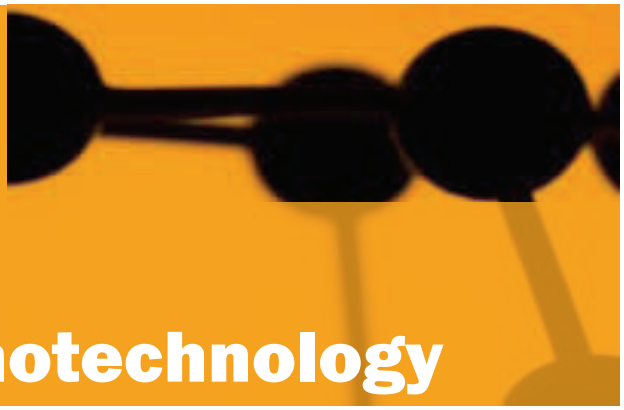
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Brave New World: Investors and Nanotechnology

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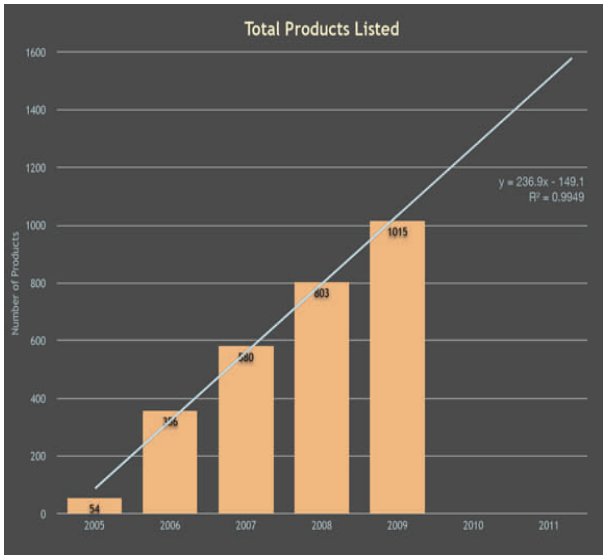


Brave New World: Investors and Nanotechnology

By Stephanie LeNguyen, Sustainability Analyst **December 2010**

Nanotechnology has silently transformed product design and innovation in a number of sectors. Today it can be found in a wide range of everyday products and packaging, from automobile tires to skin lotion. However, as with many emerging technologies, the potential benefits from nanotechnology are accompanied by emerging risks. Current understanding of the potential risks of nanotechnology is limited and regulations lag behind technological development. Given this uncertainty, how can investors address this new area? This brief offers investors a roadmap to navigate the potential risks and opportunities of this emerging industry.

Total number of products listed as using nanotechnology by date of inventory update, with regression analysis.



Source: The Project on Emerging Nanontechnologies.

Primer on Nanotechnology

Although there is no consensus on the definition of nanotechnology, it can be defined broadly as the "understanding and control of matter at dimensions of roughly one and 100 nanometres [1 nanometre = 1 billionth of a metre], where unique phenomena enable novel applications."[1] At this small scale particles have novel properties, such as magnetic, catalytic, and electronic qualities, not present in macro-sized particles of the same substances.

> **By 2015 more than USD 2.5 trillion worth of nanotechnology-enabled goods will be produced, an increase from USD 147 billion in 2007.**

Nanotechnology harnesses these properties in order to improve existing products and applications in numerous sectors, including but not limited to the personal products, food and agriculture, and medical sectors. The use of nanoparticles has enabled the creation of stain-resistant clothing, anti-microbial food containers, sunscreens, more efficient photovoltaic cells, and more effectively targeted pharmaceuticals. Research has also been carried out on the development of nanoscale edible coatings, as thin as five nanometres thick, which can be applied to meats, cheese, fruits, vegetables, confectionery and baked goods in order to increase their shelf life.[2]

Lux Research, a firm that specializes in analyzing emerging technologies, estimates that by 2015 more than USD 2.5 trillion worth of nanotechnology-enabled goods will be produced, an increase from USD 147 billion in 2007.[3] This growth is being driven by a diverse range of players. Large publicly traded chemical, personal products, and food companies, such as DuPont, L'Oreal and Unilever respectively,

Products using nanoscale materials that are commercially available or under development:

- Anti-bacterial wound dressings (Smith & Nephew)
- Sunscreens (Avon, Beiersdorf – Nivea brand)
- Personal products and cosmetics: pregnancy tests, toothpastes, moisturizers and creams (e.g. RevitaLift by L'Oreal)
- Automotive exteriors (General Motors)
- Scratch- and glare-resistant coatings
- Sports and fitness equipment: golf clubs, tennis racquets, and skis
- Clothing and textiles: antibacterial socks, stain resistant pants (GAP)
- Electronics and computers (Apple, Eastman Kodak, Intel)
- Household products: paint, toilets (TOTO) antimicrobial pillows, and stain-resistant cushions, non-stick coatings for pans, antimicrobial refrigerators (Samsung, LG)
- Food products: nutritional supplements, packaging and storage applications (BASF, Kraft)
- Agricultural inputs, e.g. pesticides (Monsanto, Syngenta)
- Coatings for photovoltaic cells (Royal DSM)

have invested in the development of nanomaterials, as have a number of smaller private enterprises and governments. Their research and development can be categorized into three groups: raw materials, intermediates and products, which to date have included a range of personal products, sports equipment, textiles, and food products and packaging.[4] As of December 2010, the Project on Emerging Nanotechnologies at the Woodrow Wilson International Center for Scholars database recorded over 1,000 products that use nanotechnology.[5] The remainder of this brief focuses on nanotechnology-enabled products in the personal products and food sectors, to which consumers have the most exposure.

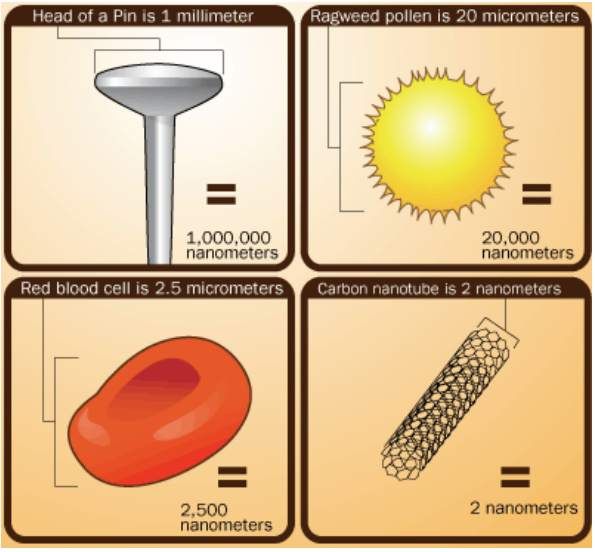
Potential Risks to Human Health

Currently the effects of nanomaterials on human health and the environment are unclear. Humans may be exposed to nanomaterials through three main routes: inhalation, ingestion and absorption through the skin. In the case of personal products, consumers are predominantly exposed by absorption through the skin as nanomaterials are largely used in topical skin products to facilitate penetration of active ingredients deeper into the skin, to solubilize non-soluble ingredients, and to improve skin texture and appearance. Exposure to nanomaterials in food and food-related products is mainly through ingestion.

Nanoparticles pose new risks for a number of reasons. Their small size gives them a relatively large surface area and makes them more chemically reactive than larger particles. Similarly, they have greater bioavailability and bioactivity. These characteristics make nanoparticles more likely to access or penetrate parts of the human body that are inaccessible to larger particles, creating the potential to compromise immune systems and cause longer-term pathological effects.[6]

It is important to note that the toxicity of different nanomaterials is not uniform and remains subject to debate. It is evident that free nanoparticles are more toxic than bound nanoparticles (particles embedded in other materials) because they have greater mobility and more exposed surface area to undergo reactions.[7]

Current research suggests that some nano-sized particles, such as titanium dioxide (TiO_2) or zinc oxide (ZnO), widely used in sunscreens, are not detrimental to healthy skin.[8] In contrast, the health effects of fullerenes, also found in some skin products, and carbon nanotubes may be a concern. Fullerenes, spheres of carbon molecules, were found to cause brain damage in fish and have bactericidal properties, while carbon nanotubes, which are similar in shape to asbestos fibres, may also have similar negative respiratory effects.[9,10] Nano-silver is another nanomaterial with questionable health effects. It is currently being used in many consumer products, especially baby products, because of its anti-microbial properties; however, it cannot distinguish between good and bad bacteria and may hinder the development of babies' immune systems.[11] The toxicity of



How nanoparticles measure up against other objects.
Source: www.howstuffworks.com

nanomaterials should therefore be considered on a case-by-case basis.

The average consumer's level of exposure to nanomaterials is not known, nor is it known what level of exposure may pose a risk. Meanwhile, the overwhelming majority of nanotechnology-enabled products do not currently undergo formal safety testing with respect to the nanotechnology that they contain, nor is there a standard risk assessment framework in place for such testing. The Royal Society in the U.K. has stated that nanomaterials should be viewed as and subject to the same testing as new chemicals.[12]

Alongside the consumers of nanotechnology-enabled products, employees at facilities that manufacture nanotechnology inputs and products may be at risk due to their constant and long-term exposure. In 2009, a study of Chinese print workers suggested a link between long-term exposure to nanoparticles and severe respiratory diseases in seven workers, two of whom eventually died. Although further research will be required to establish evidence of a general link between nanoparticle exposure and respiratory illness, this case should serve as a reminder that action needs to be taken to safeguard the health of employees exposed to nanotechnology.[13]

The effect of manufactured nanomaterials on the environment should also be noted. Although nanoparticles, such as in volcanic ash, are found in nature, it is the manufactured nanoparticles used in consumer products that are of concern. These particles are likely to end up in aquatic, terrestrial and atmospheric environments after the consumption or use of nanotechnology-enabled products, and they have the potential to bioaccumulate.[14] The effects of nanoparticles on the ecosystem and its organisms are unknown and require further study, and therefore precautions should also be taken to safeguard the environment.

The overwhelming majority of nanotechnology-enabled products do not currently undergo formal safety testing with respect to the nanotechnology that they contain, nor is there a standard risk assessment framework in place for such testing.

Insurers' Perspective

As carriers of risk, insurance companies are sometimes at the forefront of identifying and understanding emerging risks. The insurance industry was, for example, among the first industries to take seriously the risks associated with climate change. For several years a number of major insurance companies, including Swiss Re and Lloyd's, have identified the uncertainties and risks of nanotechnology and expressed concern that they have potential to become the "next asbestos," i.e. another case in which a product, years after it is introduced, is discovered to be linked to negative health effects, resulting in major liabilities. The limited historical data and research on nanotechnology has made it challenging to assess and quantify the risks involved, although Zurich and Lexington Insurance, respectively, have developed web-based tools and specific insurance policies for nanotechnology-focused clients. The attention that insurance companies have paid to nanotechnology is a significant indicator of the risk associated with it. Industry, government, the investment community and other stakeholders should take note.

The Need for Greater Transparency

Despite the risks and uncertainties associated with nanotechnology, transparency on the part of

companies involved is low, especially among consumer goods companies. Although the manufacturers of the products listed in the above-mentioned Project on Emerging Nanotechnologies database voluntarily identified their products as using nanotechnology, the products themselves are generally not labelled as such. Currently, no jurisdiction requires labelling, creating a major transparency issue for consumers and investors.



Nanotechnology is used in these and many other consumer products. Source: www.impactlab.net

Kraft and Henkel are among the few companies that have either publicly addressed their position or published a policy statement on their use of nanotechnology. Most companies, however, are reluctant to disclose the use of nanotechnology in their products, probably based in part on concerns about its acceptance by consumers.[15] In contrast, some companies have labelled certain products as containing nanotechnology when, in fact, they do not.

There is an urgent need for greater transparency so that consumers can make more informed choices, investors can better understand risks, and stakeholders can engage more effectively on the issues surrounding the development and use of nanotechnology. Some regulations on labelling of products containing nanotechnology are under development, as outlined in the following section.

Regulatory Trends

Many stakeholders have expressed great concern about the current lack of regulatory oversight over nanotechnology and are calling for more appropriate regulations. Several groups, including Friends of the Earth and the International Union of Food Workers, have called for a moratorium on the use of nanotechnology in consumer products until regulations are adequate to ensure consumer safety.[16]

Currently, the development and application of nanotechnology is regulated under legislation that was not designed with nanotechnology in mind. In the United States, the Environmental Protection Agency's (EPA) *Toxic Substance Control Act* is considered to be one of the most suitable pieces of legislation to regulate nanotechnology, while in the European Union, the *REACH* (Registration, Evaluation, Authorisation and Restriction of Chemical substances) regulation is considered the most applicable.[17]

However, given the wide-ranging applications of nanotechnology, the limited information available, the lack of appropriate risk assessment methods, as well as a lack of consensus even on the definition of nanotechnology, there are significant gaps in existing legislation. There is a great need to amend existing legislation or design new legislation in order to bring about greater transparency and ensure that nanotechnology applications are safe for consumers and the environment.

In the EU and the U.S. there is some momentum toward more adequate legislation. The following is a summary of the recent noteworthy developments regarding nanotechnology regulation in each case.

European Union

- In 2009, the *EU Cosmetics Directive* was amended to require that all nanomaterial ingredients be labelled as such on packaging starting in 2013, when the directive comes into effect.[18]

- The *EU Novel Foods Regulation* is currently under revision and the European parliament is in favour of using it to ban nanotechnologies from food products until health and environmental impacts are better understood. The parliament also wants the regulation to require that all nano-sized ingredients be clearly labelled. If adopted, the revisions will come into effect in 2012.[19,20] (Note that, according to the European Commission, there are currently no nanotechnology-enabled foods on the market in the EU.)[21]

- In addition, in 2008 the European Commission adopted the *Code of Conduct for Responsible Nanoscience and Nanotechnologies Research* to provide guidelines on responsible nanotechnology research for all member states (see text box). The code is voluntary and is meant to complement existing regulations.[22]

United States

- In April 2010, the definition of *substances* in the Environmental Protection Agency's (EPA) *Toxic Substance Control Act* (TSCA) was expanded to include nanotechnology. This will allow for greater oversight of nanotechologies under the TSCA.

- The EPA plans to issue three new regulations specific to nanotechnology under the TSCA in January 2011. The new rules will require data collection on nanomaterials, a broadening of the range of nanomaterials tested, and the treatment of nanomaterials as "significant new uses," which will allow the EPA to have increased control over the production and testing of nanomaterials.[23]

- The *Safe Cosmetics Act of 2010*, introduced in July 2010, proposed amendments to the current *Federal Food, Drug and Cosmetics Act* to bring cosmetics under the purview of the Food and Drug Administration.[24] The amendments call for the establishment of minimum data requirements and test protocols, and for manufacturers to assess the safety of cosmetic ingredients containing nanotechnology.

Regulation in the EU is moving towards increased transparency with an emphasis on safety and a precautionary approach. Although the effectiveness of new regulations will remain uncertain until they are in full effect, it is likely that Europe will lead the way in this area. In the U.S. there is some momentum as well, however given the current political climate it is unlikely that significant changes will occur in the near future.

Some other countries are also developing or considering new legislation as part of a general international trend toward increased regulation of nanotechnology. For example, Health Canada and Environment Canada, under the *Canadian Environmental Protection Act, 1999*, are proposing a mandatory reporting scheme that will require information on manufactured and imported nanomaterials to be provided, including toxicological data.[25] On the other side of the globe, Asian countries have yet to amend existing regulations specific to nanomaterials, although the responsible development of nanotechnologies is gaining attention.[26]

The EU's precautionary approach to nanotechnologies has not been embraced by all stakeholders, particularly companies who believe that taking a cautious approach will stifle innovation. This points to a challenge for governments reviewing regulations, which is to find a balance between effective regulation and assessment of nanotechnology, on the one hand, and the encouragement of innovation on the other.

In 2008, the European Commission adopted the *Code of Conduct for Responsible Nanoscience and Nanotechnologies Research*. Its principles include:

Meaning: Nanotechnology research should be conducted in the best interests of society throughout the research process.

Sustainability: Research activities should not harm people or the environment now or in the future. They should be safe, ethical, and contribute to the UN Millennium Development Goals.

Precaution: Research should be conducted in line with the precautionary principle.

Inclusiveness: All stakeholders should have access to information and be allowed to participate in the decision-making process.

Excellence: Research activities should meet the highest scientific standards.

Innovation: Creativity, flexibility for innovation and growth should be encouraged.

Accountability: Researchers and research organizations should be held accountable for the impacts of their research.

Industry and Voluntary Initiatives

In part to help fill in the oversight gap in current regulations, a number of voluntary initiatives and codes have emerged, providing guidance on best practices and principles that organizations can apply in order to use and develop nanotechnologies in a responsible manner. Table 1 provides an overview of three such frameworks.

At the core of each of these initiatives is the goal of identifying and addressing the risks and impacts of nanotechnology. The initiatives also address other factors that will help to evaluate risk, such as transparency and stakeholder participation. However, the effectiveness of these initiatives to date is unclear as there appears to have been little uptake on the part of the companies involved. Ultimately stronger regulations are needed to ensure greater disclosure and risk management. Nonetheless, these initiatives can make a significant contribution to the establishment of best practices in the development of nanotechnology.

Risks to Companies

Given the uncertainty surrounding the effects of nanotechnology, companies that manufacture nanomaterials or nanotechnology-enabled products face a number of risks.

Regulatory risks: As mentioned earlier, regulations on labelling, the disclosure of information and testing protocols on nanotechnology in products are being developed or coming into effect in the near future. Companies that do not or are not able to comply with new regulations may be faced with increased operational costs, required to reformulate products to meet new requirements, or be subject to fines for non-compliance.

Legal/liability risks: In the event that a certain nanotechnology negatively affects a large number of people, the companies responsible for the product may face millions of dollars in legal and compensation costs. Many insurance companies are concerned that nanotechnology may generate liabilities similar to asbestos.

	Principles for the Oversight of Nanotechnologies and Nanomaterials[27]	**NanoRisk Framework[28]**	**Responsible NanoCode[29]**
When	Introduced in 2007	Introduced in 2008	Launched in 2008
Who	Coalition of over 60 civil society organizations worldwide	DuPont and Environmental Defence Fund	Royal Society (UK), Insight Investment, Nanotechnology Industry Association and Nanotechnology Knowledge Transfer Network
What	Multi-stakeholder initiative outlining eight principles for oversight of nanotechnologies: • A precautionary foundation • Mandatory nano-specific regulations • Health and safety of the public and workers • Environmental protection • Transparency • Public participation • Inclusion of broader impacts • Manufacturer liability	Six-step approach to assessing nanotechnology risk and promoting responsible development: 1) Describe material and application 2) Profile life cycle(s) 3) Evaluate risks 4) Assess risk management 5) Decide, document and act 6) Review and adapt	Outlines seven principles for best practices in the research, production, retail and disposal of products using nanotechnologies: • Board accountability • Stakeholder involvement • Worker health and safety • Public health, safety and environmental risks • Wider social, environmental, health and ethical implications and impacts • Engaging with business partners • Transparency and disclosure

Table 1—Overview of industry and voluntary initiatives.

Reputational risks: Exposure to the risks mentioned above may negatively impact a company's reputation. If companies fail to communicate to stakeholders the extent of their involvement with nanotechnology and how they assess risks, over time stakeholders may lose trust in companies and their brands, negatively affecting their success in retail markets. According to a public stakeholder consultation project carried out by the EU from December 2009 to February 2010, respondents viewed nanotechnology applications in agriculture, food and personal products with more skepticism than other applications.[30] For companies in these sectors addressing issues related to nanotechnology and communicating their position and approach to risk management effectively should be a priority.

Operational risks: As noted above, the potential effects of nanomaterials on the health and well-being of employees who are consistently exposed to such materials are not well understood. If nanomaterials prove to be detrimental to human health and appropriate safety measures are not taken, companies may experience increased absenteeism or sick leave among employees, reducing productivity and, again, exposing them to legal and liability risks.



Titanium oxide (TiO_2) can be found in some sunscreens.

Toward Greater Corporate Transparency and Risk Management

To address the risks listed above, companies involved in nanotechnology should:

- Develop a policy on its use of nanotechnology, indicating its perspective on the risks associated with nanotechnology in its area of production and how it plans to address such risks. A good policy will contain many of the principles in the European Commission's *Code of Conduct for Responsible Nanoscience and Nanotechnologies Research* and the *Responsible NanoCode*;

- Commit to one of the multistakeholder or industry initiatives mentioned above and through it support the development of standards and frameworks, such as the NanoRisk Framework, to assess and address risks associated with nanotechnology;

- Implement safety systems to minimize manufacturing employees' exposure to nanotechnology;

- Increase transparency regarding the company's use of nanotechnology in products. This should include the labelling of products that are nanotech-enabled, information on the nature of the particles contained, and public reporting on any management systems or initiatives implemented to help manage risk.

Few companies have done any of the above, indicating that industries involved in this field have a long way to go to address many of the challenges and risks of this emerging technology. Nonetheless, there are some companies that are ahead of their peers with respect transparency on the use nanotechnology and involvement in nanotechnology initiatives. Examples include:

Royal DSM (chemicals industry) has published a position statement on nanotechnology that outlines associated risks and how the company is addressing these risks.[31]

Henkel (household and personal products industry) engages with stakeholders on issues related to nanotechnology through its involvement in the strategic steering committee of the German Environment Ministry's Nano Commission.[32]

Colgate-Palmolive (household and personal products industry) states that it does not currently use nanotechnology in its products, although it may do so in the future. It is committed to monitoring scientific and regulatory developments to inform product safety assessments, and it is the company's policy that, before incorporating nanotechnology into company products, it will carry out safety testing that specifically takes into account the properties of nanoparticles.[33]

Tesco (food staples and retailing) is a member of the Responsible NanoCode's multi-stakeholder working group.[34]

Conclusion

Investors and other stakeholders cannot afford to be passive actors with respect to nanotechnology. This is a dynamic field, characterized both by opportunity and by unknown levels of risk and impact, and all stakeholders, including investors, should actively monitor developments and issues in the field. Failure to do so could result in uninformed or poor decision-making, with potentially costly results as well as missed opportunities.

Uncertainties regarding the safety of nanotechnology applications, along with a lack of transparency on the part of companies regarding its use, are critical issues to be addressed. Industry and stakeholders should expect tighter regulations in the near future and be prepared to address the consequences of new regulations. Companies that adopt one of the voluntary initiatives outlined above, or a similar framework, will be better positioned to address such changes. Industry should also expect growing public debate and concern, especially as more becomes known about the potential impacts of nanotechnology on human health and the environment. Nanotechnology has not yet emerged as the subject of wide-spread public debate – but it is likely that it will. There is no question that such debate has the potential to hinder the commercial success of the companies involved. It is therefore in the interests of industry to become more transparent and to engage with stakeholders in an open manner that gives genuine consideration to concerns expressed and takes such concerns into account in the future development of nanotechnology.

Investors have an important role to play in addressing the risks and opportunities associated with nanotechnology. They can engage directly with companies that use nanotechnology in their products as well as participate in discussions with relevant working groups, roundtables, and industry associations. They can also file shareholder resolutions requesting increased transparency on the part of companies, similar to actions taken by Calvert Investments and As You Sow Foundation in 2008 and 2009.[35] Whatever actions they take, investors should:

- demand far more reporting from companies involved, including reporting on how companies are managing nanotechnology-related risk;
- encourage the adoption of policies and management systems to address this risk, including the adoption nanotechnology codes of conduct or frameworks;
- encourage companies to participate in multi-stakeholder processes and public conversations about the future of this technology.

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