

Mulch ado about nothing? ... Or the “Sand Witch?”

Environmental use of “nanotechnology” highlights regulatory inadequacies and lack of clarity in the nanotech industry

Fourteen months after the call for a moratorium, nanotech moves on unregulated – in sunscreens and now an environmental release on over 1,400 acres following a forest fire on sacred Encebado Mountain at Taos Pueblo, New Mexico.

Issue: Unique nanotechnology products and processes are entering large-scale use in the environment without regulatory oversight. Materials and processes approved at conventional scales (macro or micro) do not require re-examination when used at the nanoscale even though the impact on the ecosystem – including on biodiversity – could be radically different. A recent event on First Nations’ land in New Mexico using what appears to be a nanotech self-assembly process should be a warning to government and industry.

Impact: Companies around the world are beginning to mass produce nanoparticles and novel nanostructured materials for use in everything from automobile tires to environmental clean-up and soil reclamation. While the industry claims its products will be beneficial for the environment, in the absence of government regulatory oversight, the short- and long-term implications of these developments could actually pose new concerns for biodiversity and the environment and for the safety of lab and other workers and end-users.

Policies: By rushing into the marketplace without government evaluation, the potentially huge nanotech industry is risking self-destruction. There may be no ‘smoking gun’ yet, but it could take only one environmental misstep to jeopardize the future of the science. It is likely that the policy environment for nanotechnology will become fixed within the next two years. But the socioeconomic discussion has not even begun. Since ETC Group’s call for a moratorium on nanotech research, regulators have begun to stir on both sides of the Atlantic. Without an inclusive social debate on nanotechnology and conscientious regulation it will not be possible to avert the kind of abrasive battle that is still being waged over biotechnology.

Actions: The scientific community should immediately propose “best practices” for laboratory research using nanotechnology. Allowing for public participation and transparency, governments must then begin a process to accept, reject or modify these recommendations and put in place regulatory oversight for nanotechnologies. The potential impacts of nanotechnology on biodiversity and the environment should be placed on the agenda of the Seventh Conference of the Parties to the Convention on Biological Diversity when it meets in Kuala Lumpur, Malaysia on February 9-20, 2004. On April 19-30, 2004 the UN Commission on Sustainable Development should discuss nanotechnology, with particular emphasis on its social and economic impacts, and recommend a process that could lead to an International Convention for the Evaluation of New Technologies (ICENT).

The nanotech industry – whose best-known commercial successes have thus far been stain-resistant pants, stronger and lighter tennis rackets, and transparent sunscreens – is now introducing nano-scale processes and products to prevent soil erosion and to block the leaching of toxic substances into groundwater. While industry claims these initiatives will prove to be a boon for the environment, ETC Group is concerned that their commercialization is taking place below the radar of regulatory agencies because the novelty in nanotechnology lies in its scale, not necessarily in the often conventional substances it uses. Materials exhibit unique and sometimes unpredictable behaviour when they are reduced to the nano-scale even while the chemical composition remains unchanged.

Grey Glue? In July, lightning ignited a forest fire on Encebado Mountain (Taos Pueblo, New Mexico), considered sacred by the First Nations community. More than 5,000 acres were burned leaving the mountainside exposed to erosion and threatening the community's water source. The community and the Bureau of Indian Affairs sought to protect the land and to preserve its sanctity. The tribe avoided using bulldozers as well as air-dropped fire retardant in many areas and they used all-Native American crews in the area of Rio Pueblo.¹ In August, Aero Tech, an aerial spraying company based in Clovis, New Mexico, won a US\$4 million Bureau of Indian Affairs contract to protect the mountainside.² Sequoia Pacific Research (formerly Zion Pacific Research), a privately-held Utah-based "nanotechnology" company (www.sequoiaprc.com), supplied its soil-stabilization product to Aero Tech. The product was sprayed on over 1,400 acres of Taos Pueblo land.

Sequoia Pacific Research claims that SoilSET™ uses organic biodegradable ingredients that undergo an electrochemical reaction when mixed with water. The product can be aerosolized and dropped from helicopters and planes onto the sharply sloped land that is most susceptible to erosion and would be difficult to reach otherwise. In the presence of water, the chemical concoction causes silicate particles to "self-assemble," agglomerating into a crystal matrix. This serves as a high-tech mulch, preventing erosion while allowing seeds that have been added to the mix to establish themselves in the soil.

Grey Area? According to the company, when water is added, an electrochemical reaction occurs at the 4 nanometer (nm) level, transforming the proprietary chemicals into a slick liquid. (A nanometer is one-billionth of a meter.) This in turn catalyzes silicate particles that are already in the soil to bind together and form a kind of crust that is able to survive up to 12 months. When it rains, the electrochemical reaction – and hence the binding – are renewed, allowing SoilSET™ to persist in the environment. Asked by ETC Group for the chemical composition of SoilSET™, Paul Clayson, Sequoia's Chief Operating Officer, declined to say, citing the need to protect proprietary information pending patent approval.³ Clayson said that during the process of developing the product, Sequoia had consulted the Colorado office of the Environmental Protection Agency (EPA) and was told that no approval was required. Presumably, this is because the dry starter chemicals in SoilSET™ have been used in the environment before.⁴ Yet the company advertises that SoilSET™'s novelty lies in the fact that unusual reactions at the nanometer scale transform these chemicals into a 'new material' with very different properties when water is applied. It is this electrochemically active 'new material' that is applied to the soil and causes the silicate particles in the product and silicate particles already present in the soil to agglomerate into a resilient crust. Chemist Richard Maile, president of Sequoia, characterized SoilSET™ in this way: "Basically, it is nanotechnology because of the ingredients and how they are put together – the reactions happen on the very smallest of levels."⁵

The application of SoilSET™ to Taos Pueblo land is by far its largest use in the environment to date and ETC Group believes it is the largest single environmental release so far of a novel nanostructured product. That this product has never been studied by the EPA is worrying. In March 2002, the company field-tested an earlier-version of SoilSET™ on a very small burn area in California's Mendocino National Forest. A Mendocino hydrologist and a biologist evaluated the six-acre experiment. Photos provided by Mendocino Forest Service⁶ show a shiny slick layer of material coating the gully, which, reportedly, prevented soil erosion. But the product also affected local biodiversity. Due to the strength of the crust, only the hardest tuberous plants were able to break through; some native annual plants could not. Cost considerations

prevented both the Mendocino Forest authorities and Sequoia from undertaking detailed soil tests, although the company did contract with the University of Nevada (Reno) to evaluate the product's performance.⁷ Based on the Mendocino field-test and other tests, Sequoia added wood pulp to the mulch as well as ponderosa pine seeds to its product before applying it to the soil in New Mexico, presumably to make it more environmentally-friendly. The extent to which this modification was tested – and under what soil and slope conditions – is unclear.

The leadership in the Taos Pueblo does not appear to have been advised that a novel nanotechnology-based product would be deployed on their mountain.⁸ Contacting the War Chief, ETC Group was told that the community had asked for the standard safety information and was provided with a Material Safety Data Sheet (MSDS) and had been assured that the chemicals would reduce soil erosion. Subsequently, ETC Group spoke to the War Chief and to the Governor at Taos Pueblo. No one seemed to be aware that a nanotechnology product had been used following the fire. ETC Group has had little success reaching the responsible persons in the Bureau of Indian Affairs in the western regional offices who managed the soil protection contract. Those contacted appear not to have any knowledge of the nanotech-based character of the reclamation program.⁹

Mulch Ado About Nothing? Sequoia's Paul Clayson, in an email exchange with ETC Group, stressed that Sequoia "does not manufacture, produce, mix, purchase or use nanoparticles in any product" and he implied that Sequoia is basically a chemical company that is taking advantage of a common technological process that binds silicates.¹⁰ Yet information on the company's web site and an interview with Mr. Clayson on CNN both stress the product's unique reaction that takes place at the level of 4 nm, a reaction that can persist in the environment for up to a year.¹¹ It is quite possible that the particles active in the company's product are nothing more than some type of sand – the very stuff children mix with water to make sticky paste sand castles on the beach. Sand or not, the relevant issue is how sand performs at the nano-scale. According to the company, SoilSET™ is a new product that causes a novel reaction in the soil, one that promotes self-assembly of silicate particles that would not take

place without the product. Therefore, the EPA should have looked much more closely. If SoilSET™ is simply old chemistry dressed up to look like a new technology, the company needs to address its own lack of clarity: is it spin to sell a product or is it truly a new product using a new nanotechnological process? If Sequoia's press releases are correct, SoilSET™ takes advantage of a new understanding of directed nano-scale phenomena.¹² Kevin Ausman, the Executive Director of the Center for Biological and Environmental Nanotechnology (CBEN) at Rice University in Houston, Texas, is apparently unfamiliar with the product. When asked for his assessment for a recent article that appeared in *Small Times*, the industry's trade journal, Ausman said it "sounds like a very safe application," but pointed out that "nano is so new that you have to evaluate it very carefully."¹³ Apparently, CBEN (the government-funded center dedicated to the study of environmental nanotechnology) has not been consulted. The government agency responsible for environmental protection did not require the product to be approved. The scientists consulted by ETC Group were unable to even hazard an assessment without knowing the chemical composition of the product, which remains secret proprietary information. Who, then, is doing this careful evaluation that Ausman says is necessary?

Sand Witch? This release of an unregulated nanotech product is not an isolated example. Because existing regulations do not address the issue of the changed behaviour of nanomaterials, many products have reached the market without adequate testing. Appropriate categories do not yet exist that allow companies to classify their new products accurately. Carbon nanotubes, for example, are often classified as "graphite" because they are of the same chemical composition though their chemical properties differ dramatically. Other companies are hard at work hoping to commercialize other new nanotechnology-enabled products (see box page 5). Are regulatory agencies tracking their research? Does adhering to existing regulations allow for substantially new substances and/or new uses to slip through the cracks into the ecosystem and/or into human bodies?

Scientists need to know what novel properties the new nanomaterial exhibits; how this matrix of silicate particles forms; how long it lasts; what it

Looking Down the Nanotech-Pipeline – Is Anyone Watching?

A host of emerging products involving the use of nanoparticles and/or nanotech-enabled processes could involve large-scale environmental release. Some are already available. The following are just a few examples:

- Researchers are experimenting with self-assembly methods to turn silicates into glass at ambient temperatures in order to encapsulate oil spills, radioactive materials and other wastes. One process, called “Sol-gel,” involves an electrochemical reaction with nano-sized metal particles that causes silica particles to self assemble into a crystalline solid without requiring heat. Research funded by the US Department of Energy demonstrates that this process can be used to solidify soil around waste spills and to turn toxic or radioactive liquids into a hard ceramic.¹⁴
- Sequoia Pacific Research markets a process called SRS (super rapid solidification). According to the company, SRS can be used to encapsulate oil leaks *in situ*. The company speculates that the SRS process could also be used for transporting radioactive wastes.¹⁵
- Sequoia Pacific Research also markets two products that they advertise as nanotechnology products: Bio-DECON™ and TerraKlean™. Bio-DECON is based on nanosilicate crystals. When the crystals come into contact with water inside the target microbes they form a network of ‘nanoblades,’ effectively shredding the cell walls of the target microorganism. Sequoia claims that several million pounds of Bio-DECON were already used for cleanup in Kuwait following the first Gulf War in 1991.¹⁶
- Researchers at Lehigh University are developing ways to inject iron nanoparticles into groundwater channels of contaminated sites. The nano-sized iron is highly reactive and will, in effect, “rust” dangerous heavy metals like lead and mercury. Researchers say any remaining unused nano-scale iron will continue its way through groundwater paths until it is completely dissolved.¹⁷
- Altair, a Nevada-based nanotech company, filed a patent application last year on a water cleaning substance dubbed “NanoCheck” intended for use in swimming pools, fountains and fish farms. Nanocheck uses 40 nm particles of lanthanum to absorb phosphates from the water and prevent growth of algae. Altair is currently seeking partners to commercialize its product.¹⁸
- NanoScale Materials, Inc., a Kansas-based nanotech firm sells a proprietary nanoparticle based formula called FAST-ACT that is designed to neutralise a wide variety of toxic chemicals and chemical warfare agents.¹⁹
- Clear Spring Foods of Idaho, the third largest commercial trout farm in the US, is conducting trials on a new method of delivering DNA vaccines to fish by attaching them to nanoparticles released into fish ponds. The vaccines are intended to immunize fish *en masse* when exposed to ultrasound. The US Department of Agriculture is funding experimental trials of these nanoparticles.²⁰
- Agrochemical companies are formulating new pesticides composed of nanosized particles. For example, Pharmacia (formerly parent company of Monsanto), holds a patent for nano-liposomes, encapsulated particles of between 50 and 500 nm, which can be used to deliver bioactive chemical substances into crops as pesticides.²¹

does to the living soil; and where the changed particles go when the matrix breaks down. On the surface, it seems that this use of nanotechnology reduces the demand for water and allows conservationists to prevent erosion where other products were almost useless. In the absence of regulatory oversight and transparency on the part of the company, however, we cannot be sure of its environmental appropriateness or safety.

Historic Cues – Forty Years from “Ice-9” to “Ice-Minus” to Advice-Minus?

2003 – Advice-Minus: The Cartagena Protocol on Biosafety enters into force to establish rules for the introduction of living modified organisms across national borders. The Protocol entered into force eight years after the first GM crops were commercialized.

1983 – Ice-Minus: 20 years ago University of California (Berkeley) researchers applied to the National Institutes of Health for permission to release the genetically modified ‘ice-minus’ bacteria into the environment. ‘Ice-minus,’ a spray to make potatoes and strawberries frost resistant, was initially approved without an environmental impact assessment (EIA), a decision subsequently reversed following lawsuits filed by a coalition led by the Foundation on Economic Trends. In 1987, the US government approved the environmental release of the ice-minus bacteria on strawberries in California. The first legal, environmental release of a genetically modified organism proved so controversial that ice-minus never got off the ground. Researchers instead pursued a non-transgenic version.

1963 – Ice-9: 40 years ago Kurt Vonnegut’s *Cat’s Cradle* sounded the first warning, albeit fictional, of novel nanostructured materials getting out of control. The book describes a nanomaterial, dubbed ‘ice-9,’ that solidifies water into ice at ordinary temperatures. In the book, ‘ice-9’ turns all the world’s water to ice and the soil becomes a hard impermeable crust.

Moratorium Call: Fourteen months ago, ETC Group called for a moratorium on the introduction of new products using nanoparticles and on laboratory research until the research community could agree on acceptable laboratory protocols in handling nanoparticles. ETC Group was disturbed to discover that even after a quarter-century of lab work,

scientists have no commonly agreed-upon protocols and the range of practices varies enormously from lab to lab. If nanotechnologists had heeded the call for a moratorium, appropriate protocols would already be in place and the lab work would be able to continue with much less controversy. Instead, we are faced with a lack of clarity in the industry and a lack of certainty in the regulatory process.

“Today, there is no real regulatory policy formulated to deal with nanotechnology. No stakeholder in this arena has taken the initiative to change the status, although some experts believe it is an issue in the immediate future.” Nanotechnology & Regulation, September 2003.²²

ICENT: Although industry has not accepted the call for a moratorium, the potential toxicity of some nanomaterials is now being acknowledged and policy-makers and companies on both sides of the Atlantic are beginning to address the inadequacies of present regulations to evaluate the new properties of nano-scale products:

- In Europe, the NANOSAFE project has been launched to assess the risk of airborne nanoparticles in the workplace. The project is part of the Sixth Framework, the European Union’s main instrument for research funding in Europe.
- In January 2003, the UK’s Better Regulation Taskforce warned the UK government that nanotechnology safety regulations are needed. The UK government responded by asking the Royal Society and the Royal Academy for Engineers to undertake a study of the socioeconomic and environmental implications of nanotechnology, which is now underway.
- In July 2003, the European Parliament’s Industry External Trade Research and Energy Committee requested a study on the need for new regulations on nanotechnology
- The UK’s Parliamentary and Scientific Committee will hold a meeting on regulating nanotechnology on November 17, 2003.
- The Woodrow Wilson International Center for Scholars in Washington, DC convened a first “Dialogue on Nanotechnology and Federal Regulation” in early October 2003 involving several US regulatory agencies.

- In a report published in September 2003 the New Zealand government's Bioethics Council warned of the need for nano-regulations.

Though governments are beginning to respond, the technology is moving even faster. ETC Group expects that, in order to avoid the social and scientific chaos we have seen with biotech, the nanotech industry and some governments will scramble to have some kind of regulatory systems in place within two years. But regulating products is

not enough. Society must be fully engaged in a discussion of the socio-economic as well as health and environmental implications of nano-scale technologies. Ultimately, all these issues must be considered by civil society in open, informed debates at the local, national and international levels. ETC Group is working with partners to develop an International Convention for the Evaluation of New Technologies (ICENT), which it hopes to bring before a United Nations agency in 2004.

¹ Andy Lenderman, "Taos-Area Firefight is Culture Sensitive," *Albuquerque Journal*, July 9, 2003. Available on the Internet: www.abqjournal.com/news/59411news07-09-03.htm

² Adam Rankin, "Paste Combats Blaze Damage," *Albuquerque Journal*, August 14, 2003. Available on the Internet: www.abqjournal.com

³ Sequoia has filed a "provisional patent application," which allows the company to use the "patent pending" designation for one year before having to file a detailed and documented utility patent application.

⁴ A Material Safety Data Sheet (MSDS) provided by Sequoia states (without naming the chemical composition of the product) that "this product is not harmful to the environment."

⁵ Richard Maile quoted in Adam Rankin, "Paste Combats Blaze Damage," *Albuquerque Journal*, August 14, 2003.

⁶ Photographs of the Mendocino test were provided to ETC group by David Isle, Botanist for the Mendocino National Forest.

⁷ Jeff Karoub, "Nanomaterial Overcomes Weather Woes in Bid to Save Scorched Land," *Small Times*, August 21, 2003.

⁸ Between Sept. 24-Oct. 15, 2003, ETC Group faxed and telephoned the Taos leadership on numerous occasions and also offered to visit Taos at the convenience of the community. Although the leadership did acknowledge receipt of the faxes and telephone calls and did return three calls, they indicated that they had not read the faxes and were not aware of the technologies involved.

⁹ From late September to mid-October, ETC Group telephoned BIA officials in Utah and Washington seeking details on the requirements for the contract under which Sequoia Pacific Research's product was used. No information was available and we were referred to a BIA contractee whose telephone had been disconnected. BIA officials said they would get back to us.

¹⁰ Email communication from Paul Clayson of Sequoia Pacific Research to Jim Thomas, ETC Group, Sept. 25, 2003.

¹¹ To view the CNN interview with Sequoia, go to the company's web site: <http://www.sequoiaprc.com/new.asp> (available as of 10/16/2003).

¹² Sequoia Pacific News Release, "Nano-Technology Soil Binder Selected for Burn Area Reclamation Site," August 11, 2003.

<http://www.sequoiaprc.com/documents/08.11.03%20SoilSet%20%20Taos%20Fire%20FINAL%20Release%20Version.pdf>

¹³ Quoted in Jeff Karoub, "Nanomaterial Overcomes Weather Woes in Bid to Save Scorched Land," *Small Times*, August 21, 2003.

Available on the Internet: www.smalltimes.com

¹⁴ <http://apps.em.doe.gov/OST/pubs/itsrs/itsr2036.pdf>

¹⁵ Based on conversation with Paul Clayson of Sequoia Pacific Research. Also see company web site: <http://www.sequoiaprc.com/srs.asp>

¹⁶ <http://www.sequoiaprc.com/gende.asp>

¹⁷ R. Colin Johnson, "Iron nanoparticles make single sweep of toxic waste," *EE Times*, September 23, 2003. Available on the Internet: <http://www.eetimes.com/story/OEG20030923S0063>. See also, Tom Mead, "Iron nanodust zaps tricky pollutants," *New Scientist*, Vol. 179, Issue 2413, 20 September 2003, p. 22.

¹⁸ http://www.smalltimes.com/document_display.cfm?document_id=5568

¹⁹ <http://www.nanmatinc.com/fastact.asp>

²⁰ USDA Grant 2002-00349 - Development of an Ultrasound-mediated Delivery System for the Mass Immunization of Fish.

²¹ European Patent 0687172B1: Solid Lipid Particles, Particles Of Bioactive Agents And Methods For The Manufacture And Use Thereof.

²² Ahson Wardak, "Nanotechnology & Regulation: A Case Study using the Toxic Substance Control Act (TSCA) A Discussion Paper," Woodrow Wilson International Center for Scholars, Foresight and Governance Project, Sept. 2003.

The Action Group on Erosion, Technology and Concentration, formerly RAFI, is an international civil society organization headquartered in Canada. The ETC group is dedicated to the advancement of cultural and ecological diversity and human rights. www.etcgroup.org. The ETC group is also a member of the Community Biodiversity Development and Conservation Programme (CBDC). The CBDC is a collaborative experimental initiative involving civil society organizations and public research institutions in 14 countries. The CBDC is dedicated to the exploration of community-directed programmes to strengthen the conservation and enhancement of agricultural biodiversity. The CBDC website is www.cbdcprogram.org