Sustainable Models in the Fine and Specialty Chemicals Industry

A KnowGenix presentation
6-8 Dec, IGCW 2013
Mumbai
- Fine and specialty chemicals: Landscape
- Sustainability: Evolving trends
- Sustainable models
- Managing sustainability programmes
- Sustainable value creation approaches
- Tapping new opportunities
Fine and specialty chemicals: Landscape
Fine and specialty chemicals: Landscape

- **Characteristics**
  - Multiproduct, multisegment, multitechnology, multilocation
  - High raw material, energy and compliance costs

- **Structural shifts**
  - 1990-2000: Novel chemistry/applications, differentiated services, premium products, high growth segment
  - 2000-2013: Mature, commoditized, -ve growth, slow pace of innovation to markets, sustainability pressures

- **Growth model**
  - Emerging and transition market
  - Niche product and technology portfolio
  - Customer centric
## Landscape

### Hybrid companies
- Global presence
- Multiple technologies
- Margin driven growth
- Competitive feedstocks
- Innovation (mega trends)
- Sustainability capability

### Niche companies
- Regional presence
- Niche technologies
- Customer driven growth
- Competitive delivery
- Innovation (Customer)
- Customer sustainability
Emerging challenges

- **Innovation**
  - R&D, service, supply chain models
  - Low returns from innovation investments
  - “Banned” products to “regrettable” replacements

- **Competitiveness**
  - Eastward migration of value chains and markets
  - Fragmentation of capacities
  - Customer consolidations

- **Business models**
  - Mismatch: Market realities-Portfolios-Technologies
  - Managing regulatory and innovation priorities
  - Integrating sustainability components into business models
Sustainability : Evolving trends
<table>
<thead>
<tr>
<th><strong>Sustainability : Evolving trends</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Capturing value through sustainable practices is a reality</td>
</tr>
<tr>
<td>Assessment of base line performance in diverse portfolios</td>
</tr>
<tr>
<td>Focus on segment specific sustainability standards</td>
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<tr>
<td>Risk management of portfolios (mega trend driven)</td>
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<tr>
<td>Emergence of sustainable reporting, exchanges and indices</td>
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<tr>
<td>Investments in tools, guides, standards, innovations</td>
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<td>Enhanced regulatory response capability</td>
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## Evolution of regulations

<table>
<thead>
<tr>
<th>1970s</th>
<th>Chemical Pollution control</th>
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<tbody>
<tr>
<td></td>
<td>Waste Management</td>
</tr>
<tr>
<td></td>
<td>Haz-Chemical control</td>
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<tr>
<td>1980s</td>
<td>Chemical Information</td>
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<td></td>
<td>Pollution Prevention</td>
</tr>
<tr>
<td>1990s</td>
<td>Managing Chemicals in</td>
</tr>
<tr>
<td></td>
<td>Products</td>
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<tr>
<td>2000+</td>
<td>Safer Chemicals</td>
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<tr>
<td></td>
<td>Resource efficiency</td>
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</table>

### Regulations

- **P2, Low waste process, Accident prevention**
- **Chemical Testing, Software tools, Product ingredient disclosure, GHSCL**
- **Emission and waste water control**
- **EMR, HazWaste Mgt., Site remediation**
- **Eco labels, Eco design, Product safety directives, Product Stewardships, RC etc.**
- **REACH, Sustainable practices, GCE Sustainable SCM**
- **Pesticide regulation, EHS, regulations**

*Source: Global Chemicals Outlook: Towards Sound Chemicals Management. UNEP. 2012*
Sustainability: Evolution

End of pipe
Process optimization
Low waste process
Recycling
Byproduct utilization

Cleaner production

Novel media
New raw material
Catalytic technology
Process design
Process intensification
Product engineering
Enabling technologies

Green chem/engg

HSE
Responsible care
EMS
Eco labels
Sustainable supply chain
CSR
Carbon footprint analysis

Industry initiatives

Process integration
Waste valorisation
Cluster model
Zero economy model
Bioeconomy
REACH

Resource optimization

Eco-efficiency
Sustainable reporting/index
Tools/metrics
Innovation
Eco alliances
Resource management

Sustainable practices

1970+
1980+
1990+
2000+
2010+
Commercial innovations

- Insulation foams, reflector coatings, detergent enzymes (energy reduction)
- Light weighting polymers (fuel efficiency)
- Fluorescent lights (GHG reduction)
- Metalloocene catalysis (bio plastics)
- Energy devices (energy optimization)
- Advanced materials (fuel efficiency)
- Crop-protection chemicals (Optimal dose)
- Novel Bio- materials (GHG reduction)
Sustainable models
Sustainable models

- **Resource management**
  - Energy efficiency, solvent and water optimization

- **Leveraging GCT platforms**
  - GCE tools

- **Valorization of wastes**
  - Industrial, agriculture, fruit, vegetable process wastes

- **Bio-based products**
  - Synthetic biology
Energy Efficiency

Sustainable energy a key value driver

EE Innovation: PI, new feedstocks and novel materials

Savings from energy usage /unit rose from 10% to >60%

Climate protection products account for 30% of sales

New tools for sector specific energy efficiency
### Energy efficiency models

#### Enhance EE of production processes
- Identify high energy intensive products/processes in portfolio
- Cluster model/co-productivity concepts

#### Energy efficient systems
- Combined heat and steam systems to enable heat recycling
- TQM, ISO, PI tools to enhance energy efficiency

#### Energy saving product development
- Review of portfolio to identify products that enable EE
- Advanced materials, coatings, light weight polymers, LI-Batteries

#### Investing in renewable portfolio
- Increased use of renewable energy (wind, solar, hydro) in operations
- Development of EE bio based platforms

*Source: Accenture/United Nations Global Compact, Sustainable Energy for All*
## Energy efficiency: Company innovations

<table>
<thead>
<tr>
<th>Company</th>
<th>Innovation Description</th>
</tr>
</thead>
</table>
| Bayer                  | Oxygen depolarized cathode technology  
Fuel cells based closed cycle Chlorine, High EE                                      |
| Akzo Nobel             | Lumitec technology for energy reducing reflector coatings and low friction coatings    |
| Dow Chemical           | Novel titanium dioxide powder that requires less dispersion time and uses less associated energy |
| BASF, Evonik, Mitsubishi Holdg. | Li Ion batteries Env. Compatible mobility  
Safer and compact energy storage- |
Leveraging GCT platforms

- **Process intensification**
  - Multifunctional reactors
  - Membrane reactors
  - Reactive separation
  - Continuous flow reactors

- **Resource optimization**
  - Process integration
  - Pinch analysis
  - Waste valorisation

- **Process design**
  - Alternate raw material
  - Synthetic redesign
  - Reaction parameter

- **Reaction media**
  - Super critical solvents
  - Ionic liquids
  - Ester solvents
  - Water based

- **Catalysis**
  - Zeolites
  - Asymmetric
  - Biocatalysis
  - PTC, HPAs, etc.

- **Non conventional**
  - Solid state process
  - Cascade chemistry
  - Telescopic reactions

- **New activations**
  - Sonochemistry
  - Microwave reaction

- **Tools/ guidelines**
  - E-factor, PMI, etc.
  - Computer aided tools
  - Solvent guides
  - Ingredient guides

- **Enabling technologies**
  - Biotechnology
  - Nanotechnology
  - Material technology
  - Computational technology

GCT Platforms
## Waste valorization

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
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<tbody>
<tr>
<td>Industrial By-products</td>
<td>Recovery of chemicals and solvents (Pharmaceuticals, dyestuffs, coatings, fragrance industry wastes)</td>
</tr>
<tr>
<td>Agriculture</td>
<td>Polymers from bagasse, nutrients from dairy wastes</td>
</tr>
<tr>
<td>Fruit/ veg processing</td>
<td>Orange peel and potato processing</td>
</tr>
<tr>
<td>Veg. Oil processing</td>
<td>Palm oil, castor oil. Olive oil mills processing wastes</td>
</tr>
<tr>
<td>Flue gases</td>
<td>Carbondioxide, CO, PA vent gases, etc etc</td>
</tr>
</tbody>
</table>
## Valorization of carbon dioxide

<table>
<thead>
<tr>
<th>Company</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bayer</td>
<td>Polyether polyols&lt;br&gt;Polyurethane from waste carbon dioxide&lt;br&gt;Zinc catalysed – BMS.BTS, Univ. Aachen</td>
</tr>
<tr>
<td>Evonik</td>
<td>Carbon capture models using designer adsorbents to produce chemical feedstock</td>
</tr>
<tr>
<td>BASF/RTI/Universities</td>
<td>Carbon capture technologies (coal fired plants)&lt;br&gt;Carbon dioxide to fuels</td>
</tr>
<tr>
<td>LanzaTec</td>
<td>Ethanol and derivatives from steel mill flue gases (CO) using gas fermentation technology</td>
</tr>
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</table>
Bio based products

- **Synthetic biology** (complex yet to mature)
  - Amyris, Gevo, Solazyme, Codexis
  - Bioamber, Myriant, Allylix

- **Thermochemical conversion** (mature, scalable)
  - Virent, Ensyn, Avantium, Segetis, Elevance

- **Algae based** (nascent, early stage failures)
  - SolixBiosystems, Synthetic Genomics

*Synthetic biology – the new enabler?*
### SynBio products: varied commercial stages

<table>
<thead>
<tr>
<th>Chemicals</th>
<th>Materials</th>
<th>Medicine</th>
<th>Food</th>
<th>Fuels</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-lactic acid (Myriant)</td>
<td>Farnesene (Amyris/Kuraray)</td>
<td>Sitagliptin (Merck/Codexis)</td>
<td>Valencene/ Nootkatatone (Isobionics/DSM, Allylix)</td>
<td>Isobutanol (Gevo)</td>
</tr>
<tr>
<td>Biofene (Amyris)</td>
<td>PHA (Metabolix)</td>
<td>Cephalexin (DSM)</td>
<td>Vanillin/resveratrol (Evolva)</td>
<td>Algal oils (Solazyme)</td>
</tr>
<tr>
<td>Butanediol (BioAmber, Genomatica)</td>
<td>Isoprene (Amyris, Genencor etc)</td>
<td>Antitrypsin (Intrexon)</td>
<td>Vetivone (Allylix)</td>
<td>Butanol (Butamax/Dupont)</td>
</tr>
<tr>
<td>Adipic acid (Verdezyne)</td>
<td>PBS (BioAmber)</td>
<td>Artemisin (Amyris)</td>
<td>Corn-enzyme (Syngenta/Verenium)</td>
<td>Algal biofuels (Syn.Genom)</td>
</tr>
<tr>
<td>Succinic acid (BioAmber, etc)</td>
<td></td>
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<td></td>
<td>Ethanol (Mascoma/Qteros)</td>
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**www.synbioproject.org**

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Bio based chemicals: Early, high risk stage

- **Agriculture technologies**
  - Agricultural productivity
  - Competitive processing of complex biomass

- **Bio process technologies**
  - Cost effective biocatalyst development
  - High volume biomass conversions and scale up

- **Developing sustainable strategies**
  - Sustainability tools, metrics & measurements

- **Managing risks**
  - Policy, regulatory, markets, financial
Managing sustainability programmes
## Sustainability management

<table>
<thead>
<tr>
<th>Tools</th>
<th>BRIDGESworks Metrics, GEMI Metrics Navigator and the IChemE Sustainability Metrics, BASF eco efficiency, Bayer Climate Check etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exchanges</td>
<td>DJSE, FTSE JSE, BOVESPA, OMX, SIF, SIRAN, SEBI-NVG, Greenex-BSE</td>
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<tr>
<td>Reporting</td>
<td>Non mandatory reporting systems Global Reporting Initiative, CDP</td>
</tr>
</tbody>
</table>

*from compliance to legislation, through materials efficiency to human health risks, to product life cycle metrics, resource management, human rights etc*
Sustainable value creation tools

Cost rationalisation, risk management and customer focus models - limited in full integration of EES goals

Value based tools: finance, natural and social resource costs

New tools based on value creation and not on the basis of damage potential

Sustainable value creation tool; measures how optimally a company uses natural resources as against its competitors (www.sustainablevalue.com)
Sustainable value creation
Strategic approaches

New business models
- Sustainable models
- Focus on emerging markets
- Collaborative innovations
- New customer models

New feedstocks
- Ensure flexibility
- Newer product slates
- Newer biomass sources

New growth models
- TBL
- Tapping adjacent value networks
- Exploring opportunities from unmet customer needs

Leverage intangible assets
- IPR
- Brands
- Functional skills
- **Dupont Sustainable Solutions**
- **Dow Intellectual Assets**
Operational approaches

Investing in innovation
- New chemistries
- Bio based products
- Sustainable products
- EHS management
- Supply chain operations
- Green tools and metrics

Cost optimization
- Portfolio rationalization
- Resource management
- New operational models
- Asset management
- Best practices
- Manufacturing economics
Tapping new sustainable opportunities
<table>
<thead>
<tr>
<th>Specialty chemicals : Sector trends</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal and home care</td>
</tr>
<tr>
<td>GCE, Certified standards/metrics, tools</td>
</tr>
<tr>
<td>Oleochemicals</td>
</tr>
<tr>
<td>Biosurfactants, glycolipids APGs</td>
</tr>
<tr>
<td>Coatings</td>
</tr>
<tr>
<td>Low VOC, High-solid, water based, UV Cure</td>
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<tr>
<td>Colourants</td>
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<tr>
<td>Polyfunctional reactive dyes, Conc/liquid dyes, Encapsulated dyes, etc</td>
</tr>
<tr>
<td>Lubricants</td>
</tr>
<tr>
<td>Bio lubricants, eco labeling</td>
</tr>
<tr>
<td>Adhesives</td>
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<tr>
<td>Bio adhesives, eco labeling</td>
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</table>
Opportunities from adjacent value chains

Unilever (1990): LT bleach stains
Mn catalyst-HP bleaching
Iron catalyst-NonHP bleaching

2006: Rahu Catalytics, UK
Iron ligand chemistry
Eco friendly driers
Coatings, composites, Inks
Spun off the chemistry into RC

2011: OM Group, US
Materials, energy storage etc
Buys RCs IP, Manufacturing, SC
Leverage Iron-ligand chemistry
Borchi Oxy-Coat line

Unilever Ventures-Leveraged IP
Iron platform for drying paints
Leveraging IP to create value
## Opportunities from unmet needs

<table>
<thead>
<tr>
<th>Category</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Sciences</td>
<td>Self healing aids, biomarkers, customized cosmetics, designer CPC etc</td>
</tr>
<tr>
<td>Transportation</td>
<td>Fuel cells, bioplastics, lightweight polymers, recyclable green tyres, compact batteries</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Performance coatings, bio-cleaners, asphalt binders, cement additives, adhesives, colorants</td>
</tr>
<tr>
<td>ICT</td>
<td>Sensor networks, recyclable products, energy devices, safer electronic chemicals,</td>
</tr>
<tr>
<td>Energy/fuels</td>
<td>Designer biomass, eco efficient OFC, bio materials for solar and wind energy systems, Li–Ion batteries</td>
</tr>
</tbody>
</table>
Game changers

- Synthetic biology
- Formulation engineering
- 3rd generation biorefining technologies
- Biologically derived molecules
- Improved carbon dioxide conversion processes
- Metathesis technology
Future directions

- **Portfolios:** Customer driven portfolio synergizing with technology and sustainability capabilities

- **R&D:** Product and application engineering, integrated synthetic biology and chemical platforms

- **Innovation:** Collaborative and faster-to-market model

- **Sustainability alliances:** MWV/Albemarle tie up (mercury emission control) l Hexion/Teke (cons.chem)

- **Markets:** Catering to emerging (African, CEE, CIS, ME) and transition (BRICS) market needs