Perspectives on Nanotechnology

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Agenda

• What is a nanomaterial
• Types and characteristics of nanomaterials
• Oxonica overview and business model
• Oxonica products
• Oxonica policies and expertise
• Conclusions
• Summary
What is a nanomaterial?

• The prefix nano- derives from the Greek word for dwarf and one nanometre is equal to one billionth of a metre i.e. $10^{-9} \text{m}$

• Nanomaterials are regarded as those that have at least one dimension of size less than 100nm
Types of Nanomaterials

• Naturally occurring
  - Sea salt
  - Soil dust
  - Volcanic dust

• Man-made – adventitious
  - Soot from combustion of fossil fuels
  - Welding fume
  - Industrial dust

• Man-made – engineered
  - Carbon black
  - Metal oxides
  - Exfoliated clays
  - Quantum dots
Summary of Characteristics

- High surface area
- Catalytic surface
- Adsorbent
- Prone to agglomeration
- Range of chemistries, both organic and inorganic
- Applications as diverse as the chemistries involved
Nanotechnology – the future

• Sales of products incorporating emerging nanotechnology will rise from less than 0.1% of global manufacturing output today to 15% in 2014, totalling $2.6 trillion

• The value of basic nanomaterials will be of the order of $13 billion in 2014

- according to a report from Lux Research entitled "Sizing Nanotechnology's Value Chain."
Oxonica Overview

“To build a leading, international group by developing innovative commercial solutions for global markets using Oxonica’s expertise in the design and application of nanomaterials.”

Q4 2005
- Oxonica acquires Nanoplex Technologies Inc

Q3 2005
- Oxonica floats on AIM

Q4 2004
- First Optisol™ and Envirox™ customer adoptions

2004
- Optisol™ launched

2003
- Envirox™ launched

2002-2004
- VC investment including BASF

1999
- Spun out of Oxford University
Oxonica’s Business Model

- Develop patented product applications: 48 patent families, 198 national applications
- Outsource manufacturing arrangements in place
- Access major markets directly and through strategic partnerships with global brands

Diagram:

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OXONICA
   Identify Market Opportunities
   Develop Commercial Solutions

Outsource Manufacturers

End User

Strategic Partnerships
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Oxonica Business Divisions and Lead Products

Oxonica Energy

Oxonica Healthcare

Envirox™

Optisol™
IDENTIFIED PROBLEM:
- High fuel costs
- Environmental pressures

OXONICA’S SOLUTION:

ENVIROX™
Fuel borne nanocatalyst

Diesel fuel savings: UK c.5-7%; Asia up to 11%
Reduced emissions including CO₂ and particulates
Envirox™ Technology

Based on cerium oxide catalyst
- CeO$_2$ is a well known oxidation catalyst
- Historic use in improving combustion processes

Dispersed in hydrocarbon carrier – key technology
- Dispersant coating gives a very stable dispersion
- Extremely high surface area

Delivered to engine mixed with diesel fuel
- Fuel-borne combustion improver

Low application rates
- 5 ppm cerium oxide

No engine modifications required

Improved Fuel Economy and Reduced Emissions
OXONICA’S SOLUTION:

OPTISOL™
UV absorber

Provides enhanced and longer-lasting protection against UVA
Reduces free radicals generated by UV – anti-ageing
Stabilises other sensitive components in cosmetic formulations
Optisol™ Technology

Based on ultra-fine titanium dioxide
• Inclusion in the crystal of a small amount (<1%) of manganese

Crystal structure includes manganese
• UV energy dissipated, virtually eliminating the generation of free radicals

Manganese near the crystal surface
• Reacts with free radicals that have been generated by other sunscreen components

Formulations based on Optisol™
• Combinations with range of components at various concentrations

Stable Longer Lasting UV Protection
Competitive Advantage of Optisol™

- In-house tests show that Optisol™ is the only sunscreen component that when formulated leads to 5 star protection for 8 hours
- Formulation outperforms current leading brands by maintaining 5 star rating for longer
- Minimises free radicals which are a cause of skin ageing
What do we have to do?

• Meet regulatory requirements

• Generate test data relevant to application
  - Physico-chemical data
  - Toxicology test data

• Conduct risk assessments based on data generated
What is our expertise?

• Consultants and test laboratories have been identified and they provide valuable advice and define test programmes in support of product performance

• Participate in inter-company and international programmes aimed at defining and understanding best practices related to the production and use of nanoparticles

(Virtual) Toxicity and Regulatory Department
What are our policies?

- Exercise a responsible duty of care approach to the production and use of nanoparticle based products

- No animal testing unless mandated

- In the absence of clear regulatory guidelines carry out in vitro tests to demonstrate equivalence to conventional, accepted particles using specific application related tests
Case Study - Envirox™

- Defined key areas of potential toxicological concern relevant to the use of the product:-

  1. Free radical activity/oxidative stress
  2. Cytotoxicity
  3. Inflammation
  4. Genotoxicity
  5. Ecotoxicity
Case Study - Envirox™

• Conducted in vitro studies in each of areas 1-4

• Conducted two modelling studies on the environmental impact of the use of Envirox™

In addition:-
• Conducted tests required by regulatory bodies

• Conducted additional emissions and fuel economy tests to confirm performance characteristics

Oxonica has gone the extra mile to confirm the effectiveness and safety of Envirox™
Performance

Envirox™ promotes longer and more complete combustion, delivering significant fuel economy improvements and reduced emissions
Risk Assessment

Based upon a review of the historical literature and the test results it is reasonable to conclude that Envirox™ does not present a substantial risk to human health or the environment.
Can we sell our products?

- The nanoparticulate components of Optisol™ and Envirox™ have been tested according to standard tests and application based tests.

- Risk assessments have been conducted on both products with positive conclusions regarding their use.

- Oxonica continues to participate in inter-company and international programmes on toxicology, regulatory and standard issues related to nanomaterials.
Can we sell our products?

- Products meet regulatory requirements in markets where they are sold

- Customers are made aware of Oxonica’s focus on safe manufacture and use of our products
Conclusions

By functionalising cerium oxide and titanium dioxide, both of these materials have been transformed into useful products that can bring significant benefits to Energy and Healthcare applications.
Summary

- Nanotechnology is a major transforming technology
- Oxonica is one of the few international nanotech companies with products in the marketplace
- Oxonica is a multi-sector business with strong product opportunities
Summary

- Oxonica’s health and environmental testing goes considerably beyond what is required by current regulations.

- National Governments are supportive of nanotechnology and Oxonica engages with appropriate Government agencies where possible.

   Nanotechnology products such as those developed by Oxonica offer significant environmental and health benefits.