UK Formulated Products Sector

Strategic Priorities 2018

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The Formulated Products Sector contributed in excess of £149bn to UK GVA in 2016, compared to £6.5 bn Aerospace, £17.1bn Automotive and £32.1bn for Construction. Despite the importance of the Formulated products sector securing funding has historically been difficult with small and sporadic investment in comparison to other sectors. The UK Formulated Products Sector is vital to the UK economy and tackling the societal challenges we all face. The Food and Drink sector is the largest remaining UK Manufacturing sector worth £28.8 bn/yr to the UK economy, larger than the Aerospace and Automotive sectors combined. The Chemical Sector is a solution provider for UK industry, with a vibrant ecosystem of innovative SME’s and large global conglomerates.

With the launch of the Government’s Industrial Strategy, formation of UK Research & Innovation and on-going discussions on sector deals, the UK Formulated Products sector has completed a preliminary collaborative industry consultation to ensure the UK Formulating Industries are represented within the developing Chemistry Sector Deal. This report highlights the sector’s strategic priorities including 5 potential focus areas for UK Research & Innovation funding and makes 7 key recommendations to secure the UK Formulated Products Sector’s leading position, which include:

- **The formation of a working group to develop a Formulation Roadmap,**

- **Secure the future of the Centre for Doctoral Training (CDTs),**

- **Extend the NFC core funding**

These recommendations were developed in consultation with global companies including Astra Zeneca, Akzo Nobel, Pfizer, Procter & Gamble (P&G), PZ Cussons, Unilever, Croda, BASF, BP and Syngenta, alongside consultation with other formulations-based organisations and representative from UK Research & Innovation. Co-investment from government is needed to unlock the full potential of the formulated products sector.
Identified Opportunity

Vision

Support the Chemistry Growth Partnership (CGP) in delivering its vision for the UK Chemical Sector which states “By 2030, the UK chemical industry will have further reinforced its position as the country’s leading manufacturing exporter and enabled the chemistry-using industries to increase their Gross Value Added contribution to the UK economy by 50%, from £195 billion to £300 billion. Secure and competitive energy and feedstock, accelerated innovation and strengthened supply chains will be critical in realising this vision”.

Aim

An exercise to identify key priorities for the Formulated Products Sector, building on the 2013 Formulation Strategy [1] to align with the Industrial Strategy and provide input into the Chemistry Growth Partnership’s vision for Chemistry Sector Deal, leveraging funding in the Industrial Strategy Challenge Fund, BEIS and UK Research & Innovation to build on the consensus from industry that the sector needs to continue to develop beyond the initial investment in the National Formulation Centre. Thereby assisting the CGP in Accelerating Innovation and Rebuilding UK Supply Chains.
What is Formulation?

Formulation, is the creation of multi-component (often multi-phase) products, that act as a delivery vehicle to perform a specific function. Formulation involves developing a target molecule (active), e.g. pharmaceutical excipient, flavour, cleansing agent, perfume or lubricant etc., with a compatible carrier system (e.g. tablet, cream, lotion, solution, gel) that transports the active to the correct location and delivery system to perform a specific task at a specific location at a specific time (targeted delivery).

Realising the Potential for Formulation Sector

In 2013 the Formulated Products Sector developed a strategy [1], which identified 3 industry objectives (table 1) and has successfully established a National Formulation Centre (March 2016), secured £9.3m CR&D funding competitions (2013). The competition was one of the most successful competitions run with 16 CR&D projects and 19 feasibility studies funded. Applications were of such a high standard that an additional £3.2m was found to take advantage of the opportunity to stimulate the manufacturing sector through formulation. In addition to delivering these successes, the Formulated Products Sector has also developed new cross sector consortia e.g. ADDoPT and REMEDIES projects (funded via AMSCI) and develop new facilities with the Materials Innovation Factory and the NFC has gone on to lead the European formulation strategy framework successfully leading European consortium under the AceForm4.0 project.
2013 Industry Objectives | 2018 Industry Challenges
--- | ---
Establish a National Centre for Formulation | Increasing pressures on Circular Economy and Renewable feedstocks
Secure CR&D funding in Formulation | Market pull to Personalised Products
Develop industry formulation skills training | Late Stage Customisation and Distributed manufacturing
Digital Design/Faster routes to market

Table 1: Summary of the Industry Objectives (2013) and current Industry Challenges (2018) facing the Formulated Products Sector.

With the launch of the Government’s Industrial Strategy, formation of UK Research & Innovation and on-going discussions on sector deals, the UK Formulated products sector again recognises the need for a coherent industry strategy and the importance of securing the future of nationally important facilities such as the NFC and has identified new Industry challenges (table 1). This report highlights the Formulated Products Sector’s strategic priorities which need to be further developed into a coherent strategy to build on the UK’s current leading position.

**Future trends in Formulation**

Depending on the target markets there will be some subtle difference but in general there is a shift towards an emerging cross sector ecosystem for digital design, more sustainable formulation and personalised formulations. Understanding the principles of assembly of molecules and how this relates to the material’s properties is key to unlocking future innovations and designing functional materials for the future. Whether it be self-healing composites for aerospace and automotive or pressure sensing materials for robotics, adding functionality to materials is essential to UK competitiveness and clearly linked to the molecular assembly.
The Formulated Products Sector is vast and understanding the sector and the challenges it faces is critical to providing the correct support to accelerate the formulation value chain. **The challenges in the fundamental science of formulated products are often understated.** Though there is a diverse product offering and the context of the industry markets are different, the science is often the same (with many products made in similar ways). **Understanding where the science intersects across the market sectors and working collaboratively around common industry challenges is essential.**

The challenge in the science of formulated products is often understated. All the markets within the Formulated Products sector have challenges in the underlying science including powders, liquids, solids and polymer systems. **Stability of a product can be a real barrier to innovation as it takes a long time to understand the route-causes of instability.** This is an urgent area for innovation and is becoming increasingly challenging for the sector as consumers and regulation demand a move to more natural and sustainable materials. Identifying where the science across the markets intersects and supporting CR&D activity across the sector will deliver disruptive solutions.

“The potential to participate in a cross-industry solutions for formulated products enables transformation in finding future practical solutions and ways of working. Bringing together the formulation industry and the applications of formulation products will increase the profile of the industry as a whole”

Rebecca Yates, formulated products research manager for fuels and lubricants at BP.
Formulation in High Value Manufacturing

With the release of the Government’s Industrial Strategy [2], the formation of UKRI and ongoing discussions with UK Government on sector deals there is now a need for a strategy for the UK Formulated Products sector to ensure the Formulating Industries are suitably represented within the developing Chemistry Sector Deal. The Chemical Industry Association reported that official data shows the chemical sector (including chemical and pharmaceutical manufacturing), outpaced growth in the whole of the UK manufacturing sector at the end of 2017. Official production data shows that the chemical sector output increased by 1.7% in the three months to November 2017 compared with the three months to August 2017, higher than the 1.5% recorded by the whole of the manufacturing sector. Over the same period chemical sector exports to the rest of the European Union grew even as exports to the rest of the world declined. Over the year as a whole the production of chemicals (excluding pharmaceuticals) grew by over 4% compared with 3% for the whole of UK manufacturing, the best year of growth for UK manufacturing since 2014. (For further information please contact CIA Head of Economics Stephen le Roux).

The Formulated Products Sector which includes Pharma, Food and Drink, Home & Personal Care, Paints and Coatings, Fuels and Lubricants and Speciality and Agrichemicals is worth £180bn to UK economy. But the sector is still struggling for recognition among the public and within government. We need to raise the profile of UK Chemical Innovation. Part of the challenge lies in the perception of the Chemical Industry and the lack of visibility in how our sector supports and underpins the more visible sectors of Aerospace, Automotive, Construction, Infrastructure and Health. The Formulated products sector underpins the High-Value Manufacturing sectors, providing resins, functional materials and coatings etc.

A high-level summary of the chemical and process sector’s contribution to the UK economy, from the Northern Powerhouse: Chemicals & Process Sector: A Science and Innovation Audit Report sponsored by the Department of Business, Energy & Industrial Strategy, work in preparation for publication, Autumn 2018 [3], shows the Formulated Products Sector contributed in excess of £149bn to UK GVA in 2016, compared to £6.5 bn Aerospace, £17.1bn Automotive and £32.1bn for Construction. The figures clearly show that the Formulated Products Industries contribution to UK GVA, which includes: Chemical Manufacturing, Pharmaceuticals and Consumer products dwarfs the Aerospace and Automotive sectors. The Food and Drink sector is the largest remaining UK Manufacturing sector worth £28.8 bn/yr, 90% of the total manufacturing turnover in UK,
employing 400,000 people and is larger than the Aerospace and Automotive sectors combined. The UK Formulated Products Sector is vital to the UK economy and tackling the societal challenges we all face. Co-investment from government is needed to unlock the full potential of the formulated products sector.

KTN have been asked to produce a UK Formulation Roadmap and held a stakeholder workshop in partnership with CPI’s National Formulation Centre to provide an opportunity for delegates to discuss the current UK position, impact of mega trends such as Digital Manufacturing and Healthy Ageing and understand the issues and capabilities required to help businesses overcome innovation challenges associated with formulation. This strategy was developed with representatives from global companies including Astra Zeneca, Akzo Nobel, Pfizer, Procter & Gamble (P&G), PZ Cussons, Unilever, Croda, BASF, BP and Syngenta, alongside consultation with other formulations-based organisations and representatives from UKRI and highlights the key technical challenges faced by the UK Formulated Products Industry and what support is needed to ensure the sector continues to deliver disruptive solutions across High Value Manufacturing.

“The food and drink sector is the largest remaining manufacturing sector in the UK - it is bigger than the aerospace and automotive industries combined, and contributes over £28.8bn a year to the UK economy. As 97 per cent of companies in the sector are SMEs, the biggest challenge is getting the scale of formulations we need. CPI’s National Formulation Centre is integral to enabling the cross-sector collaboration and access to facilities required help get future food and drink formulations to scale.”

Emma McLeod, research principal at Mondelez International.
UK Position and Capabilities

The UK has a strong competitive advantage in formulation and is poised to take a global competitive lead to drive and take advantage of future market growth. Sales of formulated products by UK companies currently total around £180bn per year with a rapidly developing overseas market. The UK has significant industry centres for the design and manufacture of formulated products including laundry detergents (P&G), personal care products (Unilever), agrochemicals (Syngenta), food (Nestle), coatings (AkzoNobel) and pharmaceuticals (AstraZeneca, GSK, Pfizer). The supply chain for precursors, ingredients and enabling capabilities is well represented, with companies such as Croda, Innospec and Rockwood all having a major UK presence.

The UK has state-of-the-art capabilities including the High Value Manufacturing (HVM) Catapult and in particular with Centre for Process Innovation, and its National Formulation Centre (NFC). CPI’s was established to support the UK process industry and combines state-of-the-art facilities with technical expertise in order to overcome innovation challenges. The NFC supports the design and manufacturing processes for a range of formulated products including powders, liquids, solids and polymer systems, through the value chain from ingredient to product. The NFC is one example of how to bring together cross-sector industry which historically has been difficult to achieve. The NFC provides access to industry trained experts and open access facilities which enable the formulating industries to develop and scale up advanced formulated products productively, efficiently, and with less risk. The National Formulation Centre is based at Sedgefield in County Durham, co-located with CPI’s Printable Electronics and Graphene Application Centres providing a joined-up approach to the development of next generation formulated products and their applications. The facilities are flexible, supporting the design of manufacturing processes for a range of formulated products and help businesses explore product applications with associated mechanical and performance testing, ensuring consistent product quality is delivered across scales and from batch to batch.

Since March 2016 the NFC has carried out 12 CRD projects and 40 commercial contracts. The five major capability build projects alone have leveraged the NFC grant, with a contribution from industry of £1,334,817 and £630,774 from academia. These contributions are developing the future capability for the NFC and show the industry recognises the national importance of the facilities and capabilities being developed at the NFC. Continuing to develop beyond the initial investment in 2013 and securing the next phase of funding for the National Formulation Centre is essential to ensuring the UK maintains and builds on its leading position.
In autumn 2015 the UK Government announced regional Science and Innovation Audits (SIAs) to catalyse a new approach to regional economic development. SIAs enable local consortia to focus on analysing regional strengths and identify mechanisms to realise their potential. In the Northern Powerhouse a consortium was formed in 2017 to focus on their strength in the chemicals and process sector. Northern Powerhouse Chemicals and Process Sector: A Science and Innovation Audit Report sponsored by the Department for Business, Energy & Industrial Strategy sponsored by the Department of Business, Energy and Industrial Strategy in preparation for submission in Autumn 2018, presents the results which includes broad-ranging analysis of the Northern Powerhouse’s chemicals and process sector’s capabilities, the challenges and the substantial opportunities for future economic growth.

There is also a strong academic base that can be leveraged, for example RTO investment, including, the Materials Innovation Factory (MIF), Sir Henry Royce Institute and a number of Centres for Doctoral Training that underpin the skills base in the sector. The breadth of the Formulated Products sector requires cross-sector multidisciplinary CDTs. A number of the CDTs have a strong track record across several industries in the formulation sector, providing research and skills development to understand and predict the structure and performance of formulated products and high throughput discovery of materials. The CDTs deliver the skills which have been recognised by the formulated products sector as nationally important. Securing the future of the CDT’s during the renewal process taking place summer 2018 is an essential next step in securing the future of the formulated products sector.

Initiatives such as the EPSRC Directed Assembly Network grand challenge, aims to gain unprecedented control of the assembly of molecules, the building blocks of many functional materials and AMSClI funded ADDoPT and REMEDIES projects are excellent examples of how targeted funding support focused on addressing where the science intersects across the market sectors and working collaboratively with discussions around common challenges is essential. Recent investment in CDTs and facilities including the NFC and MIF have created the basic building blocks that with the right coordination and support, could drive globally leading cross-industry innovation from the UK. Inaction risks eroding the competitive advantage. A clear co-ordinated strategy is needed to ensure engagement with international stakeholders and customer markets, routes for public-private co-investment in R&D and developments and investments in facilities and training all drive the UK towards becoming the globally leading centre for innovation in formulated products.
Formulation Value Chain

Structure
- Molecule
  - Pigment
  - Flavouring
  - Active (API)
  - Binder
- Material
  - Surfactant
  - Encapsulant
  - Polymer
  - Emulsifier
- Manufacturing
  - Liquid processing
  - Solids processing
  - High Throughput
  - Oil-based
- Market
  - Fine Chemicals
  - Pharma
  - Food
  - HPC

Properties

Processes

Performance

Fundamental Research
- TRL1
- TRL3
- TRL5
- TRL7
- TRL9

Design
- Develop
- Evaluate
- Supply
# Formulated Products Market Sector

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<thead>
<tr>
<th>Market Sector</th>
<th>Trends</th>
<th>Challenges</th>
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<tbody>
<tr>
<td>Health &amp; Pharma</td>
<td>▪ Personalised medicines</td>
<td>▪ Regulatory constraints – new platforms locked in for 10 years.</td>
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<td></td>
<td>▪ Digital design</td>
<td>▪ Need to reduce risk of introducing new platforms.</td>
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<td></td>
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<td>▪ Targeted delivery for improved efficacy.</td>
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<td></td>
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<td>▪ Delivery systems for more than one excipient.</td>
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<td></td>
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<td>▪ Designing nanoparticles.</td>
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<td>▪ Anti-counterfeit products.</td>
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<tr>
<td>Food &amp; Drink</td>
<td>▪ Healthy Ageing</td>
<td>▪ Replacement of sugars – has a structural role (not just sweetener).</td>
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<td>▪ Move to natural products</td>
<td>▪ Materials variability, seasonality.</td>
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<td>▪ Personalised products</td>
<td>▪ Understand stability, structure, texture, taste &amp; consumer behaviour.</td>
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<td>▪ 97% SMEs, biggest challenge is achieving scale up of formulations.</td>
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<td>▪ Novel sensors to monitor &amp; control food systems – combine with packaging.</td>
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<tr>
<td>Home &amp; Personal Care</td>
<td>▪ Personalised products</td>
<td>▪ Late stage customisation of base formulations.</td>
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<td>▪ Multipurpose products</td>
<td>▪ Predicting consumer trends.</td>
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<td>▪ Sustainable products</td>
<td>▪ Quicker routes into global markets.</td>
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<td>▪ Digital design</td>
<td>▪ Materials variability – seasonality, confidence in sustainable feedstocks.</td>
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<td>▪ Reducing overall footprint; low/no-water formulations, packaging.</td>
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<td>▪ Stability of products – complex liquid systems.</td>
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## Formulated Products Market Sector

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<tr>
<td>Paints &amp; Coatings</td>
<td>- Sustainable products</td>
<td>- Materials variability – predictive modelling to forecast impact of molecule format/processing</td>
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<tr>
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<td>- Multipurpose products</td>
<td>- Stability of products – stability complex liquid systems</td>
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<td>- Personalised products</td>
<td>- Reduce water usage and downtime for cleaning</td>
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<td>- Rapid change-over in manufacture and late stage customisation</td>
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<td>- Understanding consumer behaviour</td>
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<tr>
<td>Speciality Chemicals &amp; Agri Chemicals</td>
<td>- Sustainable products</td>
<td>- Stability of products</td>
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<td>- Digital design</td>
<td>- Regulatory impact of REACH – rapid reformulation</td>
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<td>- Materials variability; measuring raw materials throughout supply-chain, confidence in sustainable feedstocks</td>
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<td>- “Right-first-time” manufacturing, fast prototyping</td>
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<tr>
<td>Fuels &amp; Lubricants</td>
<td>- Sustainable products</td>
<td>- Stability of liquid systems in harsh environments (engine)</td>
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<td>- Digital design</td>
<td>- Targeted release of multiple actives</td>
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<td>- Packaging</td>
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<td></td>
<td></td>
<td>- Biofuels, new base oils – Material variability</td>
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<td></td>
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<td>- Flexibility and resilience of ingredient source (processing to standard specification)</td>
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Industry Technical Challenges

Innovation in the Formulated Products Sector will enable faster routes into global markets. Increased understanding of ingredient specification and the impact on materials variability will be key as the sector moves towards more personalised products and increased use of sustainably sourced materials. Predicting the stability of complex liquid products in different regions and environments is essential. Depending on the target markets there will be some subtle differences but in general there is a shift towards an emerging cross sector ecosystem for digital design, more sustainable formulation and personalised formulations and understanding consumer behaviour. Along the product development journey from Design to market industry highlighted where the pain points (frustrations and/or barriers) were.

Product development journey

The key technical challenges faced by the UK Formulated Products Sector can be summarised into 5 priority areas:

1. Rapid Reformulation
2. Smarter Formulation
3. Greener Formulation
4. Personalised Formulation
5. Future Formulators
Rapid Reformulation

Late customisation of base formulation e.g. rapid replacements of key components; Regulation & REACH for Surfactants, market pull to naturals and bio-based materials and adapting to customer needs.

- Improved models of existing formulations across length scales (multiscale modelling), which provide new information on formulation architecture or product microstructure.
- Rapid formulation prototyping with high throughput techniques and characterisation.
- Increased understanding of customer’s real needs and product requirements reduce the risk of introducing new platforms/products.
- Increased knowledge of chemical supply/base formulations and Processes that are robust to production variability.
- Advanced process analytics incorporating sensors and modelling to reduce the number of trials.
Smarter Formulation

Formulation provides targeted delivery of an active ingredient to fulfill a specific role at a specific time. Technologies or methods which enable or improve the precisely controlled and targeted use of ingredients or which provide cross sector manufacturing best practice. Predictive design for new formulation development.

- Improved delivery of the active ingredient(s) or improved understanding on how to combine the active in the delivery system for example improved understanding of adsorption/desorption enabling more benefit with less active, and predicting real life delivery.
- Improvements to manufacturing processes that lead to processes which are more robust to production variability, scaling up and scaling down.
- New methods for predictive design, measurement, characterisation, control and optimisation of the stability of complex products.
- Advanced Characteristics which leads to improved understanding or clearer visualisation of product structure for example traceability of materials to address counterfeiting of high value products.
- Leverage capabilities at the Hartree Centre (part of the Science Technology Facilities Council) which specialises in high performance computing, big data analytics and cognitive technologies chain challenges and can apply these technologies to solve manufacturing and supply chain challenges.
Greener Formulation

Technologies which can be implemented in a production environment to provide better products, improved quality or a significant economic or environmental benefit towards more sustainable formulations.

- Address the instabilities added into formulations as the market moves to more Bio-based and natural materials for example product preservation for example current product attribute models. Sustainable Palm Oil for the Surfactant Industry.
- Improved understanding of materials variability: Seasonality of naturals, Branded raw materials specification. Need increased confidence in sustainably sourced feedstocks.
- Improved efficacy, concentrated products, reduction in manufacturing runs/wastage of active ingredient for example delivery systems capable of delivering multiple actives.
- Reduction of waste through lifetime for example smarter packaging, low water-content formulations and more concentrated products (challenge as consumers think they are getting less).
Personalised Formulation

The consumer products sector contributed in excess of £123bn to the UK GVA in 2016. Innovation linked to Formulation & Consumer Technologies and technologies or methodologies which can enable manufacturing base to meet the rapidly changing demands of personalised products and improved understanding of customer requirements while using existing capital infrastructure will enable the sector to accelerate new commercial products.

- Translating more rapid consumer demand into changes in formulated product for example predicting consumer trends, collecting consumer behaviour data. Devices used in combination with formulations.
- Improved use of data, sensors and feedback loops to increase understanding of user behaviour with the product for example sensors and smart packaging to enable data harvesting for consumer insight.
- Formulating for needs of consumers in different regions/cultures.
Future Formulators

Develop skills of the next generation of formulators as a key priority for the sector to maintain UK leading position. Training must include up-skilling the existing workforce and assisting in internal company redeployment. It is recognised that the need to develop skills of the next generation of formulators is a key priority for the sector to maintain UK leading position.

- The CDTs deliver the skills which have been recognised by the formulated products sector as nationally important. Securing the future of the CDT’s during the renewal process taking place summer 2018 is an essential next step in securing the future of the formulated products sector.
- Training must include up-skilling the existing workforce and assisting in internal company redeployment. The underlying science for powder and liquid systems are different and require additional skills. The formulation workforce is often redeployed within companies to different formulation areas. Access to CPD training will assist SMEs and global companies.
- The shift to digital design and intelligent data interrogation requires a wider skill set, moving away from tradition of employing predominantly Organic Chemists to integrate modelling and experimental capabilities.
- Develop skills of the next generation of formulators as a key priority for the sector to maintain UK leading position. Knowledge of stability of complex liquid systems and predictive modelling for future formulators. Renewal of the CDTs and proposals for new CDTs to accelerate a move to industrial digitisation to deliver skills is important to the sector’s future.
Summary

The Formulated Products Sector contribute £180 bn/yr to the UK economy and contains the Food and Drink sector, the largest remaining UK Manufacturing sector worth £28.8 bn/yr, representing 90% of the total manufacturing turnover in UK. The UK Formulated Products Sector is vital to the UK economy and tackling the societal challenges we all face and is a High Value Manufacturing Sector larger than the Aerospace and Automotive sectors combined.

This strategy was developed over three months with representatives from global companies including Astra Zeneca, Akzo Nobel, Pfizer, Procter & Gamble (P&G), PZ Cussons, Unilever, Croda, BASF, BP and Syngenta, alongside consultation with many other formulations-based organisations and identifies 5 priority areas to secure the UK Formulated Products Sector’s leading position. This consultation focused on the industrial perspective on the sector needs and challenges. It is a recommendation of this strategy that a working group with industrial and academic leadership validate these recommendations to include costings and timeframes for delivery, which is beyond the scope of this strategy.

Since the centre opened in March 2018 they have carried out 12 CRD projects and 40 commercial contracts. The five major capability build projects alone have leveraged the NFC grant, with a contribution from industry of £1,334,817 and £630,774 from academia. These contributions are developing the future capability for the NFC and show the industry recognises the national importance of the facilities and capabilities being developed at the NFC. Continuing to develop beyond the initial investment in 2013 and securing the next phase of funding for the National Formulation Centre is essential to ensuring the UK maintains and builds on its leading position.

This strategy make 7 key recommendations for the Formulated Products Sector and asks the Chemistry Growth Partnership to build on the recent formation of the Food and Drink Sector Council, a formal industry partnership with Government to create a more productive and sustainable food and drink sector (formed Jan 2018), with assistance from Innovate UK and The Knowledge Transfer Network to disseminate these findings across the sector and voice the recommendations directly to government as part of the Chemistry Sector Deal.
UK Formulation Strategy – Priority Areas

Rapid Reformulation
Late customisation of base formulation e.g. rapid replacements of key components; Regulation & REACH for Surfactants, market pull to naturals and bio-based materials and adapting to customer needs.

Smarter Formulation
Technologies or methods which enable or improve the precisely controlled and targeted use of ingredients or which provide cross sector manufacturing best practice. Predictive design for new formulation development.

Greener Formulation
Technologies which can be implemented in a production environment to provide better products, improved quality or a significant economic or environmental benefit towards more sustainable formulations (Renewable Surfactants).

Personalised Formulation
Innovation linked to Formulation & Consumer Technologies. Technologies or methodologies which can enable manufacturing base to meet the rapidly changing demands of personalised products.

Future Formulators
Develop skills of the next generation of formulators as a key priority for the sector to maintain UK leading position. Training must include up-skilling the existing workforce and assisting in internal company redeployment.
Key Recommendations

1. It is a recommendation of this strategy that a working group with industrial and academic leadership validate these recommendations to include costings and timeframes for delivery by developing a Formulation Roadmap, which is beyond the scope of this work, and develop a Formulation Landscape to provide access to knowledge and skills from across the Formulated products Market sectors, building on existing UK Landscape Sector Maps developed by KTN e.g. Process Manufacturing and Medicines (Medicines Manufacturing, Medicines Discovery and Precision Medicines).

2. A key priority for the sector asks the Chemistry Growth Partnership to build on the recent formation of the Food and Drink Sector Council, with assistance from Innovate UK and The Knowledge Transfer Network to disseminate these findings across the sector and voice the recommendations directly to government as part of the Chemistry Sector Deal to secure the UK Formulated Products Sector’s leading position.

3. Secure the future of the Centre for Doctoral Training (CDTs). An early opportunity via the renewal of the CDTs in July 2018 which is important to the sector. EPSRC-funded Centres bring together diverse areas of expertise to train engineers and scientists with the skills, knowledge and confidence to tackle today's evolving issues, and future challenges.

4. Extend the NFC core funding, as move to more external R&D, Industry needs collaboration and access to skills which supplement the in-house knowledge. Enabling rapid formulation prototyping with high through put techniques and increase the knowledge of chemical supply/base formulations and processes that are robust to production variability. Continue to support the five major capability build projects, which alone have leveraged the NFC grant, with a contribution of £1,334,817 from industry and £630,774 from academia.

5. Dedicated UKRI formulation call focused on addressing where the science intersects across the market sectors and working collaboratively with discussions around common technical challenges between companies that do not directly compete; digital design, materials variability, stability of complex liquid systems and reducing the overall footprint of formulated products (packaging, water use, natural feedstocks).
6. **Develop a strategy across research, skills and facilities to support an emerging eco-system for digital design across length scales for smarter more rapid reformulation** providing significant investment for industry-led, multi-disciplinary research and business/academic collaboration to leverage existing capability to enable improved models of existing formulations across length scales (multiscale modelling), which provide new information on formulation architecture or product microstructure. This strategy asks the working group to explore incorporating the Hartree Centre into the HVM Catapult to ensure future access to super-computing capabilities and skills beyond short-term funding routes for example Bridging for Innovators.

7. **Methods to accelerate the design and optimisation of (new) formulated products throughout the supply chain from R&D to production and the market. Innovation to enable quick routes into global markets via late customisation of base formulations e.g. rapid replacements of key components** - the impact of Regulation & REACH, market pull to naturals and bio-based materials and adapting to customer needs. Cross sector collaboration particularly with the Digital sector to accelerate innovations in devices in combination with formulations. Real time data collection and advanced analytics during process manufacture to smart packaging to predict consumer behaviour to provide improved understanding of customer’s real needs and product requirements.
## Vision

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<th>2018</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
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<tr>
<td>Improved delivery for less active</td>
<td>More concentrated products</td>
<td>Reduce waste</td>
<td>Improve overall environmental footprint</td>
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<tr>
<td>Increased understanding of bio-based/natural formulations</td>
<td>Confidence in sustainable feedstocks</td>
<td>Biodegradable products</td>
<td>Increased product preservation and stability of naturals</td>
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<td>All Natural Materials</td>
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<tr>
<td>Real &amp; relevant test data vs. &quot;meets specifications&quot;</td>
<td>Smarter data interrogation</td>
<td>Improved models for existing formulations</td>
<td>Faster routes into global markets</td>
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<tr>
<td>Multi-scale computational modelling to reduce trials</td>
<td>Access to High Throughput Capability</td>
<td>Processes that are robust to production variation</td>
<td>Scale-up and scale-down manufacture</td>
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<td>Faster innovation &amp; product change over</td>
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<tr>
<td>Increased knowledge of Chemical supply &amp; Base formulations</td>
<td>Ingredient Specification</td>
<td>Multi-scale modelling; Molecule, Materials &amp; Manufacture</td>
<td>Rapid reformulation</td>
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<tr>
<td>Availability of data on physical properties</td>
<td>Improved models for existing formulations</td>
<td>Modify manufacturing plant for trials</td>
<td>Late stage customisation</td>
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<td>Personalised Products</td>
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<tr>
<td>Combine devices with Formulations</td>
<td>Predict consumer trends</td>
<td>Predictive design based on consumer response to products</td>
<td>formulating for consumer in different region/cultures</td>
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Acknowledgements

The Knowledge Transfer Network would like to thank the formulated Products Sector representatives who contributed to this work:

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<th>Industry</th>
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References


5. The Science Technology Facilities Council (STFC) Bridging for Innovators (B4I).