Industrial Biotechnology in the Chemicals and Chemistry-using Industries in the UK:

Follow-up Survey to assess Barriers to Implementation and Opportunities for Growth

Survey results, analysis and recommendations

Survey conducted for the

Industrial Biotechnology Innovation and Growth Team (IB-IGT)

November 2008

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Contents

Executive Summary

From the analysis of data collected from this follow-up survey, recommendations are made to increase the take-up of industrial biotechnology (IB) in the UK and to identify those segments of the UK's chemistry-using industries that are most likely to gain from the adoption of IB.

A key barrier to IB take-up is a widespread perception that IB will not provide functional and cost-effective product solutions and, as such, is viewed irrelevant to the manufacture of many product streams established in the chemistry-using industries. A second principal barrier identified by the survey is a perceived lack of technical expertise compounded by a lack of awareness and knowledge of industrial biotechnology as a subject across the chemistry-using sector. The level of customer desire for IB-based products is low, although there is some demand for sustainable, organic or natural products. The performance and speciality chemicals and polymer industry segments in particular show low levels of IB take-up compared with the survey average. High levels of IB take-up are seen in the biotechnology, water and effluent treatment, agrochemicals and renewable energy (mainly biofuels) areas. This confirms findings from the earlier IB-IGT survey where food and brewing were also identified as key IB users[1]. These industries might prove useful sources for demonstrating capability and technical know-how to those chemistry-using segments that could benefit from IB but which are reluctant adopters.

Key recommendations from the survey are:

- Target those company profiles which have the most to gain from adopting IB. This should include consideration of current product profile, process chemistry, operating practices, market segment, supply chain positioning, in-house expertise and technical know-how. Particular focus should be placed on the performance and speciality chemicals and polymer segments where there are good opportunities to increase current levels of IB take-up.

- Review IB skills and expertise in key segments of the chemistry-using industries to determine how skills deficits underpin the current low levels of IB take-up, with particular reference to companies operating in the performance and speciality chemicals and polymer industries.

- Work with the sector skills councils (including Cogent and Semta) and research councils (e.g. EPSRC and BBSRC) to define the skills gaps that industry is experiencing in the provision of biotechnology expertise and propose ideas and mechanisms for increasing the biotechnology skills base in the chemistry-using industries.

- Provide segment-specific case studies which demonstrate the technology, cost benefit and sustainability of IB based products.

- Utilise the KTNs to provide knowledge transfer and technology translation in the area of industrial biotechnology to companies and industrial segments identified as having the most to gain from adopting IB.

- Utilise the KTNs to provide information on funding opportunities for R&D and demonstration projects.

- Raise awareness of business opportunities in industrial biotechnology through the work and outputs of the IB-IGT.

Purpose of the Survey

This follow-up survey has been performed to provide more detailed information at a national level on the use of industrial biotechnology in the chemicals and chemistry-using sectors in the United Kingdom. The aim of the survey is to more fully understand the opportunities and barriers that exist for increasing the use of industrial biotechnology in the UK.

Objectives

The objectives of the IB-IGT follow-up survey are to collect and analyse data on use, awareness and barriers to implementation of industrial biotechnology into the chemistry-using industries in order to:

- More fully understand the opportunities and barriers that exist for increasing the use of industrial biotechnology in the UK to include consideration of technical, economic, social and regulatory factors.
- Determine the degree of market pull / customer desire for IB.
- Review the nature and extent of collaborative activities in IB.
- Identify those industry segments and supply chain positions within the chemistry-using industries that would benefit the most from introducing IB into their product and process streams.

1. Introduction

The Department of Business, Enterprise and Regulatory Reform (BERR) wishes to further analyse and investigate the current and potential future use of industrial biotechnology by the UK chemicals and chemistry-using industries. This work follows on from an earlier national survey completed in April 2008 that looked at some basic questions about current levels of utilisation of industrial biotechnology[1]. BERR now require more detailed information to fully understand the opportunities and barriers that exist for increasing the use of industrial biotechnology in the UK. To achieve these objectives, a follow-up survey was conducted at national level during August and September 2008.

The outcomes from this follow-up survey are intended to assist the three working groups and the steering group to develop key messages arising from the work of the Industrial Biotechnology Innovation and Growth Team (IB-IGT) and to make recommendations for future actions, to be delivered to external stakeholders in a final report, due to be published in April 2009. The results, analysis and recommendations of this follow-up 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. 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.

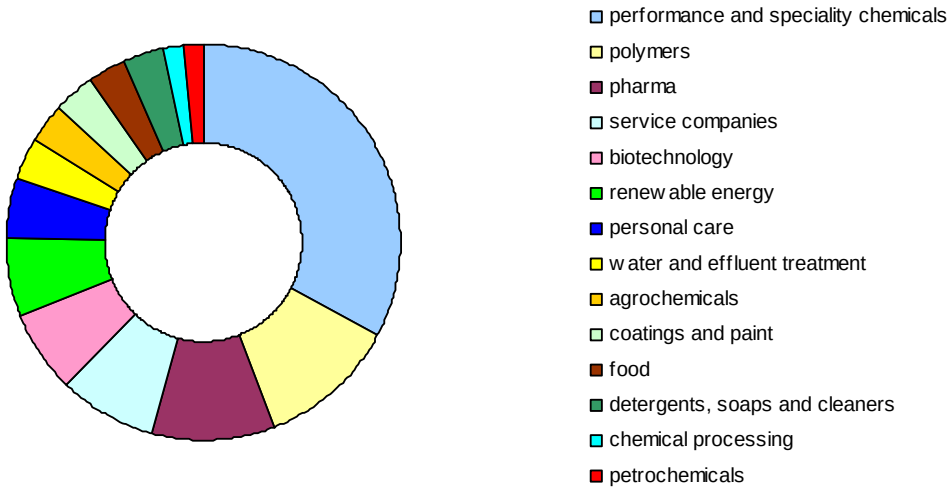
Key elements of the survey questionnaire investigated the following:

- The current IB 'landscape' for key segments of the chemistry-using industries in terms of actual or projected take-up of IB.
- Factors influencing decisions to adopt IB
- Customer desire for IB products
- Levels and types of collaborative activity in IB
- Barriers to adopting IB
- Future business opportunities

It is the purpose of this follow-up survey to provide a more detailed analysis of the reasons why businesses in the UK have chosen to adopt or reject industrial biotechnology. The data analysis is presented at national level. A full analysis of regional trends for IB take-up can be found in the earlier survey which examined a larger dataset comprising responses from 279 companies[1].

The follow-up survey was conducted between 21 August 2008 and 24 September 2008 with responses collected equally across the specified regions. 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 range of key segment industries operating within the chemistry-using sector. The performance and speciality chemicals industry accounted for about a third of companies canvassed. As in the previous survey, the polymer and pharma sectors were also strongly represented equivalent to 12% and 10% of survey respondents, respectively. A full breakdown of various segments contributing to the survey is shown in Figure 1.

Figure 1: Segment analysis of survey respondents



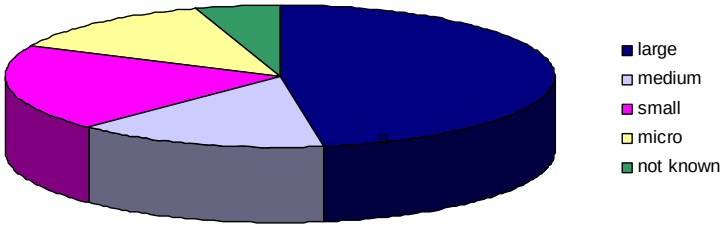
3. Survey results

A total of 61 survey responses were received. The distribution of company sizes for participants in the survey is shown in Figure 2. 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

From Figure 2, it can be seen that approximately half of the respondents originated from large companies. The remainder was distributed fairly evenly between medium, small and micro-sized companies.

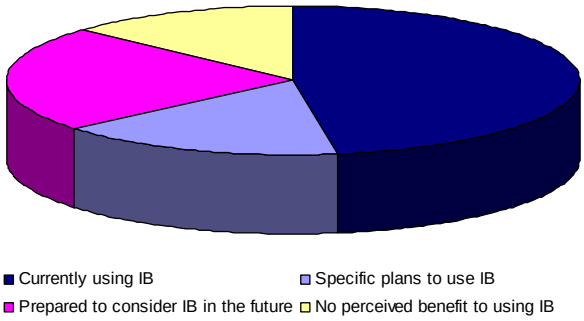
Figure 2: Size distribution of companies included in the survey



3.1 Current and projected IB take-up

The proportion of companies currently using IB in this follow-up survey is 48% which compares with 33% found in the original survey[1]. This higher proportion probably reflects some bias towards IB in the selection of segments in the current survey and the inclusion of fewer service companies (e.g. providers of analytical services, consultancy, training and business support) in the survey population than previously. Those willing to consider using IB in the future (39%), designated in this report as the potential users, can be further sub-divided into two groups: those with definite plans for IB implementation (16%) and those willing to consider IB as a possible technology route but with no defined plans (23%). A further 13% of companies did not foresee any benefit to adopting IB in their companies and did not have any plans to do so. This distribution is represented graphically in Figure 3.

Figure 3: Current and potential IB take-up



The relationship between current adoption of IB and industry segment reveals some interesting variations (see Figure 4). The segment allocation of survey respondents is summarised in Appendix B. Strong levels of IB take-up are found for companies operating in the biotechnology, water treatment agrochemicals and renewable energy industries. IB was also being used in the petrochemicals and chemical processing areas although these findings are based on single company returns. The use of IB in the pharma segment is very close to the overall survey average (47%). Significantly, the performance and speciality chemicals, polymers, personal care and detergents, soaps and cleaners segments show below the average level of take-up. However, if those companies who indicated some intention for future IB take-up (whether explicit

or unspecified) are included in the analysis then the levels of IB take-up are predicted to improve significantly across many of the segment industries examined (see Figure 5).

Figure 4: Current IB take-up as a function of segment

(size of bubble is proportional to number of segment responses)

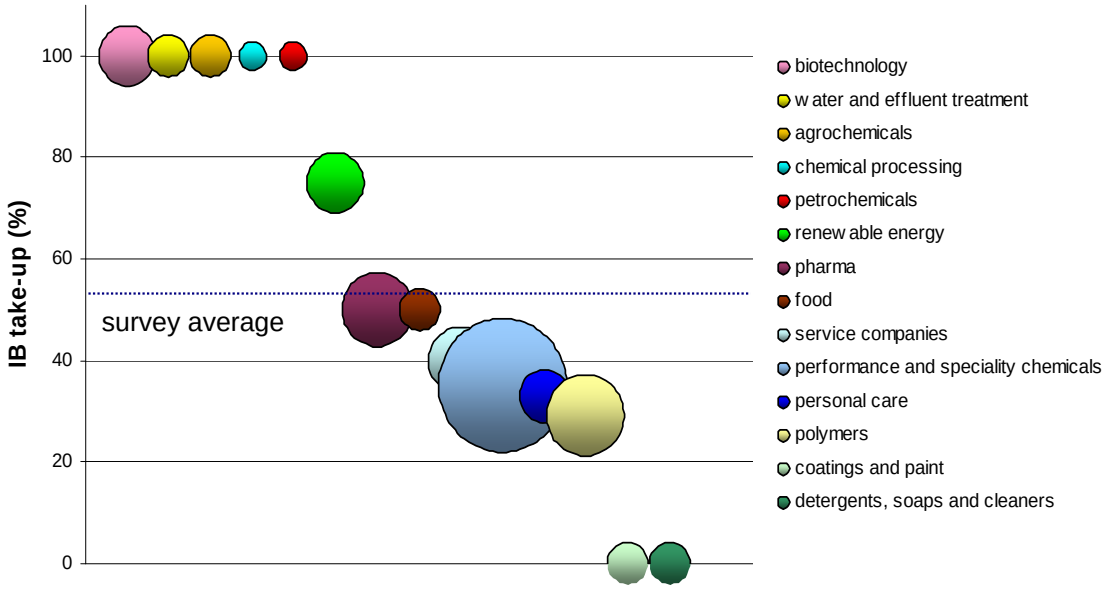
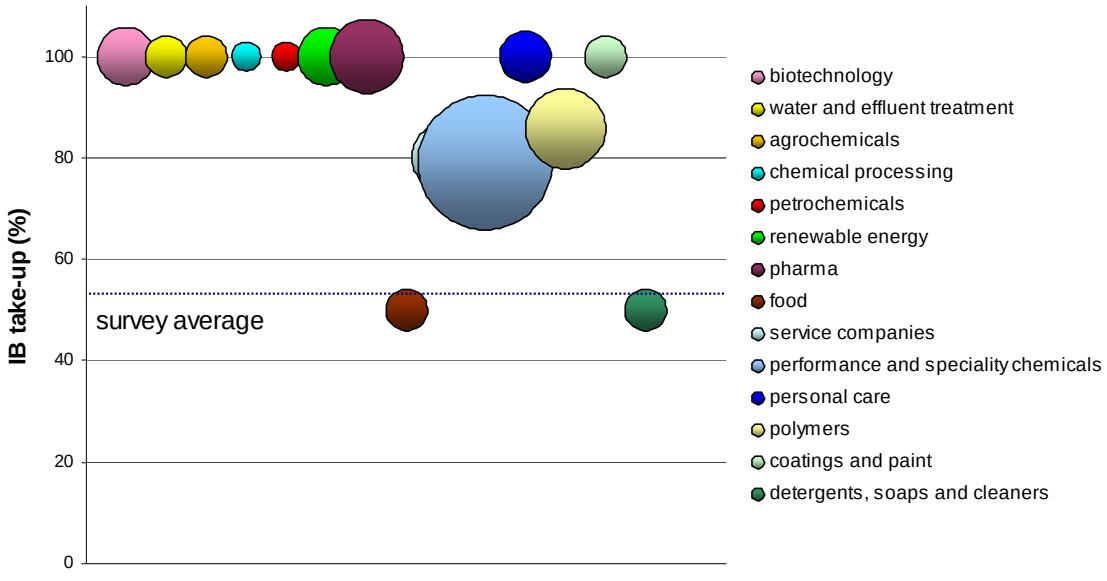


Figure 5: Current and potential IB take-up as a function of segment

(size of bubble is proportional to number of segment responses)



3.2 Factors influencing IB take-up

The survey participants were asked to identify 3 main reasons that would influence a decision to use IB. Figure 6(a) indicates the responses received taken over the whole survey population.

The top 5 five reasons cited were relevance to business, the effectiveness of IB as a route to product, customer demand, the cost benefit of adopting IB and the availability of IB expertise.

When responses to this question are sub-divided into IB users, potential IB users and those companies with no future plans, some key differences emerge. For current IB users, the effectiveness of IB as a product solution is the primary driver followed by customer demand and meeting environmental needs (Figure 6(b)). The group which represents potential interest in using IB cited relevance to their business as the most important factor followed by the cost benefit of producing IB-based products and having an understanding and awareness of industrial biotechnology (see Figure 6(c)). Clearly, the latter points to the importance of knowledge transfer in persuading this group to follow through their potential interest in adopting IB. The group with no future plans for IB use provided only a limited number of responses to this question but relevance to business, cost benefit, the availability of IB expertise, customer demand, meeting regulatory obligations and the availability of IB technology were offered as the main factors which might influence a decision to adopt IB (see Figure 6(d)).

Figure 6(a): Reasons influencing a decision to use IB

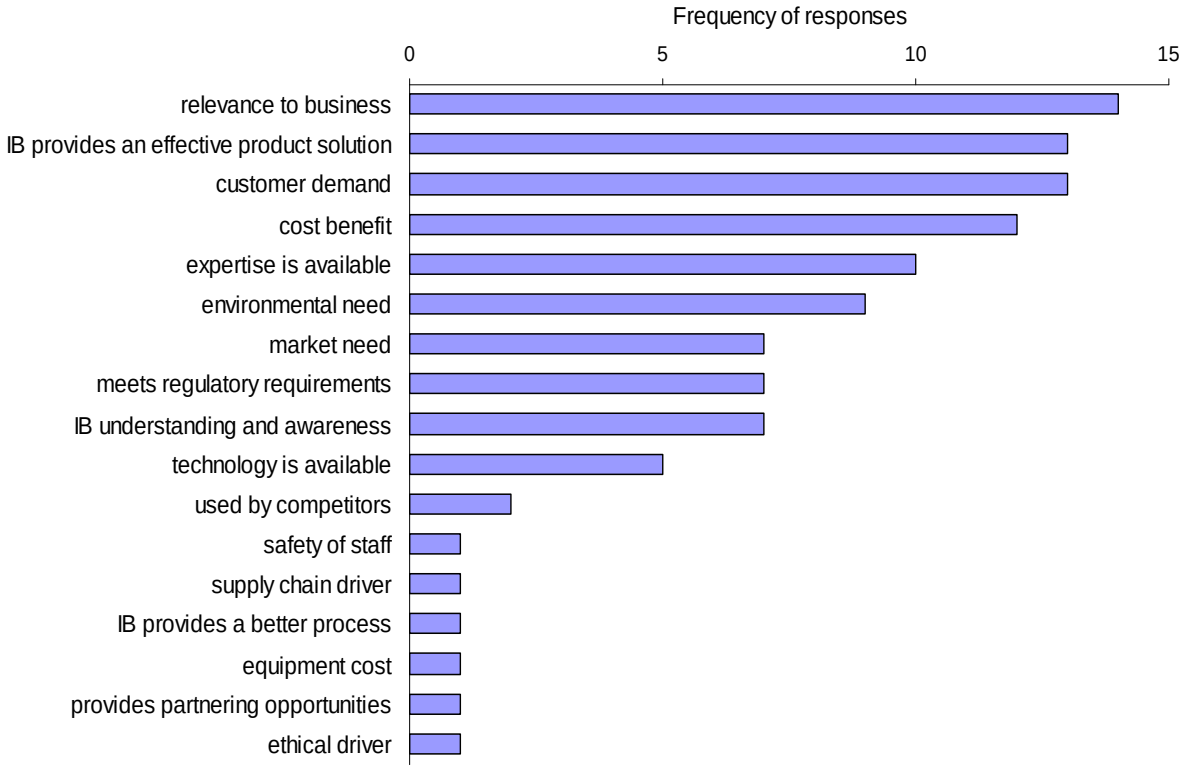


Figure 6(b): Factors influencing IB take-up for current IB users

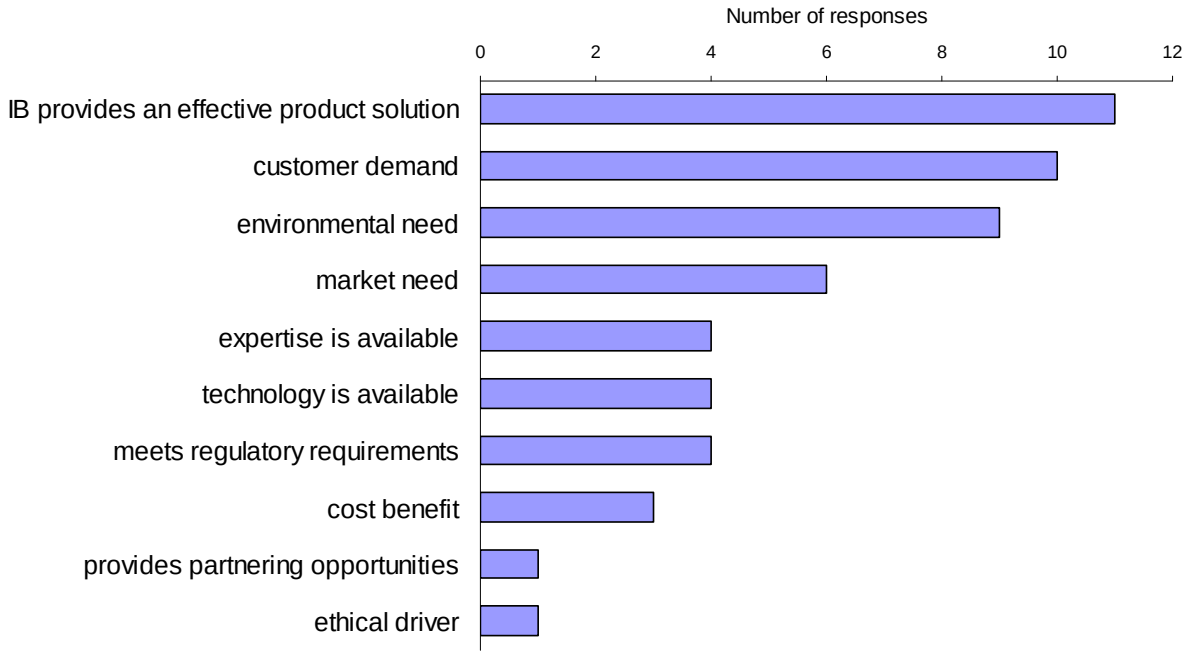


Figure 6(c): Factors influencing IB take-up for potential IB users

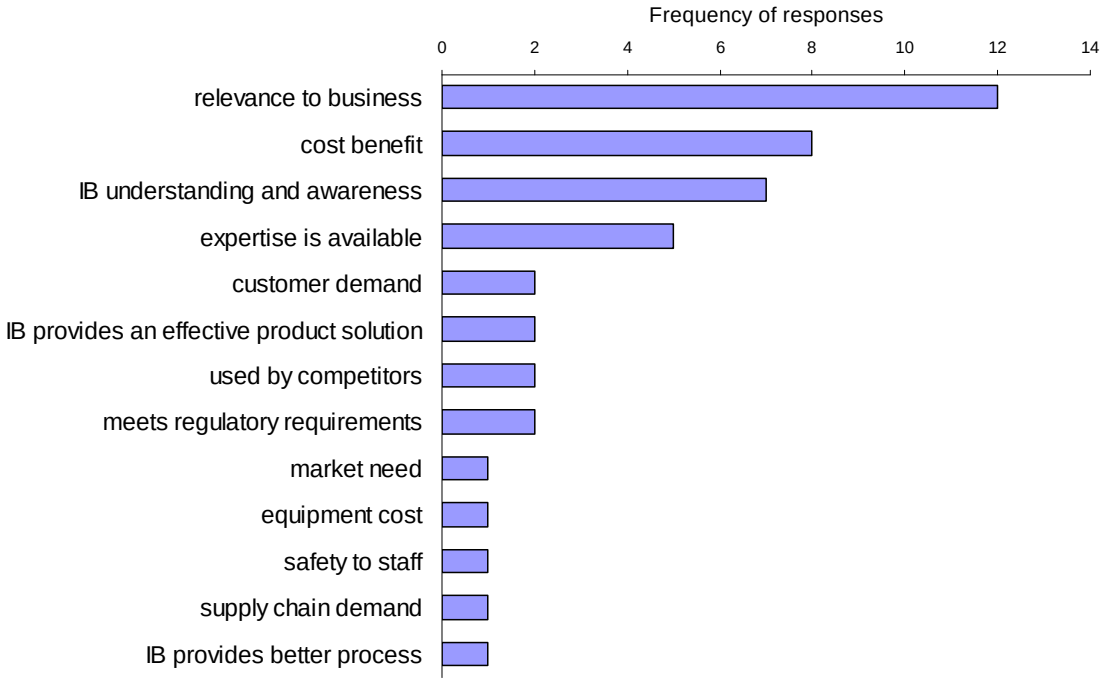
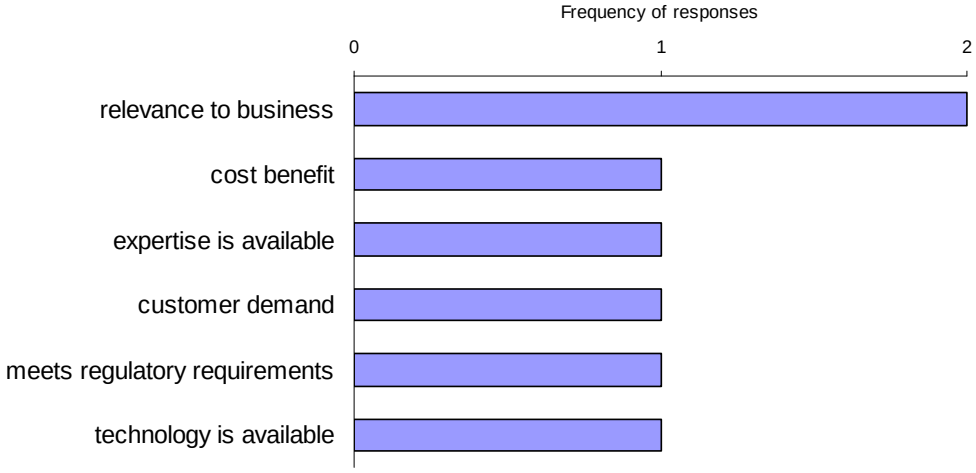


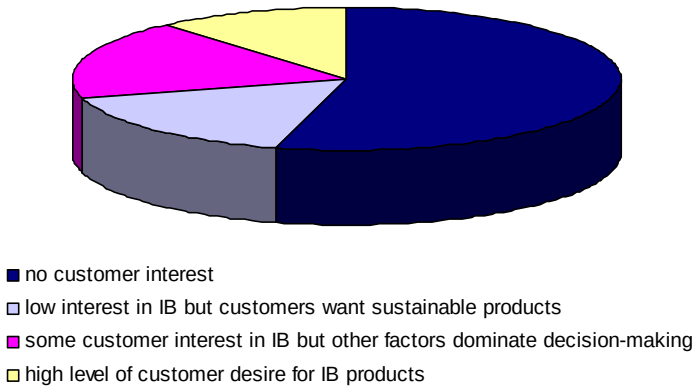
Figure 6(d): Factors influencing IB take-up companies with no future plans to adopt IB



3.3 Customer desire for IB-based products

The level of customer desire or interest in IB-based products was low with over half respondents (55%) replying that their customers had no interest in products produced using industrial biotechnology (see Figure 7). Respondents noted on several occasions that customers had no perception of what 'industrial biotechnology' actually involved and that the lexicon was unknown to them. A common thread was that industrial biotechnology had no special status and that business decisions were made on product and cost merit – whether industrial biotechnology was involved in the manufacturing process was irrelevant. However, a proportion of respondents (16%) revealed a desire for sustainable, organic or 'natural' products, particularly in the pharma, food and personal care segments. A similar proportion (18%) stated there was some interest in IB-based products but that other factors (e.g. cost, market need) would prevail in influencing business decisions. Only 11% of respondents indicated a positive desire from customers for IB-based products.

Figure 7: Customer desire for IB-based products



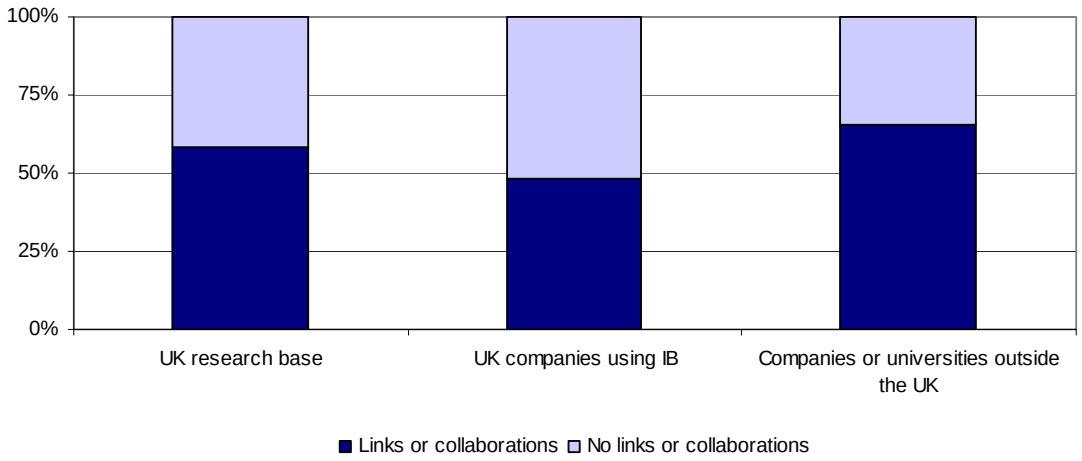
3.4 *Collaborative activity*

An initial assessment of collaborative activity in IB conducted in the earlier IB-IGT survey showed that approximately 60% of companies using IB were involved in some form of collaborative activity or project[1]. In the present follow-up survey, the nature of these collaborative activities is investigated in greater detail to establish whether these links are with UK universities, UK

companies or with companies or universities located outside of the UK. A summary of this collaborative activity is shown graphically in Figure 8.

Results from the follow-up survey show that 57% of companies using IB had some link or collaboration in place with other partners, in excellent agreement with the earlier survey[1]. Links with the UK research base were demonstrated by 59% of IB users including collaborations with the universities of York, Sheffield, Loughborough, Liverpool, Teesside, Newcastle, Nottingham, Bath, Wolverhampton, Strathclyde, Heriot-Watt and Manchester. Many of these university links were in the form of industrial CASE awards. Links were also in place with the some of the RDAs, Knowledge Transfers Networks, the Technology Strategy Board, the National Non Food Crops Centre, the Carbon Trust and Biowise.

Figure 8: Links and Collaborations in IB-related areas



The level of collaboration with UK companies was 48%. Information on the nature of these collaborations was limited due to restrictions arising from non-disclosure agreements. However, there was some indication that such collaborations were often driven by supply chain needs. Outside the UK, the level of collaborative was 66%, higher than found in the UK. This may reflect non-UK ownership of some companies where collaborations were being linked through overseas parent companies. Links with European universities and participation in the EU framework research programme also contributed collaborative activity outside the UK. Formal collaborations were in place with companies in the US, Japan, China and India as well as EU states. As with UK companies, details of these inter-company collaborations were often limited due to the requirements of non disclosure agreements.

3.5 Barriers to IB take-up

Figure 9(a) summarises the reasons cited as barriers to IB take-up across the whole survey population. The highest number of responses concerned lack of available expertise with a quarter of respondents expressing a specific concern in this area. The next most frequent concerns were relevance to a company's business, lack of IB knowledge or awareness and the cost performance of IB-based products. Interestingly, 7 participants (all current IB users) stated there were no major barriers to IB take-up.

Lack of expertise was again cited as the most common concern for the cohort of current IB users (see Figure 9(b)). Lack of access to funding, poor cost performance and lack of available technology were perceived as the next most likely barriers to implementation. For the group of potential users, demonstrating relevance to business was the main hurdle followed by lack of IB knowledge and awareness, lack of available expertise and potentially high investment/capital costs for establishing processes involving industrial biotechnology (see Figure 9(c)).

Although only a limited number of responses were received from companies with no future plans for take-up, the relevance of IB to company business was again cited as the strongest barrier to take-up (see Figure 9(d)). As for the previous categories, lack of expertise was also highlighted by this group as was lack of IB knowledge and awareness. Other perceived barriers, which did not feature highly in the user and potential user categories, was the prospect of having to respond to complex regulatory frameworks and encountering actual resistance to IB from customers. This concern may be linked to concerns over public reactions to other 'bio' related technologies such as GM foods and biofuels.

Figure 9(a): Barriers to IB take-up – all survey participants

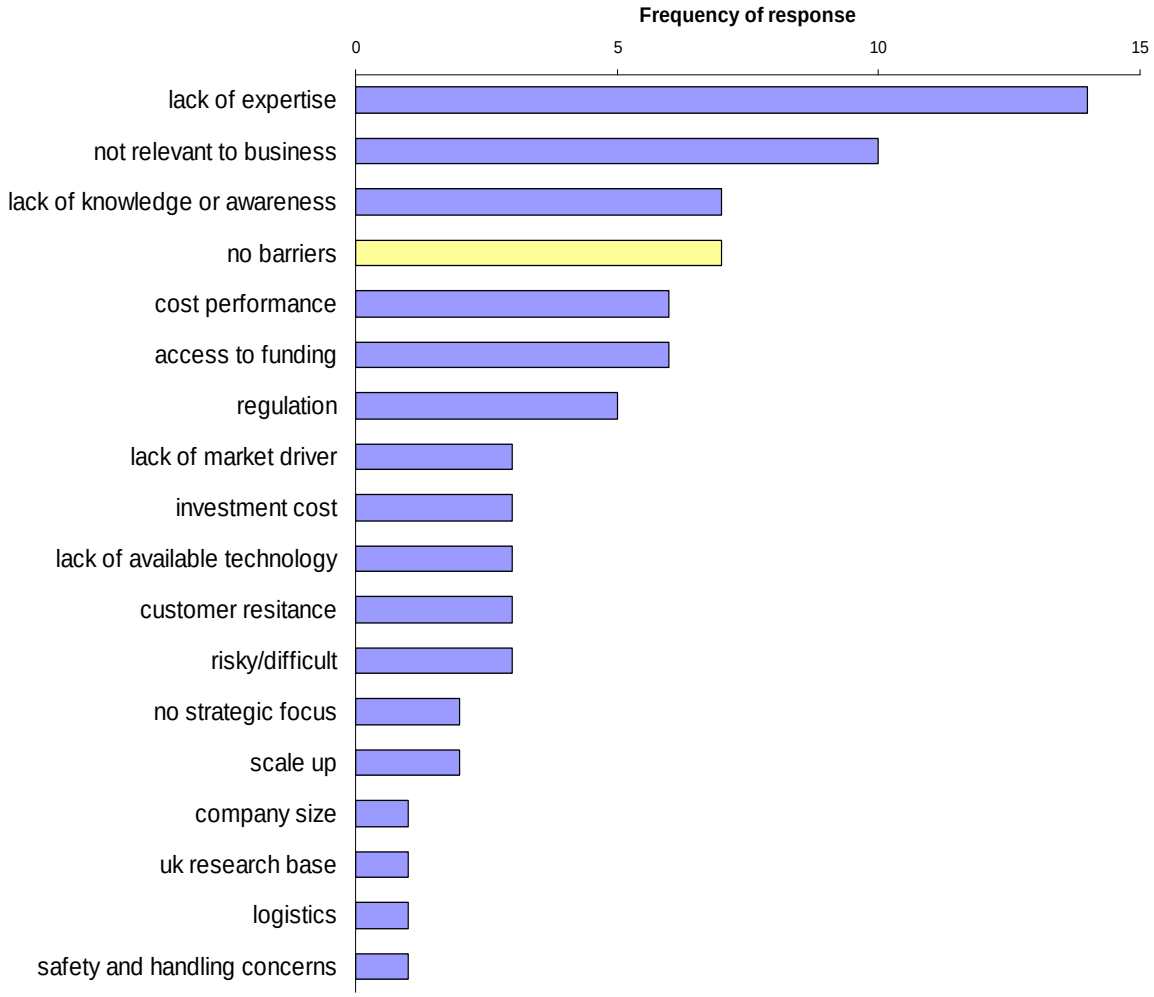


Figure 9(b) : Barriers to IB take-up – current users

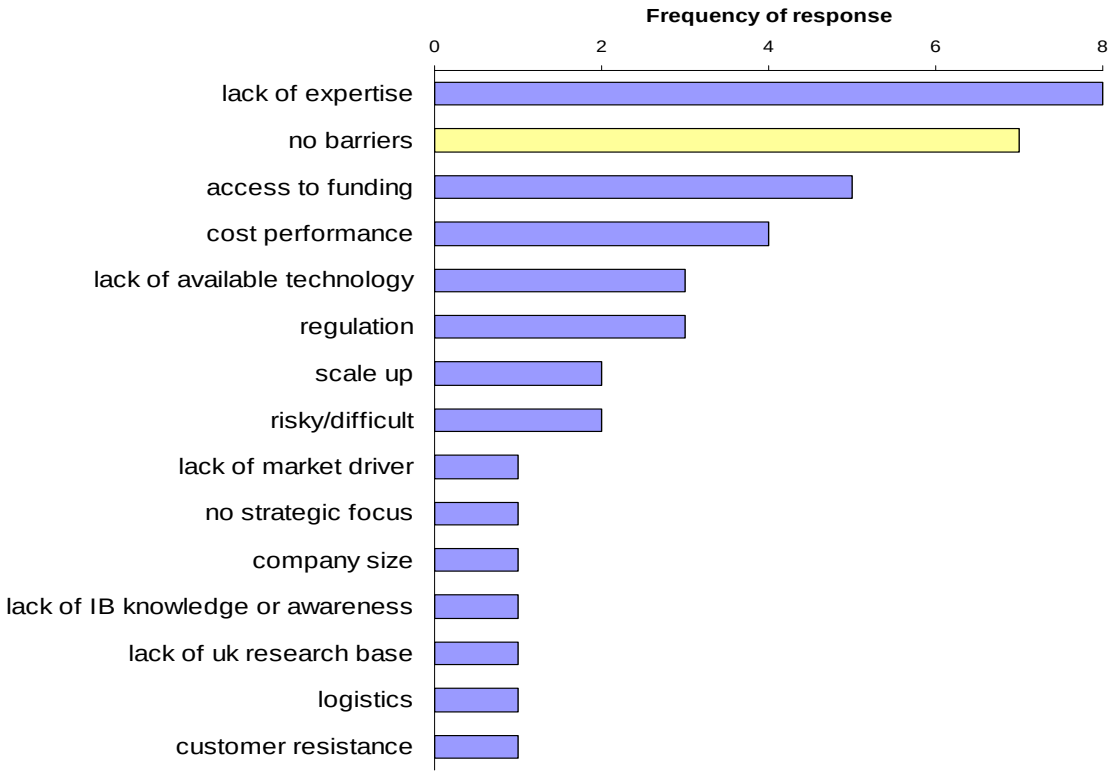


Figure 9(c) : Barriers to IB take-up – potential users

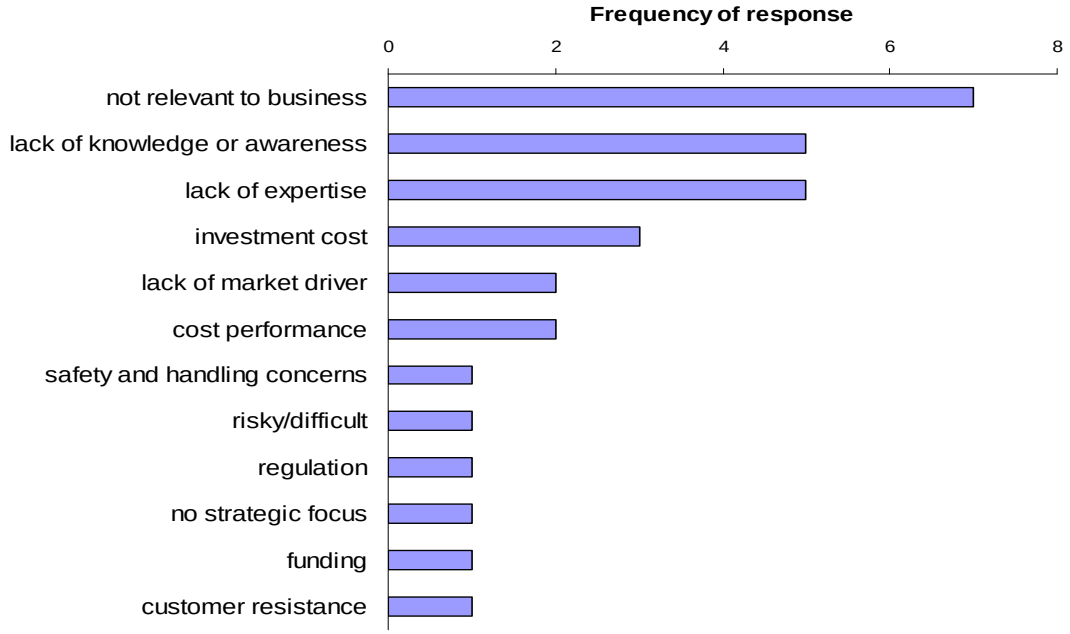
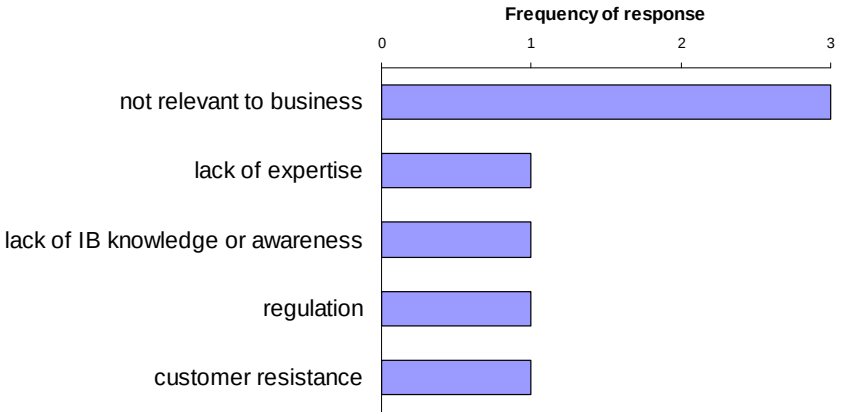


Figure 9(d) : Barriers to IB take-up – companies with no future plans for take-up



3.6 New business opportunities

As might be expected, current IB users were the most enthusiastic advocates of pursuing new business opportunities in IB. Opportunities for this group tended to focus on new developments in technology, new opportunities arising from the scaling-up of operations and the market advantages offered by products and process based on industrial biotechnology. Bioethylene manufacture, the use of enzymes in extraction processes, waste treatment, composting, biopharmaceuticals and biofuels were mentioned as potential areas for future development.

The group representing potential IB users was more concerned with finding opportunities that were economically attractive (e.g. through access to funding mechanisms) and which demonstrated a favourable market positioning (e.g. by offering sustainable products or processes). Technology areas covering natural polymers, biofuel feedstocks and by-products, synthetic peptides and enzyme-based cleaning agents were provided as examples of potential opportunities to exploit. Respondents replied that supply chain pressure and R&D developments could be the drivers that activated a switch to using IB. The less enthusiastic subset of this group, those that did not have specific plans for developing IB-based products but who were willing to consider possibilities, looked to product diversification and changes in company strategy as reasons for entering the IB sector.

4. Discussion of survey findings

Analysis of survey outcomes reveals a complex landscape for the uptake of IB in the chemicals and chemistry-using industries. On reviewing the potential to IB take-up, some distinct variations are noted between current IB users and the non-user groups. For example, users placed more importance on finding an effective product solution rather than demonstrating the relevance of IB to the strategic focus of a business.

Factors that influence decisions

Business decisions to adopt industrial biotechnology are influenced by various economic, technical social and environmental factors. However, the overriding factor influencing a decision to adopt IB is the relevance of biotechnology to a company's business – essentially how can IB meet the strategic objectives of a business and contribute positively to the delivery its product portfolio. Underlying this sentiment is a lack of awareness and knowledge about what IB actually is and what it can do. There is clearly some effort needed to explain what IB is about and how it can deliver product and process improvements to specific segments of the chemistry-using industries. This lack of awareness may encompass a number of areas including ignorance about biological conversions, the types of equipment needed, the chemicals that could be produced as well as the economic viability and sustainability of IB-based products.

The relatively poor take-up of IB in the performance and speciality chemicals area can perhaps be best understood by acknowledging the fragmented nature of this industry segment, the higher proportion of smaller companies which do not have ready access to new technologies and a lack in-house expertise to access specialist information. This is clearly an area where the Knowledge Transfer Networks have an important role to play by providing access to technical advice, citing examples and case studies and advising companies on the opportunities available for partnering and accessing funding opportunities.

A further important finding from the survey was that most companies will not be persuaded to use IB on the basis of environmental arguments only. Although benefit to the environment is cited as a key driver, many companies made the point that first and foremost IB must provide effective solutions. There is no special status for industrial biotechnology - it must deliver cost-effective and fully functional end products.

Segment variations

Of the various chemistry-using industries investigated in this survey, the dominant segments currently using IB are concentrated in the biotechnology, water and effluent treatment, agrochemicals sectors and renewable energy sectors. IB activity in the pharma industry is close to the survey average whilst those of polymers and performance and speciality chemicals are below the survey average. The latter observation is consistent with the earlier IB-IGT survey and shows that these industries possess good potential for growth in adopting IB products and processes[1]. Indeed, if future plans for adopting IB are included then levels of take-up improve remarkably across many of the segments surveyed (see Figure 5).

Customer demand

In general, the customer was found to have little desire for products manufactured using industrial biotechnology and indeed had a poor understanding of what the term 'industrial biotechnology' actually meant. This may in part be due to suppliers avoiding use of the term, perhaps fearing that it may be linked to other 'bio-based' technology issues such as GM foods or biofuels. Although the terminology of industrial biotechnology appears to remain a specialist idiom, some customers are demanding sustainable, 'green' or 'natural' products. These findings suggest that IB products that can demonstrate green or sustainability credentials are more likely to generate customer demand.

Expertise and skills

A key barrier that featured consistently across both the user and non-user groups was lack of IB expertise. It would be useful to ascertain the number and distribution of life science graduates employed across the chemistry-using industries, particularly in the performance and speciality chemicals and polymer segments where IB take-up is found to be below the survey average.

The number of students graduating in a biological science (biology, microbiology, biochemistry, molecular biology etc) is currently about five thousand per year from UK universities. If graduates with degrees in subjects relevant to bioscience are considered (e.g. chemistry, process engineering, mathematics, statistics, computer science, pharmacology and anatomy), then the number of graduates with degrees of relevance to the bioscience sector increases to a potential supply of 35,000-40,000 students per year. HESA report that the total number of students in 2006/7 specifically studying for degrees in industrial biotechnology (undergraduate and postgraduate) was 205. Of these, 55 students were domiciled in the UK[2].

Data compiled by HESA on the first destinations of graduates in subjects relevant to bioscience for 2004/5 showed that only about 5% of this graduate group was subsequently employed in key bioscience areas[3]. Based on 2003 SIC codes, the key bioscience areas addressed in this survey were the manufacture of pharmaceuticals, medical chemicals and botanical products (SIC code 2440), the manufacture of medical, precision and optical instruments, watches and clocks (SIC

code 3300) and research and development on natural sciences and engineering (SIC code 7310). For those that specifically studied a biological science (~5200 students), entry into these key bioscience areas averaged 10%. Of this graduate group, about half went into the manufacture of pharmaceuticals (SIC code 2440). For chemistry graduates (~1600 students), the entry rate into the three key bioscience areas was higher at 21%. Note that the survey response rate was 70% so actual student numbers may be under-estimated by 30-40%[3]. With the exception of the pharmaceutical industry, very little information was retrieved on the destinations of biological science graduates into specific segments of the chemistry-using industries. Cogent have reported that about 100 biology graduates per year enter the combined chemicals and pharmaceutical industries and about 20 biology graduates per year enter the oil and gas sector [4].

Consultation with the appropriate sector skills councils (SSCs) representing the chemicals and bioscience sectors (i.e. Cogent and and SEMTA, respectively) as well as SSCs representing associated downstream industries (e.g. Proskills, Energy and Utilities and Improve) may provide further insight into the employment of graduates with biological science degrees by the chemistry-using industries and the spread of IB skills across the chemistry-bioscience interface. Revised SIC codes in 2007 have introduced a new sub-category for research and experimental development on biotechnology (7211) within the category for research and development on natural sciences and engineering. Future analysis under this coding may provide a more detailed picture of employment patterns within the IB sector. However, available data suggest that the supply of personnel with training in the biological sciences into the chemistry-using industries, (excepting pharma) is very limited at present.

Going forwards, as part of the knowledge transfer process, the KTNs should examine in detail those segments where IB is now well-established practice and delivering added value. The water and effluent treatment, brewing, agrochemicals, biofuels and food and drink industries are prime candidates for providing exemplars on IB methods and best practice. Such an examination should include a technical review of the biotechnology conversions in use, supply chain relationships, cost models, employed skills sets and infra-structure/equipment requirements. The establishment of a task force to promote the introduction of IB into the chemistry-using sector could form a mechanism of delivery for such knowledge transfer activities. Such knowledge transfer and knowledge exchange activities should include engagement with the IB-IGT skills group and other IB stakeholder organizations such as the BIA.

Collaborative activity

The extent of collaborative activity amongst the IB users group was commendably high and evenly distributed across UK universities, UK companies and international organisations. In the latter case, some of the links outside the UK were being directed through parent companies based outside the UK.

Barriers to implementation and opportunities

The suggested barriers to IB take-up by the survey participants are in many ways closely related to the factors influencing a decision to use IB, although with some changes in emphasis. The most important barrier cited across the whole survey was lack of expertise. This was also the top reason given by current IB users implying that practitioners are experiencing difficulties in recruiting the right skills sets. For potential IB users, lack of knowledge and awareness and lack of expertise were the second and third ranked barriers. For those companies with no plans or interest in using IB, lack of expertise was again the second most ranked barrier.

A second common theme to emerge on barriers to implementation was that IB was not relevant to many businesses. This was found to be the highest ranked barrier for both the potential IB users group and those with no plans to adopt IB and was often cited by companies operating in the performance and speciality chemicals, detergents, soaps and cleaners, polymers and coatings industries. The fact that products for coatings, inks and pigments have traditionally been based on inorganic chemistry may underpin the opinion that IB is irrelevant to these product streams.

The reluctance of some companies operating in the performance and speciality chemistry and polymer segments to consider the relevance of IB to their businesses may well reflect a fragmented industry base and a strong legacy of methods based on chemical conversions and little experience of biological processes. Such companies also predominantly employ chemists for research and product development. Moreover, some larger companies have experienced transfer to non-UK ownership which has had the consequence of shifting R&D and innovation activity outside the UK. At an anecdotal level, there was an element of resistance from some companies to consider industrial biotechnology arising from apathy and a sense of fatigue that this is an area that once promised much but failed to deliver. The provision of convincing exemplars that demonstrate effective technology and best practice would help to counter these perceptions.

Business opportunities

The diversity of the chemicals and chemistry-using sector offers a range of opportunities for the application of industrial biotechnology. Chemicals that were previously manufactured by chemical conversions may now be manufactured using biochemical reactions, often under less extreme and energy-consuming environments. In addition, IB should enable the creation of new and different chemicals that can replace and improve upon the performance of existing products made using chemical processes.

The knowledge of how IB has successfully delivered to industries such as water treatment, brewing, food, agrochemicals and biofuels should be used to promote IB activity in industries that traditionally have little experience in applying biochemical conversions to production processes and which generally do not employ personnel with training in the biosciences. Ideally, exemplars from these industries should demonstrate the type of chemicals that can be produced using IB and the process technology that is required to generate these chemicals and products in a scaled-up commercially viable operation. The search for new opportunities should target those company profiles and industry segments which have the most to gain from adopting IB. Such targeting should include consideration of current product profile, process chemistry, operating practices, market segment, supply chain positioning, in-house expertise and technical know-how. Particular focus should be placed on the performance and speciality chemicals and polymer areas where there are good opportunities to increase IB take-up from current levels.

5. Conclusions

- The proportion of companies in the chemistry-using industries canvassed in this follow-up survey that are currently using IB is close to 50% with a further 40% considering or prepared to consider future use. These proportions are higher than the earlier survey where a greater spread of industry segments was reviewed[1].

- Biotechnology, water and effluent treatment, agrochemicals and renewable energy (mainly biofuels) sectors are major current users. This confirms findings from the earlier IB-IGT survey where food and brewing were also identified as key IB users[1].

- The performance and speciality chemicals sector, which is strongly represented in this survey, has a low take-up in IB compared with the survey average. This finding may reflect the fragmented nature of this segment and an historical exposure to cost-down pressures. In addition, non-UK ownership of some of the larger companies has resulted in R&D and innovation activities transferring outside the UK.

- Customer awareness and understanding of industrial biotechnology is very limited. Over half of companies stated their customers had no interest in IB. There is however some customer demand for green or sustainable or 'natural' products which IB-based products could seek to address.

- Lack of IB expertise is a major barrier for all companies irrespective of whether companies are current IB users or non users.

- Lack of access to funding or financing options for capital investment is a significant barrier to IB take-up for potential users, particularly for smaller companies.

- Non IB users are sometimes discouraged from IB take-up by the perception of having to respond to excessive and changeable regulation.

- IB as a technology provider must deliver value added and provide functional products or processes. IB has no special status for adoption based only on sustainability or environmental criteria, although these are acknowledged as important contributory drivers.

6. Recommendations

- Target those company profiles which have the most to gain from adopting IB. This should include consideration of current product profile, process chemistry, operating practices, market segment, supply chain positioning, in-house expertise and technical know-how. Particular focus should be placed on the performance and speciality chemicals and polymer segments where there are good opportunities to increase current levels of IB take-up.

- Review IB skills and expertise in key segments of the chemistry-using industries to determine how skills deficits underpin the current low levels of IB take-up in certain key segments, with particular reference to companies operating in the performance and speciality chemicals and polymer industries.

- Work with the sector skills councils (including Cogent and Semta) and research councils (e.g. EPSRC and BBSRC) to define the skills gaps that industry is experiencing in the provision of biotechnology expertise and propose ideas and mechanisms for increasing the biotechnology skills base in the chemistry-using industries.

- Provide segment-specific case studies which demonstrate the technology, cost benefit and sustainability of IB based products.

- Utilise the KTNs to provide knowledge transfer and technology translation in the area of industrial biotechnology to companies and industrial segments identified as having the most to gain from adopting IB.

- Utilise the KTNs to provide information on funding opportunities for R&D and demonstration projects.

- Raise awareness of business opportunities in industrial biotechnology through the work and outputs of the IB-IGT.

7. References

1. 'Survey to assess the Use and Awareness of Industrial Biotechnology in Chemicals and Chemistry-using Industries in the UK' issued by Chemistry Innovation to the IB-IGT, April 2008.

2. See www.hesa.ac.uk. View on-line data by subject, 2006-7.

3. 'Bioscience Sector Skills Agreement Stage2: Assessment of Current Provision', p16 (data source: HESA), SEMTA report; July 2008.

4. 'Skills for Science Industries', Cogent report, September 2008.

Appendix A

Follow-up questionnaire to the survey of Industrial Biotechnology usage in the UK Chemicals and Chemistry-using Industries

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.

IB-IGT Follow-up Questionnaire

Question 1 Indicate the main area(s) of your business. Please include all primary activities including those involving biotechnology.
Where possible indicate the extent of your organisation's involvement in industrial biotechnology (e.g. approximately 30% of our company's activities are related to IB).

Question 2 What are the 3 main factors that have influenced your decision regarding utilisation or rejection of industrial biotechnology.
Please indicate order of importance if appropriate.

Question 3
Provide an indication of your customers' desire for products produced using industrial biotechnology.

Question 4
Indicate any links you have with the UK Research Base (universities, research councils etc) in the area of industrial biotechnology.

Please include where possible ongoing and recent projects, partnerships, as well as informal links.

Question 5
Are you working in collaboration with other UK companies that utilise industrial biotechnology.

Please give details where possible.

Question 6
Do you have links or collaborations with universities or companies outside the UK.

Please give details where possible.

Question 7 What are the barriers that have affected the use, or lack of use, of industrial biotechnology in your organisation.
Your response might include factors related technology, skills, economics/finance and regulatory requirements.

Question 8 Do you foresee new business opportunities for industrial biotechnology in your organisation in the future
Please give details where possible (e.g. product or process areas of interest and likely timescales for development).

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

Would you like to be kept informed of the outcomes of the IB-IGT project.

Yes ☐ No ☐

Please return the questionnaire no later than Wednesday, 24 September 2008.

Appendix B

Segment allocation of survey respondents

Segment	Number of companies surveyed
Performance and speciality chemicals	20
Polymers	7
Pharma	6
Service companies	5
Biotechnology	4
Renewable energy	4
Personal care	3
Water and effluent treatment	2
Agrochemicals	2
Coatings and paint	2
Food	2
Detergents, soaps and cleaners	2
Chemical processing	1
Petrochemicals	1
Total	**61**