of bacteria as scale-inhibitors in oilfield water treatments. These examples illustrate some of the diversity associated with current IB applications.

In terms of company size and IB take-up, large companies were most well-represented with IB take-up dropping to lower levels for medium and small companies. Interestingly, the micro-sized companies scored comparably with large companies on current IB take-up. This may reflect some selection bias but also indicate a greater technology orientation and entrepreneurial drive in this size category. The smaller companies using IB often responded most emphatically on the importance of IB to their business. In such cases, IB was often the core route to their product developments. Larger companies tended to take a more strategic view reflecting the larger product mix associated with these enterprises but were nonetheless keen advocates of the benefits of industrial biotechnology when IB formed part of their business portfolio.

4.2 Reasons for using IB in the future

The potential IB users group comprised 37 companies. Areas where the take-up of industrial biotechnology was viewed as potentially useful in the future are listed below:

- Chemicals manufacture
- Polymer manufacture
- Biofuels manufacture
- Algae oil production
- Anaerobic digestion
- Enzyme production (cleaners)
- Bioremediation
- Fermentation processes
- Oil extraction (food, cosmetics)

The spread of segments represented in the above list is less broad than that found for the current users (section 4.1) and is concentrated in the biotechnology, renewable energy, waste treatment, detergents, food, polymer and packaging segments. As for current IB users, fermentation processes and the use of enzyme chemistry are viewed as key enabling technologies for the potential users group. There is wide-ranging interest in using enzymes as biocatalysts for the production of platform chemicals (e.g. C1, C2 platforms), biofuels and hydrogenated products. Plans to pursue enzyme-based methods to break down (hydrolyse) cellulose, aimed at the development of second generation biofuels as well as other products, were also in evidence.

Diesel from the trans-esterification of algal oil was another route under consideration for producing biofuels.

Similarly to the current IB users group, the use of microorganisms for water, effluent and biowaste treatment was of interest to several companies. Extraction and separation technology using IB was again highlighted with the extraction of oil from seeds using enzyme-supported aqueous solvents viewed as a prime target. Some companies were interested in converting crop-based feedstocks to plastics although no specific IB-based routes were suggested.

As might be expected, the potential IB users group was generally less enthusiastic than the current users group about using IB. Some companies, however, were keeping a watching brief on developments either to identify early on any step-changes in technology (production-based methods for cellulose breakdown is a good example) or to be able to respond quickly to changes in regulatory compliance (e.g. the water framework directive). Also of note with this potential users group is that many companies were working with suppliers already using IB. There were also some enthusiastic advocates for using IB concerned about their lack of in-house expertise. Clearly, this is a sub-group which would benefit from technology and knowledge transfer initiatives. The ability to control contamination during IB processing was raised a necessary pre-requisite for some companies before considering take-up. Others companies were concerned about the lack of available natural ingredients for use as raw materials (e.g. in polymer manufacture).

4.3 Barriers to IB take-up

Taken over the whole survey, over half of respondents (54% representing 149 companies) were not using IB and had no plans to do so in the future. The segments supporting this position were varied. Perhaps expectedly, companies involved in 'inorganic products' such as coatings, pigments, metals and fibres tended to view IB as not relevant to their product streams. Segments that took a stronger position than average in not supporting the use of IB were found in the performance and speciality chemicals, polymers and packaging segments. These are all segments where companies that are current IB users can also be found. This finding implies that there is potential within the 'non-users' group for awareness-raising, knowledge transfer and other support mechanisms to facilitate a transition for some of these companies into IB-based products and processes.

Some of the reasons given by companies for not considering IB take-up are listed below:

- Not relevant to market
- No obvious application
- No experience in this area
- No expertise or equipment for implementing IB
- No understanding of IB or how it could be applied
- IB will not deliver
- No need for IB since existing chemical processes work well and are cost effective
- IB is being used in another part of the supply chain
- IB not considered before the survey enquiry
- Will not use IB unless driven by regulatory pressures (e.g. water framework directive)
- Contamination and health and safety concerns with using IB-based processes
- Too much investment required for set up

The perception that IB was not relevant was a common thread running through these negative positions. Indeed, 'not relevant' was the most common response received in the survey from this group. These were often businesses, large or small, with an established business model and who were reluctant to experiment with new technologies when their existing chemicals-based operations were already providing a good return. A number of respondents mentioned that their suppliers were IB users who supplied the raw materials for processing or assembly. Companies involved in formulation, blending or polymer processing often expressed this view. Concerns were also expressed about a lack of expertise in biotechnology and the potentially high investment costs. Some companies were also concerned about regulatory pressures. The requirements of the water framework directive in particular concerned companies in the water and effluent treatment areas.

The view sometimes expressed that IB will not deliver is interesting since it implies some previous and perhaps negative experience of using biotechnology. A small number of companies did reveal they had returned to a chemicals-based method after experimenting with biotechnology since the chemical method was easier to operate or less expensive to run.

Overall, underpinning these observations is perhaps a lack of awareness and understanding of what industrial biotechnology can actually deliver and the potential benefits. Clearly, this is an area where knowledge transfer can play a key role in reducing barriers to take-up and in lowering perceptions of risk. A clear priority is emerging that the IB-IGT must not only raise awareness of industrial biotechnology within the chemistry-using sector but must also target those parts of the sector which will benefit most from IB. To achieve this objective, a convincing case for the adoption of IB in terms of economic benefit, technical feasibility and improvements in sustainability must be made.

4.4 Key IB technologies highlighted by the survey

It is clear that the utilization of enzymes as biological catalysts is essential to the current development of IB-based product and processes and this is likely to remain the case for the future. Whether in extracted form or hosted by microorganisms, enzymes are involved in conversions across a wide range of industries including the food, brewing, biofuels and personal care segments. In addition to processes involving sugar or starch fermentation for the manufacture of chemicals and downstream products, enzymes are being used to catalyze the hydrolysis of cellulose in biofuels and packaging materials, to extract oil from seeds (to degrade cell walls) and as soil 'digesters' in detergents. Enzymes hosted by microorganisms are being used to digest organic waste or remove soil materials during water, effluent and cleaning treatments; for bioleaching in the recovery of metals and as microbial hosts during fermentation processes (e.g. for food and biofuels).

The availability, efficiency, specificity, stability, safety and cost of enzymes, whether extracted or hosted by microorganisms, will be key deciding factors in integrating industrial biotechnology into the chemistry-using sector. At present, IB feedstocks are derived from living organisms with most extracted enzymes being derived from microorganisms rather than from plants or animals. Enzymes from microorganisms (usually bacteria) are generally preferred since they are cheaper to produce, more predictable and less likely to contain other potentially hazardous materials compared with plant and animal sources. However, developments in plant and animal cell culture may oppose this trend. Looking further forwards, the industrial-scale production of synthetic enzymes or engineered microorganisms may provide alternatives to existing natural sources and research is already underway in these areas. Researchers are working at different ways to improve enzymes (a relatively low proportion of known enzymes are used commercially) whether through selection pressure, genetic engineering or more recently through evolutionary approaches to synthesizing biomolecules (e.g. RNA catalysts). Clearly, the availability of expertise in enzyme technology will be essential to industrialists in designing new IB-based products and processes. This is an interdisciplinary area that draws on a number of subject areas including microbiology, biochemistry, chemistry and process engineering. Research

activity at these subject interfaces will be vital for enabling new technologies and innovations to emerge.

In summary, the survey response has provided a comprehensive and informative view of current and potential IB take-up within the UK's chemistry-using industries. The total number of responses (279 companies) accounts for close to 10% of the sector. Although the survey has provided useful information on the extent of collaborative activity between academia and industry, it has not addressed explicitly the level and focus of IB activity within the research base. It is recommended that comprehensive scan of IB research activity and capability covering universities, RTOs and industry, at both UK and international level, should be conducted in order to evaluate the current strengths of the UK's IB sector and to identify where effort should be focused to nurture new and emerging technologies.

5. Conclusions

- The results of the survey provide clear evidence for significant take-up of industrial biotechnology over a wide range of industries operating within the chemistry-using sector: 33% of companies canvassed in the survey currently use IB and a further 13% are considering take-up. The higher levels of current take-up were concentrated in the renewable energy (mainly biofuels), biotechnology, water and effluent treatment, brewing and chemicals processing market segments.

- The action of enzymes as biocatalysts underpins many of the IB-based activity identified by the survey. Examples of biocatalytic processes in use include sugar and starch fermentation, protein degradation and cellulose hydrolysis.

- Of the companies having no plans to implement IB (approximately half), a significant proportion did not view IB as being relevant to their markets. This was a diverse group not only characterized by companies operating in the downstream part of the supply chain (e.g. formulators and polymer processors) but also included companies involved in the production of chemicals and polymers from base feedstocks.

- Lack of awareness, knowledge, expertise and experience plus the high risk and investment costs associated with implementing a new technology were all perceived as significant barriers to IB take-up.

- The benefits to business of adopting IB, particularly in terms of economic gain and sustainability, are not clear for many potential users. As a consequence, the case for adopting IB is not seen as an attractive or even viable investment. The cases for generating added value, technical feasibility and making achievable gains in sustainability need to be better defined and convincingly communicated to the sector to help overcome these negative perceptions.

- Integration of industrial biotechnology into the chemistry-using sector must be viewed as a targeted activity. Not all areas will be benefit from IB adoption and strategies formulated for enabling better IB integration should target the segment areas and parts of the supply chain that have most to gain.

6. Recommendations for future work

The findings from the survey demonstrate that the IB-IGT needs to work towards raising the awareness and knowledge base of industrial biotechnology as a means of increasing integration of IB into the UK's chemistry-using sector. There is some recognition amongst potential users that the production of chemicals and downstream products using industrial biotechnology may provide viable manufacturing routes in the future. However, companies who are not currently using IB need to be persuaded of the potential benefits and added value. In particular, companies need to have a better knowledge base from which to make decisions on investment returns, technical feasibility, skills needs and operating costs.

- Raise awareness throughout the chemistry-using sector through the work and outputs of the IB-IGT.
- Demonstrate a strong economic case for innovation using IB.
- Demonstrate how IB can help to achieve sustainability goals.
- Prioritize which parts of the supply chain and segment industries in the chemistry-using sector would gain most benefit from adopting IB.
- Recognize and encourage the role of the supply chain in promoting innovation in IB.
- Find mechanisms for providing technical and business support to reduce barriers to take-up, particularly for small and medium-sized companies.
- Utilize the Devolved Administrations, RDAs and RCIs to connect companies to IB expertise.
- Utilize the knowledge transfer networks (KTNs) to increase access of companies to IB expertise and to connect expertise along supply chains.
- Conduct a scan of IB research activity and capability covering universities, RTOs and industry, at both UK and international level, and use this information to identify strengths within the UK's IB sector and to identify where effort should be focused to nurture new and emerging technologies.
- Encourage research and development in IB through collaborative projects and industry-academic links and ensure that this R&D effort demonstrates good alignment with the market-based and societal drivers underpinning this sector.
- Develop mechanisms for promoting interdisciplinary research in IB, particularly at the chemistry-bioscience and bioscience-process engineering interfaces.
- Recognize the importance of biocatalysis and enzyme technology in developing new IB applications and ensure expertise is maintained and cultivated in these subject areas.

Appendix A

IB Questionnaire

What is industrial biotechnology?

For this purpose, industrial biotechnology (IB) is defined as “the application of biotechnology for the processing and production of chemicals, materials and energy”.

This is the definition currently used by the EU.

For those familiar with IB this project covers mainly white (use of micro organisms, biochemistry, biocatalysts, biochemical engineering and fermentation), though it will also look at green (discovery and use of novel genes, processes and materials in plants, crops and forestry) and blue (discovery and use of novel genes, processes and materials in freshwater and marine organisms) biotechnology.

1. Do you currently use IB?

Yes ☐ No ☐ (check box)

If Yes to question 1, please go to question 5.

2. If no to question 1, are you considering using IB in the future?

Yes ☐ No ☐ (check box)

3. If no to question 2, please explain why not?

4. If yes to question 2, what are you considering using it for, why and when? Then please go to question 6.

5. As you currently use Industrial Biotechnology, how do you use it?

6. How vital is IB to your company?

7. Are you working in collaboration with another organisation?

8. What is the chemistry involved or technical scope of your organisation?

COULD ALL RESPONDENTS PLEASE PROVIDE THE FOLLOWING INFORMATION

What is the size of your company? (check box)

Large (over 249 employees) ☐

Medium (50 – 249 employees) ☐

Small (10 – 49 employees) ☐

Micro (0 – 9 employees) ☐

Spin-out from a University or Higher Education Institution ☐

Are you prepared to receive follow-up questions at a later stage in this project?

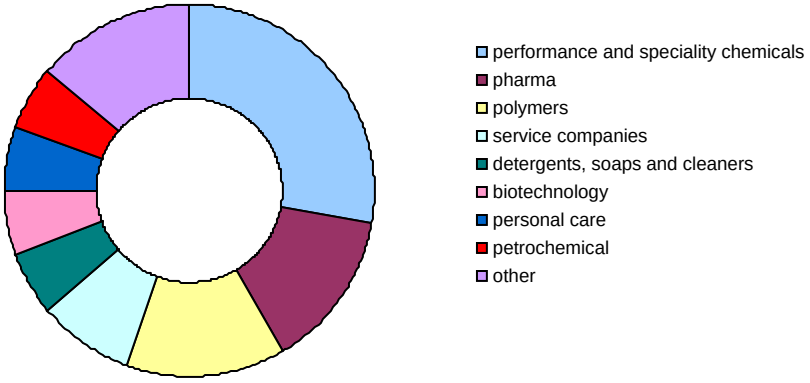
Yes ☐ No ☐ (check box)

Responses are confidential and will be non-attributed in collation of data to BERR.

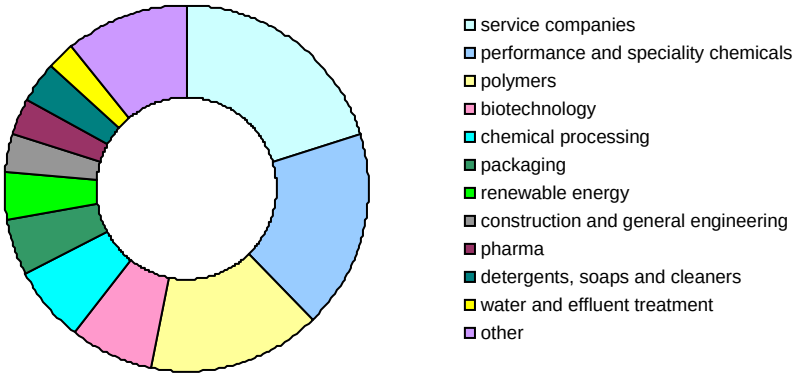
Appendix B

Segment analyses for the regions

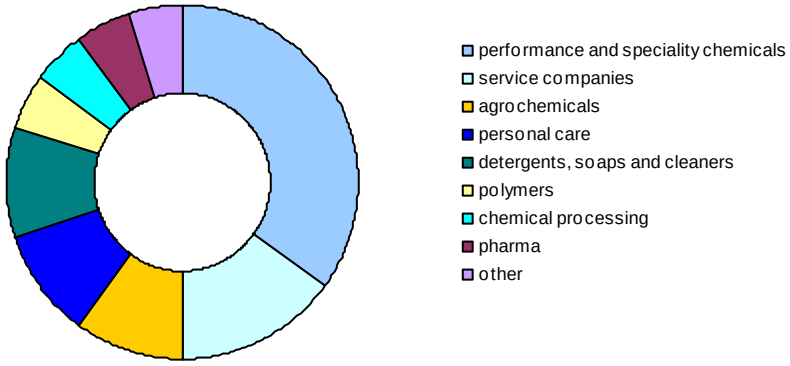
Midlands and South



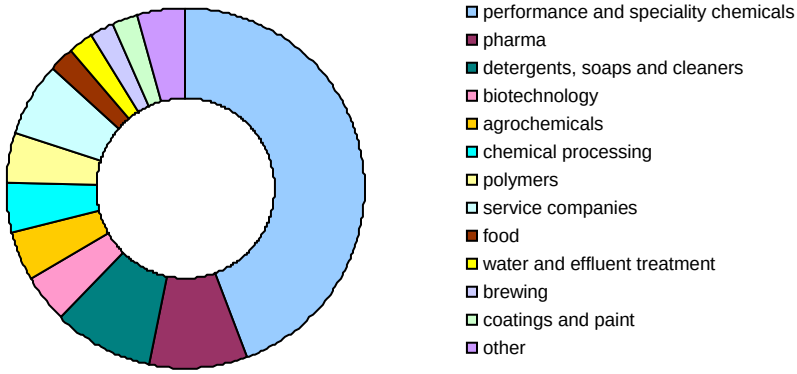
Northeast



Northwest



Scotland



Yorkshire and Humber