InCrops Project

Networking Session on

"Green and high value chemicals, renewable polymers and co-products"

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Session layout

- Introduction to the sectors: bulk chemicals and high value chemicals
- Example based on a regional company
- Presentation by Dr. Jonathan Clarke from the John Innes Centre
- Open discussion

Bio-based bulk chemicals

- Monomers, polymers, solvents, surfactants, lubricants, paints, co-products (high volume products ≥ 20 kt/a)
- Already used by following industries:
  Consumer products (Croda, Kemcare, Unilever, Boots)
  Coatings (AkzoNobel, Arizona Chemicals, Croda)
  Polymers (Lucite International, Industrial Copolymers, Warwick International, Lake Chemicals & Minerals)
  Solvents (Bioniqs)
- Existing examples include polyethylene based on bioethanol (Braskem), monomers (Du Pont and Tate & Lyle – 1,3 propanediol; lactic acid), potential momoners (succinic acid, 1,4-butanediol, poly(butyleneterephthalate)

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Bioethanol

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- The largest segment of bulk chemicals market
- Used as solvent and for production of ethyl halides, ethyl esters, diethyl ether, acetic acid, butadiene, and ethyl amines
- Global market 43,501 million litres (2005), 21% as chemical
- Used for production of polyethylene (Braskem, Brazil)
- 70 million litre capacity plant in Wissington, Norfolk (British Sugar)
- UK market expanding rapidly, predicted 1.2 billion litres in the next 2-3 years Plans for two 400 million litre facilities in Hull (BP and DuPont) and on Teeside (Ensus Group)

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Bio-based polymers

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- Global plastics use 250mt ($80bn), primarily in packaging and construction
- Bioplastics represent 1-4% ($1.2-1.6 bn)
- Market potential up to 20-30%
- Current consumption 500kt including bio-polyethylene from Brazil
- Annual market growth 15-25%
- The UK manufacturing base is limited
- Market dominated by a small number of large companies
- Drive to recycle existing plastic. LCA performance depends on waste management scenario after use
- Issues with biodegradability

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Biodegradable bioplastics on the market

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Starch-based polymers, 39%	Novamont (MaterBi), Rodenburg (Solanyl), Plantic Technologies Bioplast (Biotec), Biop	films, moulding, extrusion
Polylactic acid (PLA), 26%	NatureWorks PLA, Pyramid Bioplastics Synbra Technologies	films, moulding, fibres
Polyhydroxy-alkanoates (PHA)	Kaneka, Metabolix, Telles, PHB Industrial	moulding, films
Cellulose-derivatives	Innovia Films (NatureFlex), FKuR	films, injection moulding
Bio-polyethylene	Braskem	films, moulding, fibres

Souce: European Bioplastics Association

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Applications for nanotechnology

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- Nanocomposites based on cellulosic nanoparticles
- Fibre applications based on highly-crystalline cellulose nanofibres
- Used for high-performance packaging components in the pharmaceutical, health care and food industries, flexible display panel and electric device components, high tensile strengths fibre and film composite materials

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Chemical co-products from biofuel production

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- Glycerol as a co-product of biodiesel, used for the production of propanediol, epichlorohydrin, propylene glycol, branched polyesters and glyceraldehyde
- Global market for glycerol: 900,000 tonnes (2005)
- Co-products of the second generation biofuels might include alkylated (poly-) phenols, low molecular weight oligo- or poly-saccharide compounds, hydroxyacetaldehyde, acetal, carboxyllic acid, furfural and furfurylalcohol

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Biorefinery concept

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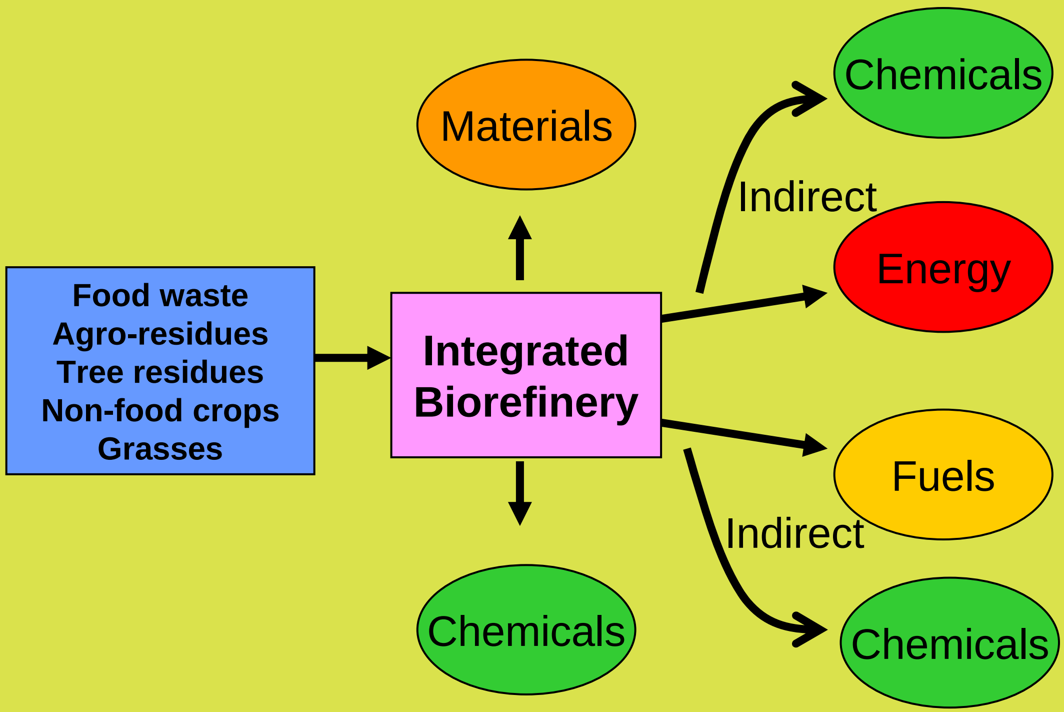
- Use of a shared feedstock streams
- Use of co-products arising from first and second generation biofuel production as chemicals



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Trends and challenges on the bulk chemicals market

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- High cost and unsatisfactory performance of some materials
- Limited production in the UK, lagging far behind other European countries (Germany, France and Spain)
- Most likely markets are polymers (e.g. packaging), solvents (e.g. printing), resins (e.g. inks), surfactants/detergents, personal care products
- Big long-term potential
- Not all the biomass feedstock has to be grown in the UK (conversion of imported renewable chemicals)

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Trends and challenges of the bulk chemicals market

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Market development relies on:

- Access to price-competitive feedstocks
- Supportive legislation
- Technological improvements, in particular second generation biofuel technologies

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Cambridge Biopolymers

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Technologies

- Thermostable gels based on arabinoxylan ferulates from maize bran
- Thermoset resin made from vegetable oil reduced via a reductive ozonolysis
- Mixed resin (20% phenolic crosslinker) and 100% bio-resin
- Vegetable oils (oilseed rape, linseed and soybean) sourced commercially; scope for using spent oil

Information on this slide provided by Dr Colin Fitchett, Cambridge Biopolymers and Cambridge Biopolymers website

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Properties of bioresins

- Can be delivered as aqueous or oil based systems
- Can be cured either in acidic or alkaline conditions, over temperatures from ambient to in excess of 200ºC
- Provide environmental, health and safety benefits
- Less brittle, have improved impact resistance and reduced dusting during manufacture

Information on this slide provided by Dr Colin Fitchett, Cambridge Biopolymers and Cambridge Biopolymers website

Cambridge Biopolymers

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Applications

- Timberboards (OSB, MDF, Chipboard)
- Laminates
- Mouldings
- Mineral wool insulation
- Foundry sands and casting materials
- Glass-reinforced and fibre-reinforced plastics
- Mineral and structural composites
- Non-wovens
- Furniture

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High-value chemicals

- Environmental control agents, pharmaceuticals and nutraceuticals
- Based on plant secondary metabolites or transgenically expressed proteins
- Wide range of high-value, low volume products from a diverse crops and supplied through a number of different manufacturing processes

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Plant derived pharmaceuticals

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- Plant-derived single molecules, plant extracts and complex ‘biologics’ transgenically produced in plants
- Global market £15 billion (2006), UK’s market £340 million (2005)
- Predicted growth despite the recession. Annual sales growth in 2007 about 14%
- 10-25% of prescription medicines are derived from plants. By 2010, 50% of new medicines will be of biological origin
- The vast majority of revenue generated from single molecule drugs
- Cancer treatment the largest application by 2011
- Pressure to develop biosimilars (due to patent expiry)

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Herbal remedies and traditional medicines

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- Medicinal products that exempt from the Medicines Act 1968 (like ginseng and aloe vera)
- The largest segment of the global health and nutrition market (£20.5 billion)
- Market dominated by Japan. The UK’s market is relatively small £126 million (2004), but it is considered to hold potential for future growth

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Plant-derived nutraceuticals

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- Include “functional foods” and dietary supplements
- Global market £18.2 billion, the UK market £1 billion (2005)
- Annual market growth 7-8%
- Market players are consolidated food and manufacturing companies (Unilever, Nestle), specialised nutrition companies (Vitabiotics)
- These companies maintain substantial research and development capabilities into functional foods and nutritional supplements

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Biocides and Biopesticides

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- Contain biological control agents (microbials, pheromones, plant extracts) used for plant protection, insecticides, algaecides, repellents, fungicides
- Biopesticides represent 1% of the total pesticide market
- Global sales growing from $268 million (2005) to $1billion by 2010
- At the end of 2001, 195 registered biopesticide active ingredients and 780 products
- Development driven by EU regulation, Biocidal Products Regulations and the Control of Pesticides Regulations
- High cost for efficacy testing (50% of the registration cost)
- Problems with approvals among 27 member states

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Trends and challenges of the high value chemicals market

Trends

- Japan and US are an international leaders with strong growth in Asia
- Significant scope for economic gain, limited potential in carbon savings
- Market driven by industry's response to consumer demand and technical need
- Transgenic plants as "factories" to produce pharmaceutical products
- Need to develop sustainable supply chains to protect wild species
- Limited potential for establishing combined supply chains with other renewable materials, limited fit within a biorefinery

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Trends and challenges of the high value chemicals market

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Main challenges

- Identifying and characterising the active compound
- Elucidating the structure of these often complex organic molecules
- Synthesising the material at a commercial level
- Protecting IP and raw material access
- Expensive and lengthy approval systems

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Summary for renewable chemicals market

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- Big potential in the long term (technological improvements, higher oil prices)
- Driven by consumer demand, government policies and obligations in response to climate change
- Relies on innovative and multidisciplinary approaches
- Policy measures to reduce financial risks and stimulate innovation (e.g. subsidies, grants for demonstration work, funding for academic research aimed towards industrial use)
- Academia needs steer from industry
- Development of an integrated technology supply chain
- Requires developments of tools for Life Cycle Analysis

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External Links of InCrops

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- Industrial membership in IBTI- Integrated Biorefinery Technologies Initiative

EPSRC Engineering and Physical Sciences Research Council

bbsrc

TMO renewables

HGCA

bp

BRITISH SUGAR

CRODA

green biologics

biocaldol

KWS

Bioscience for Business

GENENCOR A Danisco Division

syngenta

- Partnered with Bioscience for Business KTN and NNFCC

Bioscience for Business Knowledge Transfer Network

NNFCC

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Open discussion

- Market needs for the relevant sectors
- Barriers for market penetration and economic growth
- Regional opportunities on this market
- Role of InCrops and its partners
- Future InCrops activities that would address those issues and facilitate the development of new products/technologies