Nanotechnology Spin-off: Oxonica

Professor Peter Dobson
Academic Director
Oxford University Begbroke Science Park, Oxford, England
Oxford’s spin-off culture.

• The change in IP management in the university helped with the formation of Oxonica
• Oxonica’s original vision and how it changed
• The fuel combustion additive
• The sunscreen
• The lessons
Begbroke Science Park

- Purchased 1998 with 7500m² lab/office space.
- Initially mainly Materials Dept. and spin-off activities
- Being expanded to 13,000 m²
- Investment ~£35M (2005) from University, JIF, SRIF, Industry sources
- Prof Peter Dobson Academic Director (2002)

6 miles north of Oxford city centre

Initial Focus on Advanced Materials and Nanotechnology
Transfer of Intellectual Property in Oxford University

Assignment of intellectual property rights

Inside the University

Research
funding source

Government

Charities

Industry

Research Services
40 Staff
85% Graduates
33% Post grad degrees

IP Due Diligence Team

Outside the University

Isis Innovation
36 staff
75% Graduates
50% Science doctorates

Spin-outs
Consulting
Licences

New sponsored research
Innovation at Oxford

“Innovation is what happens between invention and revenue generation”

Invention by academic

OxSec and Venturefest raise awareness

Licence Deal

Device or materials supplier

End-user

Continuing Professional Development
KTN and KTP activities

Spin-off Company

Begbroke Science Park: space and industrial links

Flotation or acquisition

INVENTION

REVENUE
How Oxonica started: the original vision

- Research on manufacture of luminescent nanoparticles in the late 1990s led to belief that we could offer low voltage nanoparticle phosphor materials to the field emission display industry.
- This idea was flawed, because industry wanted a complete solution and not a small part of the solution. Note a field emission display needs electron emitters, the phosphors, a screen, fully integrated into a product.
- Attention was then given to nanoparticle sunscreens and diesel fuel catalyst additives. The former had strong internal University IP, the latter did not.
Oxonica plc

- University of Oxford spin-out formed 1999 after 7 years background research
- Focus on Energy, Environment and Healthcare
- “Solution Provider” ethos
- £2.3M from Angels and DTI awards
- £8.2M from Institutional Funding
- Revenue generating from 2002
- Tailoring nanoparticles for customer applications, building revenues based on IP generation
- Floated on AIM 20-7-05, market cap. £35M
- Took over Nanoplex (US) 20-12-05
- Deal with a Turkish oil company broke down in 2007, reduced valuation.
- ~40 Employees, strong commercial and industrial experience.
- Current shares trade at ~25p
Early Oxonica products

Grown by colloidal solution growth
Size-tuning of optical properties

Quantum dots are still looking for a high value application!
Nanophosphor particles $\text{Y}_2\text{O}_3:\text{Eu}$

Mild anneal

High temperature heating

Detail of surface
The early lessons

• Discard the idea of pushing clever nanotechnology
• Try to provide a complete solution to a market need
• Quantum dots were “fashionable” but where is the market? (this is true today!)
Oxonica product pipeline

**Phase 0: Idea**
- TCOs for devices
- New product concepts for Healthcare & Environment
- Printing Inks

**Phase 1: Feasibility**
- Biodiagnostics

**Phase 2: Proof of Concept**
- Sunscreens

**Phase 3: Scale-up**
- Fuel Emission Catalyst

**Phase 4: Pre-commercial**

**Phase 5: Commercial**

- Early Revenue Generators

TCOs have become a very important market need.

Biodiagnostics is risky unless you have quantified the market need and supply chain.
Cleaning up diesel exhaust

Examples of diesel exhaust particles
Envirox Technology reduces diesel particulates

- Based on a Cerium Oxide dispersed in hydrocarbon solvent
  - Fuel-borne additive

- Nanoscale particle size
  - Extremely high catalyst surface area

- Cerium Oxide has a long history in smoke reduction
  - used in paraffin light mantles

- Approx. 5ppm Cerium Oxide
  - Low application rate – only 1 litre of Envirox to 4000 litres of fuel
  - No engine modifications required
Envirox additive is a stable suspension

Diesel fuel with Envirox 5ppm 10nm particles added. Key point is that fuel must be stable and remain haze free.
Envirox™: Fuel Economy Performance

Hong Kong Field Trial – Cummins Engine

Pre-trial period

Trial period

Post-trial period

Fuel Consumption km/litre

Apr-02 May-02 Jun-02 Jul-02 Aug-02 Sep-02 Oct-02 Nov-02 Dec-02 Jan-03 Feb-03 Mar-03 Apr-03

Additised Group

Unadditised Group
Envirox™: The Process

The Benefits:
1. Higher energy (power) output translates to fuel economy
2. More complete fuel burn reduces hydrocarbons and particulate emissions
3. Combustion of carbon deposits provides engine clean-up
Envirox™: Emissions Reduction

• Tests carried out at a range of independent laboratories
  Immediate reduction of up to 14% in particle and hydrocarbon emissions – may further improve over time

• No increase in ultra fine particles emitted

• Potential to enhance Diesel Particulate Filters performance – lower emissions and reduced regeneration temperature
Has Envirox worked?

• Yes, it has proved its value in conventional diesel engines and turbodiesels.
• But, it is not effective in high sulfur content fuels
• It may yet find other applications as an “in situ” combustion catalyst
Envirox Future

- Need to expand into biodiesel and other heavy oils for transport
- Possible uses in oil-fired heating and coal-fired applications?
- Can cerium oxide be enhanced?
- Can it be adapted to cope with high sulfur content fuels?
Optisol™

• The “driver” for this product was the evidence that most “transparent” sunscreens in the 1990s posed a health hazard.
• Nanoparticles of titania are used so that they appear transparent to visible light on the skin, but block UV
• The titania is doped in a special way so that it does not behave as a photocatalyst (that would cause skin damage)
• The new titania particles prevent the formation of “free radicals” and hence the formulation lasts much longer in sunlight and protects the skin.
Other thoughts to improve sunscreens (1999-2000)

• Could we convert uv light to visible? ZnO could be used as a “convertor”

• Was the idea of using TiO$_2$ doped to make it p-type a general solution?

• Could this be used to make other uv protective layers in the paint and plastics industries?
Titania sunscreen nanoparticles

These are Mn-doped rutile particles, small enough not to scatter light, but still absorb the harmful UV rays.
OPTISOL: Mode of action

Rutile P4_2/mnm Titanium Oxide lattice

Schematic band structure

Surface Mn^{2+} free radical scavenging

\[
\begin{align*}
\text{Mn}^{2+} & \leftrightarrow \text{Mn}^{3+} + e^- \\
\text{Mn}^{2+} + \text{OH}^- & \Rightarrow \text{Mn}^{3+} + \text{OH}^- \\
\text{Mn}^{3+} + \cdot \text{O}_2 & \Rightarrow \text{Mn}^{2+} + \text{O}_2
\end{align*}
\]
**Optisol™** based on nanoparticles of titania

**Photostable UV absorption with enhanced UVA protection for skincare & materials applications**

- Safer sunscreens and cosmetics
- Anti-ageing properties
- Skin-lightening applications
- Formulation enhancement
- Extended in-use product lifetime
New doped titania products

- Enhanced performance for many other cosmetic foundation formulations
- Possible use as a uv protective agent in coatings and polymers: “Solacor”®
Oxonica, new lessons!

- Make use of core technology to provide solutions
- Provide solutions where there is a market need
- Early revenue generation is essential
- Balance the team, remember sales/marketing, but keep a strong technical base
- Collaborate with many universities
- Form strategic alliances to speed time-to-market and reduce costs
Overall Conclusions

How can we speed up Innovation?

- Never “push technology” but look for market-led solution provision
- Develop a balanced team, especially help with sales/marketing, but do not neglect the technical team
- Try to shorten the time from invention to revenue generation by partnerships
- Treat investors’ money as your own and respect their risk and confidence