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NanoSafety in Thailand

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R O O M D O C U M E N T

NanoSafety in Thailand[1]

Abstract

Thailand is a Southeast Asian Kingdom that has evolved from a strictly agricultural economy to follow the dream of becoming a newly-industrialized country. In the age of nanotechnology, both the academic and industrial sectors are quickly investing resources into research, development and production of various nanotechnology-based products including nanocomposite food packages, nanosensors, water-repellent fabric coating made of nanoparticles, nanoclay membranes for water treatment, curcuminoid nanoliposomes (whitening) face creams, nanoalumina-doped ceramics-based artificial gemstones, nanochitosan-based slow-release drug vehicles, nanoparticle Organic Light Emitting Diodes (OLEDs), and nanodye-sensitized solar cells. Although the safety issue of nanotechnology and nanotechnology-based products has only been discussed in limited circles during recent years, the country has a well-established, albeit imperfect, framework for hazardous material management that includes environmental hazards, health hazards, and workplace hazards. The legal framework consists of many laws, notably the Hazardous Substance Act of B.E. 2535, the Enhancement and Conservation of National Environmental Quality Act of B.E. 2535, and the Labour Protection Act of B.E. 2541. Governmental Offices and Bureaus responsible for dealing with these hazards are affiliated with several Ministries and have formed networks for expediting their responses. With regard to nano-hazards, Thailand's National Nanotechnology Center (NANOTEC) is the policy focal point and an active implementor. It has already sponsored a Phase I NanoSafety and NanoEthics study that was conducted by Chulalongkorn University. The study identified the issues, the global players, and the present and future policy options that the country should consider. In 2008, NANOTEC is expected to sponsor Phase II of the NanoSafety and NanoEthics study, where a critical review of current scientific studies will be conducted in order to provide a defendable basis for subsequent NanoSafety and NanoEthics Guidelines. Meanwhile, NANOTEC has set its strategic goals for nanosafety research, including measurements of nanomaterials, risk exposure measurements, toxicity determination, screening test developments, risk assessments, and model validation. Thailand has thus set its course to become both an informed consumer and a nanomaterial manufacturer with social responsibility that is compatible with global standards. Towards this end, the country needs to maintain strong international linkages for best-practice information, research collaboration, as well as standard and guideline development.

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1. Country Background

Thailand is a Kingdom in Southeast Asia with an area of approximately 514,000 square kilometer and a population of approximately 63 million at the end of 2007 (roughly the area and the population of France, respectively). The country is well-known for its beautiful beaches and friendliness of the Thai people. According to the Tourism Authority of Thailand, 15 million tourists visit Thailand each year and stay for 10 days on the average.

Thailand is the world's No. 1 exporter of rice. Other major exports include textile and footwear, fishery products, rubber, jewelry, automobiles, computer and electrical appliances. The 2006 estimated nominal per capita GDP of Thailand is USD3,136 (or USD 9,200 Purchasing Power Parity). Although Thailand is considered by many to have graduated from a developing country into a Newly Industrialized Country (NIC) status, there are still large gaps in the distribution of income, the development of indigenous technological capabilities, and the level of research and development, especially in the private sector.

Merely half a decade ago Thailand was perceived to attain a moderate level of competitiveness. In 2003, the International Institute for Management Development (IMD) ranked the country as the 10th out of 30 contenders in overall competitiveness. Thailand, however, did not score so well in the 2003 IMD infrastructure component ranking, being assigned the 20th out of 30 countries. Also in 2003, the World Economic Forum (WEF) put Thailand in the 32th place out of 102 in the overall 5-year Growth Competitiveness Index (GCI). Four years later, the country's rank has slipped quite a bit. In 2007, IMD ranked Thailand as the 33th out of 55 countries[2] (down from the 29th place in 2006 and 25th place in 2005). In the 2007 IMD infrastructure ranking, Thailand has fallen to 48th out of 55 (down from 42th in 2006).[3]

The degrees of research, development and design in Thai industries are relatively low on a global scale, as evidenced by a score of approximately 13 in the 2002 KBI (Knowledge-based Industry) Index,[4] which should be higher than about 25 for industrialized countries. This figure reflected the 2001 overall research and development expenditure in the country of 0.26 per cent of GDP (0.16 in the public sector and 0.10 in the private sector), which was about one-tenth of those in first generation Newly Industrialized Countries (NICs), i.e. South Korea, Taiwan, Singapore and Hong Kong.[5] For the past 15 years, most research and development work in high-technologies are funded by the National Science and Technology Development Agency (NSTDA) and the Thailand Research Fund (TRF). NSTDA is exceptional in that it also conducts advanced research in various fields, including nanotechnology.

In 1991, the literacy level in Thailand (63 per cent) was among the highest in Asia but the fraction of students that graduated from primary schools and continued their studies in secondary schools was among the next-to-lowest

figure (approx. 30 per cent) for NICs. For first generation NICs, the figures lay somewhere between 60 and 90 per cent. In December 2007 there were 78 higher educational institutes (universities, institutes of technology, technical universities, etc.) in the Thai public sector, 67 private higher education institutes, 404 vocational colleges, and 78 specialized colleges and institutes (e.g. for national defense, police, public health works, etc.).[6] Nevertheless, it is difficult to estimate the level of nanotechnology education in Thailand, mainly because various parts of the subject exist in many curricula under other titles besides nanotechnology. These include solid-state physics, material science and technology, biochemistry, food science and technology, medical science and technology, chemical technology, and pharmaceutical technology, to name just a few.

2. Public Perception of NanoSafety

Owing to the global publicity that nanotechnology receives and the marketing success of the locally-manufactured nanotechnology-enabled functional fabrics/apparels and cosmetics, Thai consumers have slowly entered the age of nano-hypes. The general public was led to believe that a product manufactured using nanotechnology must possess superior quality , regardless of any possible health or environmental risks.

Possible adverse effects of nanotechnology and nanoparticles in the environment were virtually unheard of until quite recently. Although frightening science fictions involving nanotechnology, such as Eric Drexler's "Engine of Creation" and Michael Crichton's "Prey," have not been popularized in Thailand, the possibility of harmful effects from nanoparticle-containing cosmetics have recently been the topic of discussion in the Thai language in various news media and over the Internet.

Since potential risks of nanotechnology for the developing world have been documented in the health, environment and social aspects,[7] NANOTEC and CIN are both interested in the handling of nano-risks (characterization, identification, assessment, management, mitigation, prevention, etc.). For example, it is expected that a precautionary approach will be used in the eventual regulation of nanotechnology and manufactured nanomaterials. Meanwhile, owing to potential benefits of nanotechnology, the general public should be informed but not caused to panic over unsubstantiated incidents. In the next few years we should see more research projects on public risk perception in Thailand that are similar to the ones supported by US-NSF through several of its Programs[8].

3. Legal Infrastructure

Due to the pervasive nature of nanotechnology, safety issues of manufactured nanomaterials may come under the coverage of several legal regimes such as environmental laws, public health laws, and occupational safety and health protection laws (http://www.oshthai.org/legisra.aspx). A complete list of applicable laws would contain at least a dozen Acts and Draft Acts, not to mention many more Ministerial Regulations and Announcements. On the foreground, however, are the Hazardous Substance Act of B.E. 2535 (A.D. 1992), the Enhancement and Conservation of National Environmental Quality Act of B.E. 2535 (A.D. 1992), and the Labour Protection Act of B.E. 2541 (A.D. 1998).

3.1. The Hazardous Substance Act of B.E.2535/A.D.1992 (http://fda.moph.go.th/eng/hazardous/laws.stm)

This law is quite unusual in that it is administered by three ministries: the Ministry of Agriculture & Cooperatives (for hazardous agricultural chemicals), the Ministry of Industry (hazardous industrial chemicals), and the Ministry of Public Health (hazardous substances in food, cosmetics, medication, and consumer goods). Other ministries such as Ministry of Defense, Ministry of Interior, and Ministry of Natural Resources and Environment are also involved in the enforcement of the Act. The Act establishes the Committee on Hazardous Substances with power to administer various aspects of the law.

Manufactured nanomaterial of various kinds need to be assigned to the 4 types of hazardous substances that range from Type 1 (low hazard, requiring no registration certificate to produce, store, export, or import), Type 2 (monitoring and control required), Type 3 (permit required for production, storage, export or import), and Type 4 (production, storage, import and export prohibited due to vital risk to humans). Up to now, no manufactured nanomaterial have been assigned to any type of hazardous substances.

3.2. Enhancement and Conservation of National Environmental Quality Act of B.E.2535/A.D.1992 (http://www.mekonglawcenter.org/download/0/thai.htm)

Aside from several provisions built into the past few Thai Constitutions, the Enhancement and Conservation of National Environmental Quality Act of B.E. 2535 serves as the main pillar of the Thai environment laws. The Act consists of 115 Articles, not a short law by Thai standard, covering water pollution, air pollution, noise pollution, as well as hazardous wastes. The Act established the National Environment Board to deal with environmental matters at the policy level and the Environmental Fund to help with building expensive waste treatment facilities as well as conducting environmental conservation promoting activities. The Act is also the umbrella for national

environmental standards, the Environmental Management Plan, and the Provincial Action Plan.

At the enforcement level, the Act established the Pollution Control Committee as well as a framework for setting up all types of emission or effluent standards, including those for vehicle emission. It also provides a mechanism for designating pollution control geographical areas where action plans are taken to reduce or eradicate environmental contaminations. Polluters may face civil liabilities as well as penal provisions.

Better understanding of emission, exposure, and fate of manufactured nanomaterials in the the environment and in human and animal tissues will help clarify the applicability of this Act to such materials.

3.3. The Labour Protection Act of B.E.2541/A.D.1998 *(http://www.oshthai.org/CmsLite/download/pdf/labour_protection_en_1998.pdf)*

An Occupational Safety and Health Act has been drafted and is going through a lengthy tripartite discussion. In the absence of such a specific law for occupational safety and health, workers need to rely on the Labour Protection Act of B.E. 2541, which covers all aspects of labor protection including employment issues, rules on basic pay, holiday pay and overtime, remuneration including minimum wages, welfare, suspension from work, severance pay, and, of course, occupational safety and health. In case an occupational safety and health risk has resulted in actual disability, affected workers may have the rights stipulated under the Thai Consitution and the Rehabilitation of Disabled Persons Act of B.E. 2534 (A.D. 1991).

The Labour Protection Act of B.E. 2541 establishes the Occupational Safety, Health and Environment Committee that is chaired by the Permanent Secretary of the Ministry of Labour and Social Welfare. The Committee makes policy recommendations while the Minister of Labour and Social Welfare has the power to issue Ministerial Regulations prescribing occupational safety, health and environment standards for employers to follow. Failure to comply with such Ministerial Regulations may ultimately result in closing down the unsafe machinery or equipment, with financial remedies payable to employees.

4. Institutional Players

Several public and private bodies are (or will potentially be) involved, directly or indirectly, with safety and ethical issues of nanotechnology in Thailand. These institutional players may be classified as belonging to the public sector, the private sector (for profit legal entities), the universities (both public and private), and the people (grass roots) sector.

4.1. The Public Sector

4.1.1. Department of Disaster Prevention and Mitigation, Ministry of Interior (http://www.disaster.go.th/html/english/index.html)

The principal role of this governmental department is co-ordination of public and private reliefs in case of disaster - natural or man-made.

The Chemical Disaster Mitigation Center (http://www.disaster.go.th/html/hazard/hazard.htm) seems to be of relevance to manufactured nanomaterials. The Center's activities, in addition to its mitigating role, is in chemical safety education such as the safety handling of hazardous chemicals and what to do in case of spills. Once Thailand has drafted its manufactured nanomaterial handling guideline, this Center will certainly be one of the implementing agencies.

4.1.2. Department of Industrial Works, Ministry of Industry (http://www4.diw.go.th:8080/about_personal.php?staff=y&org_id=1024)

The Hazardous Substance Control Bureau, Department of Industrial Works, is the arm of the Ministry of Industry that basically administers the Hazardous Substance Act of B.E. 2535 (Section 3.1). It is expected to become a key regulator for manufactured nanomaterials in a few years from now.

4.1.3. Department of Disease Control, Ministry of Public Health

The Department of Disease Control consists of several important Bureaus such as Bureau of Epidemiology and Bureau of Occupational Disease Control.

4.1.3.1. Bureau of Epidemiology, Department of Disease Control, Ministry of Public Health (http://203.157.15.4/)

This Bureau of Epidemiology serves as the focal point for virtually all kinds of health monitoring in Thailand. It was established in 1959 and was assisted by the World Health Organization four years later to establish and then enlarge its disease monitoring program. The present monitoring program includes non-communicable diseases such as injuries and various health hazards. The Bureau issues Weekly Epidemiological Survey Report on their web site (http://203.157.15.4/wesr/) with back-issues dated to 1996. In case of problems, it can trigger the Surveillance and Rapid Response Network (SRRT Network, http://203.157.15.4/srrtnetwork/) It also keeps track of long-term health effects of various agents.

4.1.3.2. Bureau of Occupational and Environmental Disease (former Division of Occupational Health), Department of Disease Control, Ministry of Public Health (http://occ.ddc.moph.go.th/)

The Bureau of Occupational and Environmental Disease is basically a research center of excellence for occupational safety and health promotion, prevention, and control. They are equipped with a reference toxicology laboratory, a research laboratory, an occupational health training center, and a vast network of the Ministry of Public Health.

The Bureau is expected to collaborate or complement NANOTEC in research work leading to the formulation of the Code of Conduct for Responsible Nanotechnology (Section 5.6).

4.1.4. Department of Medical Sciences, Ministry of Public Health (http://www.dmsc.moph.go.th/2008/)

In addition to its various duties, the Department of Medical Sciences routinely conducts toxicology and microbial services for the private sector, e.g. exporters, and for government agencies in order to enforce consumer protection laws related to food, drinks, cosmetics, food containers, etc., and in order to estimate export and import duties of goods. Occasionally, the Department conducts analyses of court evidence for safety standard violation cases. Their laboratory is also equipped to handle radiation testing.

Currently the Department is not ready to handle manufactured nanomaterials. Once testing standards have been determined, budgets can then be allocated to acquire appropriate equipment and manpower.

4.1.5. The Thai Food and Drug Administration, Ministry of Public Health (http://www.fda.moph.go.th/eng/hazardous/index.stm)

The Hazardous Substance Control Group of the Food and Drug Administration is responsible for the public health aspect of the Hazardous Substance Act of B.E. 2535 (Section 3.1).

In the pre-marketing control, the Group is in charge of the registration and license issuing process for products with different levels of hazard, e.g. toxicity, according to the Hazardous Substance Act of B.E. 2535.

After a hazardous substance is registered, officers of the Hazardous Substance Control Group will regularly visit the licensed site(s) without prior notice in order to inspect whether the approved conditions are still maintained. (According to the FDA web site, unlicensed sites are inspected as well.) Products in the process of manufacturing as well as those on the market are randomly sampled for chemical analysis or for label inspection. Legal actions are

then taken against any violator. Furthermore, the Group conducts surveillance of advertisements in all media to check for over-claims and misleading statements. Finally, the Group monitors consumer complaints about the adverse reactions of hazardous household products.

In addition, the Hazardous Substance Control Group oversees a voluntary project on Good Manufacturing Practices (GMP) implementation for hazardous substances, as well as "Codes of conduct" for Pest Control Operations (PCOs). The Group also runs the safety surveillance under the Adverse Product Reactions (APR) Program to obtain poison information from hospitals in order to analyze and assess the health status related to hazardous substances exposure. Such results are used for setting rules and regulations for controlling suspected products.

Recently, the Hazardous Substance Control Group has been participating in brainstorming exercises for the nanosafety IFCS preparatory sessions. It is also expected to collaborate with NANOTEC in setting up risk assessment framework in nanotechnology applications for the advancement of occupational safety and health in the workplace (Section 5.6).

4.1.6. Pollution Control Department, Ministry of Natural Resources and Environment (http://www.pcd.go.th/indexEng.cfm)

The Pollution Control Department was established on June 4, 1992 as result of the Enhancement and Conservation of the National Environment Quality Act B.E. 2535 (A.D. 1992). The key role of the Pollution Control Department is to investigate public complaints on pollution and then take legal actions to control such pollution as specified by the Enhancement and Conservation of National Environmental Act, B.E. 2535 (Section 3.2) and other related laws.

Additionally, the Department is responsible for a number of academic and policy functions such as (1) Submit opinions for the formulation of national policy and plans for the promotion and conservation of environmental quality with respect to pollution control; (2) Make recommendations for the establishment of environmental quality standards and emission/effluent standards; (3) Develop environmental quality management plans and measures to control, prevent, and mitigate environmental pollution, (4) Monitor environmental quality and prepare an annual report on the state of pollution, (5) Develop appropriate systems, methodologies, and technologies for the application in the management of solid waste, hazardous substances, water quality, air quality, noise level, and vibration; (6) Coordinate and implement measures to rehabilitate and remedy damages caused by pollution in the contaminated area and environmental damage appraisals; (7) Provide assistance and advice on environmental management; (8) Cooperate with other countries and international organizations on environmental management.

Specific offices within the Department of Pollution Control deal with specific types of pollution such as water pollution, air pollution, noise pollution, and toxic wastes. How nanosafety would fit into the existing organizational structure remains to be decided.

4.1.7. Department of Labour Protection and Welfare, Ministry of Labour (http://eng.mol.go.th/provincial_labour_protection.html , http://oshthai.labour.go.th/index.aspx)

Department of Labour Protection and Welfare basically administers the Labour Protection Act of B.E. 2541 (Section 3.3). The Department is expected to become the key regulator for nanosafety in the workplace.

4.1.8. The Thai Industrial Standard Institute, TISI, Ministry of Industry (http://tisi.go.th/eng/tisi.html)

The Thai Industrial Standard Institute was established in 1969 under the Ministry of Industry as a result of the Industrial Product Standards Act of B.E. 2511 (A.D. 1968). Ten years later it was upgraded to the departmental status in the Ministry. The Institute is well-known locally owing to its volunteer () and mandatory () certification marks.

TISI participates in development international standards of the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC) and the FAO/WHO Food Standard Program (Codex Alimentarius Commission). TISI also participates in activities of the International Accreditation Forum (IAF), the International Auditor and Training Certification Association (IATCA), and the International Laboratory Conference (ILAC).

TISI develops both mandatory and voluntary Thai Industrial Standards (TIS) to suit the need and the growth of industry, trade and economy of the country. TISI standards are developed according to the government policy in consumers protection, industrial promotion, environmental protection and natural resources preservation.

With respect to manufactured nanomaterials, TISI regularly sends delegations comprising its people and those from related agencies like NANOTEC to participate in ISO TC229. Up to now, however, manufactured nanomaterials are not covered in TIS.

4.1.9. The Thailand Research Fund (http://www.trf.or.th)

The Thailand Research Fund (TRF) was established in response to the Research Endowment Act of B.E. 2535 (A.D. 1992). The organization is an independent juristic body that is part of the government system with flexible non-government administrative bureaucracy. TRF is governed by an

administrative board comprising the Minister of the Prime Minister's Office, the Minister of Science, Technology, and Environment, and the Minister of Industry. TRF's objectives include (1) building up professional researchers and strengthen the research community, (2) supporting research that is significant to national development, both for basic research and research where results can be used directly, (3) promoting the dissemination and use of research findings, and (4) raising funds for the national research and development system. Two groups of TRF programs are related to Nanotechnology, as outlined below.

The Program on Public Welfare (Division 3) of TRF deals with public policy issues including public safety and health. Handling of toxic chemicals and wastes has been a supported subject matter of Division 3. During 2007-8, the Program sponsored a couple of roundtable brainstorming sessions directed at the issues of nanosafety and nanoethics. Speakers at these roundtables include the authors of this paper.

Scientific and industrial research work are sponsored through Program on Agriculture (Division 2), Program on Industry (Division 5) and Program on Academic Research. Any update on nanosafety and nanoethics standard or guideline will be applicable to these Divisions.

4.1.10. NANOTEC (http://www.nanotec.or.th/)

The National Nanotechnology Center, Thailand, (NANOTEC) was founded in 2003 as an autonomous agency under the umbrella of the National Science and Technology Development Agency (NSTDA), Ministry of Science and Technology (MOST). Its vision is to create micro- and nanotechnologies that would enrich Thai industries, protect the environment and give rise to niche innovative products, processes, and competitiveness in the global market. NANOTEC's missions are to promote, establish, deploy and support the development of new research innovations, technology transfer, human resource development, and S&T infrastructure. The main objectives of NANOTEC are:

- to conduct and promote research and development (R&D) in nanoscience and nanotechnology (N&N) as enabling tools to improve the competitiveness of Thai industries
- to develop well trained human resources in the field of nanotechnology
- to establish R&D collaboration among academics, industry and government, national and internationally
- to promote public awareness and understanding of nanotechnology

Since its inception, NANOTEC has played two major roles – a national R&D center for science, technology and policy and a granting agency for R&D in N&N. Over the years, it has become the national institution for N&N R&D funding. In addition to pushing forward its own R&D, the Center also

provides services in nanoscale measurement and characterization using state-of-the-art equipments to the academics, industry and government.

The Center has divided its focus in R&D into two sectors – Basic R&D and Directive R&D. Basic R&D consists of 3 essential platform technologies: Nano-coating, Nano-encapsulation, and Nano-devices. Directive R&D, which answers the need of the industrial sector more directly, involves Nano-simulation, Nano-Safety and Functional Fiber Technology. In addition to those in-house arrangements, Consortiums and Collaborative Research Programs (CRP) have been formed – Computational Nanosciences Consortium, Functional & Technical Textiles CRP and Cosmeceuticals CRP.

In response to the "nanohype" trend, NANOTEC in collaboration with regulatory agencies, are developing the system to verify properties and qualities of nanotechnology products and manufactured nanomaterials.

In 2007, to drive the nano-safety plan forward, NANOTEC has established the Nanomaterials Safety Program whose goals are as follows :

- To conduct research on nanomaterials exposure and to determine the fate of nanomaterials in the lab environment
- To develop and validate new measurement protocols for nanomatierials that best suit our environment
- To investigate toxicity and related factors of some nanomaterials whose toxicity data are unavailable.
- To develop screening tests and predictive models for toxicity, and to determine the dose metrics
- To conduct risk assessments pertinent to nanomaterials. To evaluate the role of their properties in the exposure-dose-response relationships, and to develop and validate models for nanoparticles risk assessment.

4.2. The Private Sector

Although most nanotechnology-based industries in Thailand are still in their infancy, several private and public companies are engaged in developing and manufacturing nanomaterials. Notable products include: nanocomposite food packages, alcohol nanosensors, water-repellent fabric coating made of nanoparticles, nanoclay membranes for water treatment, and curcuminoid nanoliposomes (whitening) face creams. Other products in the pipelines include nanoalumina-doped ceramics-based artificial gemstones, nanochitosan-based slow-release drug vehicles, nanoparticle Organic Light Emitting Diodes (OLEDs), nanodye-sensitized solar cells, etc.[9] At the policy level, the industrial sector in Thailand is regularly represented by the Federation of Thai Industries (FTI), whose consultants have been studying the safety issue of manufactured nanomaterials for the past year or two.

4.2.1. Federation of Thai Industries, FTI (http://www.fti.or.th/FTI%20Project/index_mainEng.aspx)

The Federation of Thai Industries was established by the Federation of Thai Industries Act of B.E. 2530 (A.D. 1987). At present it consists of 9 Industrial Clusters (automotive/auto parts, construction, electrical/electronics/air conditioning, fashion, machinery/metal, petroleum, pharmaceutical/food processing, pulp/paper/printing, supportive products) and 35 Industrial Clubs (food processing, pharmaceutical, automotive, auto parts, iron & steel, plastics, electrical & electronics, rubber, textile, garment, gem & jewelry, leather, footwear, air-conditioning & refrigeration, environmental management, cement, furniture, glass, ceramics, roofing, aluminum, panel, granite & marble, petroleum refining, chemical, petrochemical, gas, machinery & metal, agricultural machinery, pulp & paper, printing & paper packaging, gift & decoration, sugar, renewable energy, power producing). A majority of these Industrial Clubs either utilize or manufacture nanomaterials.

FTI has been participating regularly in chemical safety forums that are arranged by governmental regulators, including the nanosafety session in preparation for the IFCS Forum VI.

4.3. Universities

Research involving nanomaterials are conducted at dozens of universities under the disguise of various disciplines ranging from material science, biochemistry, food technology, pharmaceutical science, etc. Nevertheless, only Chulalongkorn University (CU) is aggressively building a nano center of excellence, with activities related to nanosafety at both science and policy levels.

4.3.1. Chulalongkorn University (http://www.chula.ac.th)

Chulalongkorn University is Thailand's oldest, most prestigious and most endowed land grant university that is situated next to the largest shopping district of Bangkok. It was established in 1917 by the late King Rama VI originally as the school to prepare youngsters for civil servant positions. Over the years, the university has expanded to include a total of about 20 Faculties, 3 colleges, and 2 institutes, with about 3,000 faculty members and 5,000 staffs serving some 20,000 undergraduate and 10,000 graduate students. The strength of Chulalongkorn University resides in its multi- and inter-disciplinary capability in natural sciences, social sciences, and humanities. Over the past 30 years, many national policy studies that were conducted at Chulalongkorn University have been implemented through legislative and administrative instruments. In 2004, the university was ranked 46th in the world for social sciences and 60th for biomedicine according to Times Higher Education Supplement World University Ranking. Resources of the university include several museums and sporting facilities, easy access to the National Stadium,

which is built on the university's property, and even a 5-KW FM radio station that is well-known for news, commentaries, and classical music programs. The Faculty of Science also maintains a weekly talk show at a local TV station in order to educate lay people on science and technology advancement and policy issues.

Currently the university offers many courses related to nanotechnology and two nanotechnology curricula: an international undergraduate curriculum at the Faculty of Engineering and an international doctoral curriculum at the Faculty of Science. Research projects related to nanotechnology have been conducted at the two faculties as well as in other schools, notably the Polymer Program in the Petroleum and Petrochemical College. In 2007 the university established the Center of Innovative Nanotechnology (CIN) in order to exert momentum on R&D in the nano-fields. In the fiscal year 2008, CIN's procurement includes approximately USD 660,000 (Baht 20,000,000.00) worth of analytical equipment for R&D on nanomaterials and nanomaterial composites. A total budget of approximately USD 1,320,000 (Baht 40,000,000.00) has been allocated from fiscal year 2009 through 2013 for R&D support of 7 programs: nanomaterial, nanobiology, nanoelectronics, nanosafety, nanoethics, nanoinstrument, and nanocurriculum development. It is expected that once the programs are running smoothly, cross-cutting projects among different programs will start to emerge.

At the national policy level, Chulalongkorn University received a grant from NANOTEC in 2007 to conduct a Phase I Policy Study on NanoSafety and NanoEthics. The second phase, more in-depth, study is due to begin some time in the last quarter of 2008. The Faculty of Science is also preparing radio and TV segments on nanosafety in order to raise well-informed and unbiased awareness among the Thai people on such issue.

4.4. The People Sector

Following the "Civil Society" concept that underpinned the 1995 World Summit for Social Development in Copenhagen, attempts have been made in both the Thai Constitution of B.E. 2540 (A.D. 1997) and subsequent National Economic and Social Development Plans to empower lay people to make informed decisions on matters that affect their livelihoods. Public health and safety are among these matters.

4.4.1. **The National Health Commission, NHC** (http://www.nationalhelth.or.th/eng/)

The National Health Act of B.E. 2550 (AD 2007) established the National Health Commission to be the country's top-level health policy forum among representatives of government agencies (7 persons), non-government

public agencies (2 persons), local government organizations (4 persons), public health professionals (one from each organization established by law, plus one person from professional committee on healing), and non-profit citizen groups (13 persons). The jurisdiction for this Commission cover all aspects of health, from birth, living, aging, injury, and death.

For the past year or so, the National Health Commission has become interested in the issues of nanosafety. Officers from the Office of the National Health Commission have participated in nanosafety-related activities including preparatory meetings for the IFCS Forum VI.

5. NanoSafety and NanoEthics Policy Studies

Thailand presently has no regulation specifically addressing the safety of any type of nanomaterial. Safety legislations that have been briefly reviewed in Section 3 may be applicable to certain nanomaterials under certain circumstances.

In 2006, NANOTEC considered commissioning a study that would lead to a detailed guideline for nanotechnology research, manufacturing, transportation, etc. The guideline was supposed to be backed by solid scientific data on the health and environmental fate, exposure, and effects of nanomaterials as well as risk analyses. After NANOTEC[10] represented Thailand to observe the first OECD Working Party on Manufactured Nanomaterials (WPMN1) on 26-27 October 2006, it became apparent that such a detailed guideline would not be feasible at the time due to lack of supporting scientific data. The Center decided to proceed in a more cautious manner towards understanding the safety issues before attempting to draft a detailed guideline.

The Phase I Policy Study on NanoSafety and NanoEthics was therefore designed to shed light on international best practices as well as identify international institutional players in the fields of nanosafety and nanoethics. The Center commissioned Chulalongkorn University (Section 4.3.1) to conduct the study in 2007.

At the time of this writing, the scope of Phase II Policy Study is not yet settled. It may cover the valuation of scientific observations and experiments and/or a review of the status and trend of nanosafety in Thailand and/or the drafting of a general Code of Conduct for handling manufactured nanomaterials.

5.1. Understanding International Institutional Players

Phase I Policy Study identified dozens of international institutional players in the field of nanosafety and nanoethics. They were grouped geographically (country, region) as well as by their status category (such as developed country government, developing country government, private sector, and non-government organization, NGO). Each institution was reviewed with

respect to its history, mission, accomplishment, and standpoint or mindset on matters regarding the safety of manufactured nanomaterials. This review serves as an introduction to Thai policy-makers who are new to the field of nanosafety and nanoethics to get accustomed to the major players in the field in a short time.

5.2. International Best Practice and International Collaboration

In the absence of a comprehensive set of international standards, international attempts to arrive at guidelines for dealing with manufactured nanomaterials have been reviewed. Globally, this includes the activities of ISO, OECD, and IFCS. Regional and national projects, as well as those of NGOs and the private sector, are also reviewed in this exercise. The technology, manpower, and funding necessary to expedite the tasks such as selecting what to test, arriving at acceptable test protocols, and drafting test guidelines as well as proposing & testing risk models demand international collaboration in which Thailand should be willing and ready to participate.

5.3.Status and Trend of NanoSafety in Thailand

Although the status and trend of nanotechnology and nanosafety in Thailand was not part of Phase I study, such information was preliminarily gathered by NANOTEC personnel and by a TRF-supported mini project that was conducted by experts at www.chemtrack.org.[11] A more systematic survey is still needed.

5.4.Certification Marks

Up to now a few public-sector agencies, notably NANOTEC, has expressed interests in setting up certification mark(s) for products containing nanomaterials. Actual implementation has been delayed for several years due to uncertainty in liability risk assessment. It is possible that a certification mark may be in place by the end of 2008 or early 2009. The first certification mark would be patterned after Taiwan's NanoMark (http://www.nanomark.itri.org.tw/Eng/regulation.asp) in the sense that it would only address the size and dimension of the nanomaterials, not their behavior and certainly not their biological effects. The mark and its qualifications must be publicized to the public in order to minimize confusion as to the scope of the certification.

One possible cooperation scenario for the Thai nano-certification mark is for NANOTEC to sponsor the certification process while leaving universities and governmental laboratories to do the actual testing of nanomaterials. Up to now there has not been any round-table discussion regarding such a cooperation scheme.

5.5. Valuation of NanoSafety Observation and Research

Confusion about the toxic effects of manufactured nanomaterials may have resulted from some unconfirmed and potentially conflicting results from quasi-scientific to scientific observations and experiments related to such materials. Valuation of scientific studies (environmental, toxicological, safety testing & standard) should help in the assignment of credibility to these documents. This exercise is likely to be supported by NANOTEC during the 2008-9 fiscal year.

5.6. Code of Conduct for Responsible Nanotechnology in Thailand

Owing to the potential and rapid growth of nanotechnology in various branches of industry, NANOTEC has established in 2007 a "Nanomaterials Safety Program" with three principal components: research, standards and policy. The objective is to develop recommendations on the safe handling of nanomaterials using the available information and new findings that are relevant to the local needs in the country. Towards such objectives, NANOTEC has strategically put together a development plan that includes a roadmap for risk assessment in the potential nanoscience and nanotechnology (N&N) applications for the advancement of occupational safety and health in the workplace. The plan involves relevant regulatory bodies such as the Thai Industrial Standards Institute (TISI, Section 4.1.8) and the Thai Food and Drug Administration (Thai-FDA, Section 4.1.5).

The goals of NANOTEC nano-safety research encompass the whole spectrum of nanomaterial measurement, risk exposure measurement, toxicity and screening test evaluations, as well as risk assessment model validation. Research plans have been drafted for long-term (over 15 years), medium term (5-15 years), and short-term (under 5 years). In the short term, detection and characterization methods for nanomaterials will be developed as well as exposure measurement protocols. In the medium terms, in situ detection of nanomaterials as well as understanding of interaction between nanomaterials and biological environments will be emphasized. More complicated studies such as those involving whole body exposures are left for the long-term plan.

A more detailed description of NANOTEC activities leading to the Code of Conduct for Responsible Nanotechnology in Thailand is distributed as a separate document that will be presented by Dr. Noppawan Tanpipat of NANOTEC in a separate session at the IFCS Forum VI.

6. Future Outlook

During the past few years, Thailand has determined to become both an informed consumer and a nanomaterial manufacturer with social responsibility that is compatible with global standards.

The most comprehensive nanosafety research program seems to be the one planned by NANOTEC mentioned in the preceding paragraphs. Results are expected to be confirmed and complemented by similar work done at universities and research institutions. In a year or so, furthermore, a conclusion should be reached regarding the types of nano-certification mark to be established and the effective administration of such marks.

The establishment of Center of Innovative Nanotechnololgy at Chulalongkorn University with a decent seed budget and separate programs for nanosafety and nanoethics will set an example for the academic and intellectual circles with respect to the importance of nanosafety and nanoethics. Similar centers and programs may be set up at other universities as well. Meanwhile, the Center will need to strengthen its linkage with the lay people, who are the consumer of nanotechnological products. This can be done, for example, through radio and TV programs that the university has access to.

In 2009, the authors expect the institutional players to be more familiar with the issues of manufactured nanomaterials. Clarification will have to be made regarding interpretation of the current laws and regulations when applied to manufactured nanomaterials. These tasks is expected to be catalyzed by NANOTEC. In cases where laws and regulations need to be amended, NANOTEC again may need to initiate and expedite the ordeal.

At the national policy level, NANOTEC is expected to continue the push for the Code of Conduct for Responsible Nanotechnology. Meanwhile, Phase II of the NanoSafety Policy Study, which may include valuation of previous scientific studies, is expected to commence by the end of 2008. By the end of Phase II, we may be able to pool nanosafety information and guidelines from various sources including OECD and ISO in order to formulate our own version of the nanosafety guidelines.

Nanosafety and nanoethics issues are too big and too complicated for a single small nation like Thailand to tackle alone. The country, therefore, needs to maintain strong international linkages for best-practice information, research collaboration, as well as standard and guideline development.

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References

Respective references have already been embedded in the text and the endnotes.

End Notes

[1] Written by Lerson Tanasugarn, PhD, Faculty of Science and Center of Innovative Nanotechnology (CIN), Chulalongkorn University (http://www.lerson.org) and Noppawan Tanpipat, PhD, NANOTEC. This paper was presented at IFCS Forum VI in September, 2008 in Dakar, Senegal. A pdf-file of this article is available on-line at http://www.lerson.net/nano/. The views presented here are those of the authors and not necessarily those of the organizations with which the authors are affiliated. For the purpose of improving the article, readers may report errors and omissions at LERSON@LERSON.ORG.

[2] IMD 2007. The World Competitiveness Scoreboard 2007 accessed on 15 March 2008 at http://www.imd.ch/research/publications/wcy/upload/scoreboard.pdf?prog=

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[7] See for examples (1) Council of Canadian Academies. 2008. Small is Different: A science perspective on the regulatory challenges of the nanoscale (available on-line at http://www.scienceadvice.ca/documents/(2008_07_10)_Report_on_Nanotechnology.pdf), (2) Invernizzi, N. and G. Foladori. 2005. Nanotechnology and the developing world: Will nanotechnology overcome poverty or widen disparities? ***Nanotechnology Law & Business Journal*** **2**(3) Article 11:1-10. (available on-line at http://pubs.nanolabweb.com/nlb/vol2/iss3/11) One of the authors (LT) was delighted to attend a presentation by Dr. Invernizzi at the AAAS Annual Meeting in St. Louis in February, 2006, where she elaborated on the issues and examples in the paper.

[8] See the "Five Minute" Project Presentation of the 2007 NSF Grantees Meeting on Ethical, Legal and other Social Implications of Nanotechnology, held on 15-16 March 2007 in Room 375, 4201 Wilson Boulevard, Arlington, VA 22230. (available on-line at http://www.nsf.gov/crssprgm/nano/2007_nano_elsi_grantees_meeting.doc)

[9] OECD. 2006. Current Developments/Activities on the Safety of Manufactured Nanomaterial/ Nanotechnologies. Working Party on Manufactured Nanomaterials. [ENV/JM/RD(2006)20/ ENG]

[10] One of the authors (LT) represented Thailand and NANOTEC at the OECD WPMN1 in 2006.

[11] Chuankrerkkul, N. and Sangsuk, S. "Current Status of Nanotechnology Consumer Products and Nano-Safety Issues". The First Thailand National Nanotechnology Conference, Chiangmai, Thailand, 14-16 August 2007. See also http://www.chemtrack.org/News-Detail.asp?TID=5&ID=4.