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RESEARCH ARTICLE

ENVIRONMENTAL SUPPLY CHAIN MANAGEMENT IN NANO TECHNOLOGY BASED INDUSTRIES

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ABSTRACT

Environmental nanotechnologies have the possibility to contribute to economic growth and innovation while at the same time allowing sustainable development and protecting the environment. There is considerable commercial potential in environmental technologies because the development of innovative solutions to prevent and remediate pollution is needed to ensure sustainable development.This projected world market can be sub-divided into four principal sectors: Remediation, Protection, Maintenance, and Enhancement, of which remediation represent the fastest growing area, while maintenance and protection constitute the bulk of the remaining applications, and enhancement is the smallest sector. Present day filtration and purification plants used for supplying drinking water generally achieve only partial success because the active materials are of limited efficiency. However,because of their much greater specific surface area, nanoparticles are able to perform significantly more effectively as filtration media than larger particles with the same chemical composition.Companies and organizations involved in nanotechnology are intrinsically linked within the start of a much longer supply chain, as nano materials developers working with composites, ceramics and coatings require nano scale instrumentation and nano scale instrumentation developers require the scientific know how and equipment to manipulate and measure materials at an atomic level. Hence, It is only by understanding this supply chain that we can see where 'traditional' industries such as aerospace and automotive manufacture integrate and how, if at all, the supply chain is working together to solve business problems and provide market leadership for companies.A strategic issue therefore is to address the stage at which the relevant technology is added to the product and whether this becomes an OEM (original equipment manufacturer) process or whether the process can be reengineered to enable the nano supply chains to effectively engage with the OEM within the final stages of product assembly.By mapping nanotechnology supply chain, back from user demand, through technology developers to science initiators. Supply chain management providing a solution consisting of three parts, Supply Chain Planning: covers the demand flow and how companies, organizations, and units collaborate ,environmental risk of nano particles within supply chains.Supply Chain Execution: covers the flow of materials, products and services as well as informational and financial flows both upstream and downstream including enviro risk.Supply Chain Performance: supports the decision-making process along the supply chains

INTRODUCTION

A growing number of companies realize that to achieve their environmental goals and satisfy stakeholders' expectations, they need to look beyond their own facilities and to involve their suppliers in environmental initiatives. Examples of supply chain management include screening suppliers for environmental performance, working collaboratively with them on green design initiatives and providing training and information to build suppliers' environmental management capacity. Working with suppliers on environmental issues not only generates significant environmental benefits, but also opportunities for cost containment, improved risk management and enhanced quality and brand image. Customers do not always differentiate between a company and its suppliers and hold companies accountable for suppliers' environmental and labour practices. In addition, many companies are working to streamline their supply base and develop more co-operative, long-term relationships with key suppliers, a practice that has fostered greater opportunities to work together on environmental issues, includes the suppliers of products or services in a two way or even a cyclical perspective. In its broadest application, ESCM considers the full life cycle of a product from cradle or extraction to grave or disposal. It also seeks opportunities to share ideas and best practices among non-competing organizations, facilitating collaboration that has positive environmental implications.

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What is Supply Chain Management?

SCM includes the management of materials, information, financial flows in a network consisting of suppliers, manufacturers, packers and distributors and customers. The coordination and integration of these flows within and across companies are critical in effective supply chain management. Supply chain management helps in (1) Lowering sourcing cost of finished goods and raw materials (2) Improves customer service. (3) Dramatically lowers the inventory levels. (4) Leverages all resources to bring substantial benefits to a company.(5) Increased dividends of lower future costs and reduced environmental impact. (6). Enhance business ties in particular business fields or commodities. (7) By cooperation, tangible benefits in terms of reduced costs, quicker transfer times and fewer quality failures can be achieved.

What is Nano Technology?

Nanotechnology is the design, characterization, production and application of structures, devices and systems that entail controlling the shape and size at the nanometer scale. The size range of nanotechnology is often delimited to 100 nm down to the molecular level (approx 0.2 nm) because this is where materials have significantly different properties. Nanotechnology is commonly understood as dealing with very small things. A nanometer (nm) is indeed small, one thousand millionth of a meter. For visualization

purposes, the width of the dot above the letter "I" in this sentence is approximately one millionth nanometers. The significance of the nanoscale, however is not only that things are small but that materials obtain new properties at this scale. This is mainly due to two factors. First nano strength and electrical properties. Second, quantum effects can begin to dominate the behavior particularly at the lower end of the nanoscale. This affects the optical, electrical, and magnetic behavior of materials. Materials can be produced that are nanoscale in one dimension, such as very thin surface coatings or two dimensions such as nanowires and nanotubes or in three dimensions such as various kinds of nanoparticles.

Nanotechnology and the supply chain

At the most simplistic level, those companies and organizations involved in nanotechnology can be segmented into three distinct groups

a.Those involved in the manipulation of matter at a nanometer (atomic or molecular) level

b.Those involved in the measurement of properties or quantum effects at a nanometer scale (often within micro technology devices)

c.Those involved in the development of materials (such as coatings, nanocomposites, nano polymers and nano ceramics) incorporating properties or quantum effects only exhibited at a nano scale.

There is a viable developing nanotechnology supply chain that can overtime integrate into existing 'traditional' sectors. However this will be on a global, rather than regional or national basis and will only be achieved if a number of 'barriers' to new technology implementation can be better understood and surmounted.

Environmental supply Chain Management

ESCM integrates environmental and supply chain management. Environmental supply chain management recognizes the crucial role to be played by the purchasing and the function's involvement in activities that include reduction, recycling, reuse and the substitution of materials. Working with suppliers on environmental issues not only generates significant environmental benefits, but also opportunities for cost containment, improved risk management and enhanced quality and brand image. This will also help companies streamline their supply base and develop more cooperative, long tem relationships with key suppliers, a practice that has fostered greater opportunities to work together on environmental issues. ESCM involves identifying the most significant environmental improvement environmental impact. Manufacturer encourages suppliers to adopt green practices, environmental management systems etc. Main focus is on the material content and environmental practices of suppliers. Environmental supply chain improves operations by employing environmental solution. Environmental supply chain management is a driver for process improvements. In general, pollution and waste represent incomplete or inefficient use of raw material. Supply chain analysis provides an opportunity to review processes, materials and operational concepts. Under utilized resources ESCM

Improves Agility: Environmental supply chain management help mitigate risk and speed innovations

Improves Adaptability: Environmental supply chain analysis often lead to innovative processes and continuous improvements.

Promotes Alignment: Environmental supply chain management involves negotiating policies with suppliers and customers, which results in better alignment of business processes and principles.

Supply Chain Integration to Environmental Management

The starting point as for any other major strategy is the top management commitment to the environmental issues. This is not only essential but is critical for the overall success of the project. It should be the mission of the company's top management to sensitize everyone in the company towards environmental issues. It will also be a good idea to have a separate environmental department reporting directly to the top management. This department should look at all the aspects of the environment barometer and track its progress on a regular basis. It is important to spread the message to the customers and thereby making them participate in the environment journey. This can be achieved by branding the company and its products on environmental lines. This can be done by bringing out the synergy between the company's strategy and its strong environmental image and reputation, and environmentally sensitive products, suppliers etc it deals with. Next in the supply chain management, it is important to connect with the most vital link of the company-its suppliers. A holistic approach, such as supply chain integration to environmental management links reduction in energy consumption to waste generation and release of pollutants. Setting aggressive and progressive environmental goals is important. This can be done by using tools such as Life cycle Management (a valuable tool to document the environmental impacts from the entire life cycle of products and services addressed that need to be part of decision-making towards sustainability*)* and environmental audits (EA) improve environmental and operating performance, by involving employees form quality assurance, environmental affairs, purchasing and financial analysis

Environmental Management System

EMS is a problem identification and problem solving tool, based on the concept of continual improvement, that can be implemented in an organization many different ways, depending on the sector of activity and the needs perceived by management in particular, standards for EMS have been developed by ISO and by the European commission-Eco Management and Audit scheme. Environmental supply chain management is ensured by its direct impact on the supplier selection and management processes. Change should be viewed as a competitive tool and environmental efficiency viewed as a positive catalyst for change. Applying an innovation economic perspective focus is placed on analysing *the direction* of the nano search and technology development processes and how environ-mental issues enter into these. Hereby, the future trajectories of nanotechnology development is sought captured, indicating likely long-term perspectives of the nanotechnology development.

Environmental Risk Management in the Supply Chian Related to Nanotech

Until recently there has been very little research into nano related risks. Thus health, safety and environmental impact assessment of nano-particles and nano-materials are encumbered with huge uncertainties due to lack of knowledge. Increasing attention is being paid by authorities, however, to nanorelated risk issues, and several surveys are underway around the globel. Concerns of nanotechnology are particularly related to:

- The particles large surface area ,crystalline structure and reactivity, which could facilitate transport in the environment or the body that could be difficult to control or harmful because of their interactions with other elements.Some manufactured nanoparticles will be more toxic per unit of mass than larger particles of the same chemical.
- Ultrafine particles have a different biological behavior and mobility than the larger particles.it will penetrate cells more readily than larger particles.
- The invisible size of the particles developed, accidentally enter in to the food chain, initially causing damage toplants and animals while eventually becoming a hazard to humans

- Free nanoparticles that may penetrate into the brain, lungs, and other tissues and possibly cause cancer and other deceases.

Environmental impacts in the product cycle

Life Cycle assessment is an environmental management tool for assessing the environ-mental impacts of a service or function. All use of materials, resources and energy as well as all emissions from the processes in the life cycle are aggregated and interpreted in terms of their impacts on the environment and health, e.g. their contribution to global warming, acidification etc. As described above specific concern is related to the release of free nanoparticles. An inventory of possible sources of potential particle release from the use and production of nanoparticles can be made by addressing the life cycle from nanoparticle generation to end products and finally disposal. It must be stressed that due to the variety of different production methods, the process conditions vary widely; thus, in principle the risk of potential particle release has to be considered separately for each different process. The International Organization for Standardization (ISO), a world-wide federation of national standards bodies, has standardized this framework within the ISO 14001.The possible routes for an exposure of the environment range over the whole lifecycle of products and applications that contained engineerd nanoparticles:

- Discharge / leakage during production / transport and storage of intermediate and finished products,
- Discharge / leakage from waste,
- Release of particles during use of the products
- Diffusion, transport and transformation in air, soil and water.

Policy Management on Nano Enviromental Risks

Existing regulations indexing chemicals and measuring new products' toxicology need to be adapted to the special properties of nano-materials. According to Nanoforum (2004), nanotechnology leads to a need for new norms, standards and testing procedures for assessing risks to the environment and health (e.g. for nanometer length scales, calibration of instruments, health effects of nanoparticles, toxic effects of nanometer size of particles rather than on their chemical composition). Recently, considerable attention is being devoted to the issues of regulation and legislation of risks related to nanotechnology, particularly in USA and Europe. Most countries and international institutions are still in the phase of raising awareness and investigating what the regulated topics should be. Some of regulation topics,

-To identify and address safety concerns (real or perceived) at the earliest possible stage.
-To reinforce support for the integration of health, environment, risk and other aspects related to R&D activities together with specific studies.
-To support the generation of data on toxicology (including dose response data) and eco friendly and evaluate potential human and environmental exposure.
ISO proposes to create international standards to "assist the efficient and effective development of world and local markets for nanotechnology products".

ISO proposes to develop standards related to nanotechnology in the following areas:

- Classification, terminology and nomenclature
- Metrology and characterization (including calibration and certification)
- Test methods for determining physical, chemical, structural and biological properties of nano materials or devices and Risk and environmental, health and safety issues.
- The legal consequences of this initiative could include:
- Intellectual property(defining ,classifying and characterizing nanomaterials will be essential to resolving the innovators patent protection).
- Health, environmental and safety requirements(e.g., regulatory status for pharmaceutical or medical device purpose and occupational and environmental issues related to manufacturing, distribution and use)
- Commercial (e.g., ability to claim that a product is made of nano materials)

ISO nanotechnology standards also effect supply chain management issues, such as ability to determine whether supplied products contain nanomaterials. Extreme caution will have to be exercised to ensure that any ISO standards writing activity does not get ahead of or hinder science. Effective participation requires not only an understanding of the scientific and technical issues of nanotechnology, but also a firm grip on the commercial and legal implications and the ability to develop and execute advocacy strategies and tactics.

Conclusion

The current uses of nanotechnology are still in the first or early second of four stages as defined by the Joint Economic Committee of Congress. They define those stages as passive nanostructures, active nanostructures; systems of nanosystems and molecular nanosystems. For the supply chain one result will be packages and packaging, that ensure the quality of products from initial packaging through transport to ultimate consumption:

-strong materials resist tearing or even bending (carbon nanotubes are 400 times stronger than steel).
-ultra light materials reduce added weight (Aerosol are solids with the feel of Styrofoam but are nearly as light as air)
-Ultra-efficient materials provide superior insulation and protection from chemical or UV effects (Polymer nanocomposites show significant improvement over conventional materials)
-Ultra-clean materials battle microbiological effects (25nm silver particle antibacterial and anti fungal coatings are being used on some cell phone
- Designer packaging that meets specific requirements of manufacturers and transporters will have a major impact on the supply chain
-A second area of impact is the use of nanotechnology to provide protection from counterfeiting. According to Industry Week, the cost of counterfeiting and piracy to the world economy is anywhere in billion. Nanotags built into unit products can be used to verify authenticity. NanobarcodesTM are being developed for paper, plastic, metal and textiles that allow for trillions of unique codes. Surface enhanced Raman (SERS) nanotags give a unique fingerprint when interrogated by lasers. Pharmaceutical companies are particularly interested in these capabilities because their products are highly targeted for counterfeiting
-nanotechnology moves beyond enhancements to the creation of new capabilities for the supply chain. Some of the most interesting will require active and systems of nanosystems capabilities, one such is the creation of Nanoelectromechanical Systems (NEMS). NEMS devices are part electronic and part mechanical allowing for the creation of ultra-small, ultra-efficient sensors. NEMS sensors will sample the quality, temperature, and other characteristics of products throughout the supply journey and signal for action should any degradation occur. A primary difference with today's sensors, aside from their ultra-low size and cost, will be their ability to be parasitic powered by harnessing the energy in motion, ambient temperature or even radio waves in the atmosphere.
-Another ruse nanotechnology to enable the economic creation of high capability robots. In other words, it will move robots from isolated usage into nearly every aspect of the *supply chain.* One primary difference in these robots is that they will have capabilities similar to human beings. These robots will have artificial muscles

powered by chemical sources, similar to human muscles fueled by glucose and oxygen in our blood. They will utilize NEMS sensors mentioned above and will be controlled by computers built ultra capable with nanotechnology as well.

Critical aspects of eco-efficiency which may also be addressed in a management system are

1. Each organization should ensure that responsibility for guiding and managing its involvement nanotechnologies resides with board of governing body.
2. Each organization should identify and minimize sources of risk for workers handling products using nanotechnologies, at all stages in the production process or in industrial use, to ensure high standards of occupational health and safety.
3. Each organization should carry out through risk assessments and minimize any potential public health, safety and environmental risks relating to its products using nanotechnologies.
4. Each organization should adopt responsible practice in the sales and marketing of products using nanotechnologies
5. Each organization should proactively engage with its stakeholder and be responsive to their views in its development or use of products using nanotechnologies.

Therefore, a time has come to integrate all functions with a view to achieve overall excellence. Probably this is why supply chain has suddenly become an all-important arena where all the action is. Simultaneously, advances in technology have fuelled the growth of supply chain solutions.

Thus, one can look at overall supply chain by eliminating/simplifying many mundane activities. In fact, if you observe the emergence of supply chain... it has come only after ERP has become a 'must have' from a 'can have' for the corporate world. The environmental segment of Supply Chain Management is in a state of turmoil, with each nanotech based manufacturer having its own set of material requirements that often differ with those of other manufacturers.

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