The Voice of OECD Business

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Responsible Development Of Nanotechnology: Turning Vision Into Reality

BIAC Expert Group on Nanotechnology – Vision Paper

1 INTRODUCTION

Sustainable economic growth is an overarching strategic challenge for the 21st century. Innovative technological change plays a key role in helping to ensure this growth. It raises living standards, improving quality of life, and offering global society new or improved means by which to enhance, for example: energy security; healthcare water treatment; food production and storage; environmental protection; and information and communications. Fundamental to this effort, our scientific understanding has significantly advanced, allowing for the design and manipulation of materials at the atomic scale. This results in the expansion of nanotechnology (the ability to engineer materials at the nanoscale) in a growing number of economic sectors with enormous potential to improve a broad range of human activities.

As nanotechnology continues to rapidly develop and change a wide range of activities, growing numbers of governments and international organisations have focused on how to stimulate its development while considering environment, health and safety issues. BIAC believes that the OECD is proving to be the most effective multi-stakeholder forum within which to explore the right policies towards addressing this balance.

The goal of this vision paper is to identify the strategic priorities from the perspective of the OECD business community. It is meant to serve as guidance to both the private and

> *"Innovative technological change plays a key role in helping to ensure growth."*

the public sectors as international nanotechnology policy is debated and formulated. Relying on BIAC's formal role with the OECD, this paper will pay particular attention to those areas where the OECD can and should take action in order to help achieve the goal of the responsible development of nanotechnology.

2 PRESENT AND FUTURE OPPORTUNITIES

Nanotechnology is a tool whose potential is currently being sought across a number of economic sectors. Thus products that are produced using nanotechnology are not strangers to the marketplace, as nanotechnology is already used in many mass-market consumer products such as scratch-resistant and protective sunglasses, "self-cleaning" coated windows, and personal care products. At the same time, it is expected that major forthcoming benefits of nanotechnology will be reaped from its giant potential in helping to: increase energy security; improve food security; counter disease; provide clean water; enhance information exchange and communications; and remediate pollution. Nanotechnology provides a growing range of tools for industry to improve product performance beyond what could normally be achieved using conventional technologies. The contribution of the following applications, while by no means an exhaustive list of applications or uses within a specific sector, should be considered in the debate on nanotechnology:

Energy

Nanotechnology holds great potential towards helping to meet the world's energy needs in environmentally-friendly ways. For example, nanotechnology-based products can be used to reduce energy consumption through better insulation systems, more efficient lighting (e.g. using LED technology), highly energy-efficient ICT products (such as nanowires), and by the use of lighter and stronger materials in transport vehicles. Similarly, nanotechnology is being employed for the design of more efficient combustion engines due to increased surface areas. The use of cost-effective "ultra-capacitors", which allow for the storage of large amounts of energy, could furthermore come to play a key role in engine design. Nanotechnology can also be further harnessed for producing more efficient solar cells and hydrogen-powered fuel cells.

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Food and Agriculture

The complete chain from agricultural and industrial food production to consumption could be significantly influenced by nanotechnology developments. Society can expect to reap the benefits from higher quality, more sustainable food production due to applications of nanotechnology. Such benefits could include:

- Increased yields through smart fertilisers that react to environment conditions such as temperature or humidity;
- Reduced overall fertiliser consumption due to more timely and targeted use, rendering agricultural production more environmentally friendly;
- Improved food quality monitoring with nanosensors making it possible to effectively detect minimal contaminations at an early stage;

- Higher bioavailability of food ingredients such as essential vitamins and minerals;
- Longer shelf life, increased pathogen control and reduced spoilage.

Healthcare

Nanotechnology holds enormous potential to revolutionise healthcare, with possible applications including diagnostic imaging agents, drug delivery systems, thermal therapy delivery agents, body sensors, displays, high performance X-ray tubes, tissue engineering, microfluidics, pathogen detection systems and compact electronic systems. The size of nanoparticles permits the production of advanced materials as well as the possibility to enter cells and pass through physiological barriers. Nanomedicine, focusing on nanoscale interactions within individual cells and biomolecules, aims to detect changes and problems at the molecular and cellular levels, and has the potential to treat them, *before* symptoms express themselves. Ways in which nanotechnology can significantly enhance current healthcare include:

- Designing delivery vehicles that can improve the circulatory presence of drugs to reach the treatment sites;
- Reducing toxicity by using lower doses of highly targeted drugs;
- Developing delivery systems that enable the slow and continued release of a therapeutic dose of a certain drug;
- Building the scaffolds that support tissue growth, enabling oxygen delivery to cells, as well as nutrients and the removal of waste products;
- Using magnetic or paramagnetic nanoparticles in conjunction with Magnetic Resonance Imaging (MRI) to track the movement of nanomedicines towards target sites, thus providing advanced medical imaging;
- The use of MRI can be used to slightly heat targeted areas of nanoparticles that can then kill surrounding cancer cells without causing damage to other tissues.

> *"Nanotechnology holds enormous potential to revolutionise healthcare."*

Infrastructure costs for the incorporation of nanotechnology into health care applications are expected to be high, and intellectual property protection could be complicated as different sub-systems are integrated (for example, in the combination of different drugs in drug delivery vehicles). As nanotechnology develops, it will also be key to update medical education so that healthcare professionals understand and introduce new applications.

Water treatment

Nanotechnology has the potential to play a significant role in making water treatment affordable for the masses. Nanomaterials are therefore currently being tested for their effectiveness in water treatment in the following areas:

- Removal and/or remediation of contaminants in drinking and waste water, such as trace heavy metals and organics;
- Improving membranes to enhance flux and selectivity in membrane-based separations;
- Developing nano-surfaces to increase the surface area for reactions, thus reducing friction.

Significant investment will be required in the near future to develop nanotechnology applications for water treatment that are decentralised, clean, safe and affordable solutions. The OECD Working Party on Nanotechnology work on water treatment is welcomed by the business community to help address the global water challenge.

Information and Communication

As in other sectors, the implications of nanotechnology on the future of information and communication technologies (ICT) are impossible to predict fully, but nanotechnology will be critical to solving challenges faced by the ICT industry. ICT platforms are currently pushed to their fundamental physical limits, in which traditional approaches to reduce feature size and increase functionality are becoming prohibitively difficult and expensive. The incorporation of nanomaterials in ICT systems allows extension of conventional ICT platforms and enables new innovations and technologies beyond the current platforms.

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For example, nanowires can be used to create devices that are even more minuscule than the current microelectronics, resulting in millions more transistors being packed onto a microprocessor, and computers that are dramatically smaller and faster. Moreover, nanotechnology will lead to a revolution in smart sensors, novel semiconductor devices, logic elements and computer chips, memory and storage devices, optoelectronics, molecular electronics, quantum computing, and other applications and technologies. These will spearhead the creation of new products, services, and economic growth, and new channels of global communication, interaction, and collaboration. Advanced nanotechnology manufacturing processes and new nanomaterials will be essential to meet the future ICT needs.

Pollution remediation

The use of nanotechnology has made substantial contributions to improving the efficiency of waste disposal site cleanups, treatment of air pollutants, and wastewater treatment technology. These improvements will continue as nanotechnology is incorporated further into existing environmental remediation technology, and as new technologies are investigated and commercialised. The use of nanotechnology in site remediation technology includes:

- Nano-scale iron particles to oxidize organic contaminants;
- Heavy metal separation (mercury, lead, arsenic) using nano-porous materials;
- The use of dendrimer polymers to separate and trap pollutants; and
- Nano-scale colloids to treat dense non-aqueous phase liquids (DNAPL) or high concentrations of adsorbed chlorinated volatile organic compounds (CVOC).

Other innovative uses include new approaches to providing clean drinking water, the synthesis of single wall carbon nanotubes by laser vaporisation of diesel soot, the use of ceramic-based nanomaterials in fuel additives to improve fuel efficiency and reduce air pollutants, and nano-scale metal catalysts to improve the efficiency of catalytic converters.

3 PRESENT AND FUTURE CHALLENGES

Hand in hand with the above-mentioned nanotechnology applications and their far-reaching benefits is the discussion about their potential impacts as well as the factors that may limit the development of nanotechnology. International cooperation is critical for addressing these issues effectively. The OECD is in a prime position to help lead the way in international research and cooperation about both the potential benefits and the potential challenges associated with nanotechnology development. The following key challenges, identified by the OECD business community as some of the key issues that will increasingly affect nanotechnology development in coming years, should be duly considered in future OECD work:

Environmental, health and safety issues

A major challenge facing the stimulation of nanotechnology development is its potential impact on environment, health and safety (EHS) issues. Public interest in EHS issues related to nanomaterials continues. This, in part, leads to a significant increase in public and private funding for research and development both in EHS issues as well as in developing new nanotechnologies.

Research efforts are focused on identifying, understanding and managing the risks that may be associated with the responsible development of nanotechnologies and nanomaterials. Identifying and adapting internationally accepted risk assessment methodologies should be fostered through achieving consensus on the appropriate scientific principles and technical requirements. Scientifically sound risk assessments, in turn, should inform protection of workers, consumers, the public and the environment.

BIAC calls on OECD policy-makers to help facilitate such efforts by fostering consensus-based risk assessment approaches, enabling access to sound scientific data and other relevant information, and increasing coordination of activities concerning nanotechnologies and nanomaterials among OECD member states and interested non-governmental organisations.

Responsible Development

Enabling technology innovation and application, while identifying and addressing EHS concerns, requires an oversight system that utilises all viable options in an integrated manner. Business supports the need for a sound and enabling regulatory framework, which is an essential part of an overall policy mix. At the same time, it should be noted that there exists a range of options to provide appropriate oversight for

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the responsible development of nanotechnology. This includes both voluntary business-led initiatives and government regulation. Due to strong variation in the defining characteristics of nanomaterials and their related-EHS

impacts, business-led initiatives will continue to play an important role in coming years towards developing guidelines and practices that are tailored to suit different types of nanomaterials, industrial processes, applications, and economic sectors. This is particularly essential in cases where regulation may currently be unsuitable or simply lacking in certain jurisdictions. The private sector will thus continue to develop and implement appropriate product stewardship actions, including the sharing of relevant information throughout value chains in order to ensure effective risk assessment and management of EHS issues.

"Business supports the need for a sound and enabling regulatory framework."

A key issue remains as to whether existing legal frameworks be used to adequately assess the risks of the use of nanomaterials or whether separate legislation is needed to ensure the safe management of nanomaterials. Governments around the world are addressing this issue. Examples include:

- The European Commission, in its communication on regulatory aspects of nanomaterials, has made it clear that EHS risks of nanomaterials are in principle covered by EU regulatory frameworks. For example, although there are no specific provisions for nanomaterials, the Registration, Evaluation and Authorisation of Chemicals (REACH) requirements apply to nanomaterials. The EU Commission has established a working group comprising Competent Authorities of EU Member States, industry representatives and other non-governmental organisations to examine how nanomaterials can be dealt with under REACH. Additionally, one EU member state has implemented a voluntary reporting scheme for engineered nanoscale materials.

- Meanwhile, the United States Environmental Protection Agency (EPA) has determined that nanoscale materials that are new chemical substances are covered under existing chemical regulations and are subject to pre-marketing notification rules. EPA also formally requested information for its Nanoscale Materials Stewardship Program (NMSP). This EPA voluntary programme is intended to help provide a firmer scientific foundation for future regulatory decisions by encouraging submission of hazard and other information, including risk management practices for nanoscale materials. Nanoscale materials that are either new or existing chemical substances are included in the scope of this programme.

- Similarly, Health Canada and Environment Canada are planning to gather basic information on nanomaterials that are in or soon to enter commerce, so that the government can assess potential risks and address them adequately.

For the responsible development of nanotechnology, BIAC calls upon policymakers to consider the range of public and private-led initiatives that are currently in operation in different countries, and to consider the effectiveness of such approaches in different national and international contexts.

Human resources

In addition to a sound framework for the responsible development of nanotechnology, industry requires highly-skilled labour for the continued development of the technology. However, the vast interdisciplinary, cross-sector and emergent nature of nanotechnology development poses a challenge for the academic community to train students with the necessary knowledge, understanding, and skills to interact and lead the research and development of nanotechnology. Skills shortages for nanotechnology development could significantly diminish the opportunities that stand to be gained from the technology vis-à-vis global challenges, such as water and food availability, climate change and energy security. Similarly, skills shortages could limit international understanding about related EHS issues and potential risks.

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In order to avoid such skills shortages, BIAC calls upon OECD policy-makers to support work towards measuring and forecasting labour market needs for nanotechnology development. The OECD, together with business, trade unions, academia and other stakeholders, can also work together to develop common understanding as to which skill competencies should be fostered within educational institutions for careers in nanotechnology.

Intellectual property rights

International cooperation, both public and private, will help accelerate the responsible development of nanotechnology. At the same time, it is critical that high quality patent and other intellectual property rights (IPR) continue to protect innovation in the nanotechnology area. Intellectual property protection creates incentives for investment in the costly R&D necessary to bring new nanotechnology products to market. Universities and research institutions conducting basic research in chemistry, physics and materials science license their patents to emerging companies, fuelling entrepreneurship and jobs creation. Meanwhile, balancing the protection of regulatory data with the need for transparency is likely to become an increasingly important challenge for the responsible development of nanotechnology, given its newly-emergent nature. The ability of large enterprises to protect their discoveries enables these organisations to take risks on unproven technologies. The OECD business community therefore reminds policymakers that without effective and high quality intellectual property protection, incentives for innovation would be greatly reduced and technical advancement in this burgeoning field would suffer.

Marketing and consumer issues

Industry is committed to maximise transparency and foster public trust by informing the public about the outcome of the risk assessment of their new products. More and more products which are manufactured using nanotechnology processes are on the market. But as with any new technology, public trust in industry to fulfil legal and ethical requirements must be gained. Therefore, in addition to existing product stewardship processes and practices, industry is gathering hazard data, assessing possible risks and recommending, where necessary, appropriate risk management measures for

the handling, transportation, use, and disposal of nanomaterials.

Consumers also want assurance that the products they buy are worth buying. Product enhancement aspects need to be clearly communicated to the public. Industry is working on performance standards within the appropriate standardisation organisations (for example, the German quality performance labels for textile features and further discussions within the International Standards Organisation (ISO) towards various standards on specific applications of nanomaterials). BIAC stands ready to further engage with the OECD on the crucial issues of marketing and consumer concerns.

4 PRESENT AND FUTURE ROLES FOR BIAC AND THE OECD

As is clear from this paper, nanotechnology has enormous potential for helping to address many of the global challenges of the 21st century, and its current rapid development should therefore be actively encouraged. At the same time, the development of nanotechnology needs to be carried out in a responsible manner in order to more fully understand its impacts and the factors that limit its development. In our view, this responsible development of nanotechnology on an international level constitutes the best way forward for the realisation of its full potential.

"BIAC remains committed to provide the OECD with business expertise and guidance."

The OECD Working Party on Nanotechnology and the OECD Working Party on Manufactured Nanomaterials are at the forefront of international efforts to improve global understanding towards the responsible development of nanotechnology. Their comprehensive programmes of work lead to policy recommendations and information sharing for policy-makers and other stakeholders. BIAC, already actively participating in both working parties, remains committed to provide the OECD with business expertise and guidance.

In order to address current and possible future opportunities and challenges with respect to nanotechnology development, BIAC calls on the OECD to address the following priorities in future programmes of work:

- Continued high attention for the OECD Sponsorship Programme for the Testing of Manufactured Nanomaterials.
- Development of thorough case studies that demonstrate the important contributions of nanotechnology towards addressing selected global challenges.
- Development of standardised hazard and risk assessment procedures for manufactured nanomaterials.
- Analysis of relevant statistical data and indicators relating to nanotechnology development in the world.

- Continued research into the safe handling of manufactured nanomaterials in the workplace.
- Assessment of the framework conditions necessary and conducive for the development of nanotechnology.
- Assessment of public attitudes towards nanotechnology in general, and engineered manufactured nanomaterials more specifically.
- Protection of intellectual property rights in association with the responsible development of manufactured nanomaterials.

OECD business will continue to strive towards the responsible development of nanotechnology by: supporting global research schemes; promoting harmonised global safety testing standards; assessing the value and limitations of existing legal frameworks; and ensuring that sound science forms the basis for efficient and proportionate regulations. Fully aware of the importance of EHS issues and public acceptance, OECD business will maintain a strong focus on maximising transparency and stakeholder engagement towards reaping maximum benefits from uses of nanotechnology to address global challenges and thus sustain economic growth. In cases where new and accepted evidence demonstrates that additional oversight for the products of nanotechnology is needed, the OECD business community will support its implementation.

BIAC calls on the OECD leadership to continue to offer strong support for the ground-breaking work that the OECD is carrying out with respect to nanotechnology. OECD business will take every effort to support the work of the OECD towards creating a policy environment that fosters the full potential of nanotechnology, hence turning the responsible development of nanotechnology from a common vision into a global reality.

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About BIAC

The Business and Industry Advisory Committee to the OECD (BIAC) was constituted in March 1962 as an independent organisation officially recognised by the OECD as being representative of business and industry.

BIAC's primary objectives are to:

- positively influence the direction of OECD policy initiatives,
- ensure business and industry needs are adequately addressed in OECD policy decision instruments and
- provide members with relevant and timely information on OECD policies and their implications for business and industry.

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