

HSE/HSL Research Projects

Table 1 - Research

Description	Progress
<p>NanoAlert The work provides an information bulletin service reviewing studies on exposure and potential health effects of nanomaterials relevant to the occupational setting. The bulletins are available on the web.</p>	<ul style="list-style-type: none"> • HSL have completed key word lists for the literature searches. The December bulletin comprises a consideration of papers since 2000. Subsequent bulletins cover 4 months. Second bulletin issued May 2007. Third Bulletin published October 2007. Fourth Bulletin published March 2008 (http://www.hse.gov.uk/horizons/nanotech.htm)
<p>NANOSH This European multi-centre research project focuses on occupational exposure to nanoparticles and their health effects. The overall goal is to delineate exposure and health effects of selected nanoparticles relevant to the occupational environment. This includes University research departments. As part of the proposal, the laboratories involved in WP2 will assess the performance of RPE and protective clothing against nanoparticle penetration in real-life conditions.</p>	<ul style="list-style-type: none"> • HSL is involved in WP1: particle characterisation and WP2: workplace exposure assessment (especially in research laboratories in universities) and associated control issues. • Particle characterisation parameters of bulk nanomaterials have been agreed taking account of measurement capability as well as desirability. Will be used for toxicology work and to develop database. • Outline sampling strategy for work place exposure monitoring inc. contextual info (sampling instruments, where to sample and for how long, etc) agreed using experience gained in NANOSAFE 2 and other internal work. All partners concluded pilot study. HSL has carried out sampling in 2 Universities and plans to visit more. Initial results show rush hour peaks but no increase over background. Difficulties of determining exposure to <i>engineered</i> nanoparticles very clear. Developing protocol for elemental mapping by X-Ray analysis/electron microscopy to distinguish between natural and engineered particles collected onto filters or carbon film supported on TEM grid. Initial results at the second University include observation that clean rooms seem to provide a well controlled environment. Other partners looking at other sites. • Information on control measures and dermal exposure noted via observation. Programme to assess performance of RPE and protective clothing in real conditions discussed for implementation in second year of project. Will take account of work carried out elsewhere. • Discussions have been held about setting up EU-wide database on anonymised measurements and associated contextual information • A project report is due December 2007

HSE/HSL Research Projects

Table 1 - Research

Description	Progress
<p>Nanosafe2 A consortium of European companies and research laboratories has developed a research programme for the safe production and use of nanomaterials. The project has 4 main scientific subprojects – Measurement of exposure to and characterisation of airborne nanoparticles, Potential health effects of nanoparticles, Procedures for safe production and handling of nanoparticles, and Standards, regulations and societal implications of nanoparticles.</p>	<ul style="list-style-type: none"> • HSL is mainly involved in SP4: standards, regulations and societal implications. Has produced a preliminary report on review of regulations (summarising UK government reviews) and on the suitability of current standards for measuring and controlling exposure to nanoparticles, and controlling fire and explosion risks. Report will be updated as more information becomes available. • HSL contributed to the drafting of the sampling strategy in SP1 and will visit one industrial workplace as part of SP3 Will use NANOSH/University kit. • Review of existing Life Cycle Analysis programmes carried out and found to be in need of modification. Work started on modification of programmes with intention of using incorporation of carbon nanotubes into tyres as a practical case. (Consortium has CNT manufacturer but work needs cooperation from tyre company)
<p>Investigation of the fire and explosion properties of nanopowders (R03.038/9926) This project aims to understand the fire and explosion hazards of selected nano powders. Areas for investigation comprise: explosion properties; ignition properties; accumulation of electrostatic charge; fire properties; ease with which selected powders can be made to form a cloud; and the suitability of standard test methods.</p> <p>The work identified is divided into the work packages that deal with the potential key issues relating to the fire and explosion hazards, in terms of their basic properties as dispersed clouds, layers and when stored in bulk. At this time, the work is focused on the handling of such materials on a small production or laboratory scale.</p> <p>The project will result in guidance on handling the potential explosion and fire hazard properties of</p>	<ul style="list-style-type: none"> • Funding has been agreed. Literature search is complete and a report is completed. New small scale test rig is nearly completed.

HSE/HSL Research Projects

Table 1 - Research

Description	Progress
nanoparticles, and an article(s) suitable for a scientific peer reviewed journal describing the work completed.	
<p>Investment Research Programme – Nanochallenge Objectives of this programme include</p> <p>1. The exposure assessment and control project includes:</p> <p>i) ‘The development of the HSL aerosol generation and measurement capabilities’. This aims to enhance capabilities for evaluating the performance of instruments used for assessing exposure to nanoparticles and for the performance testing of PPE and RPE, containment systems and other methods of exposure control.</p> <p>ii) The development of improved methods of collection and characterisation of airborne nanoparticles.</p>	<p>Close links between this project and NOSH, NANOSH and NANOSAFE 2.</p> <ul style="list-style-type: none"> • Particle generation techniques for instrument evaluation The efficiency of different sampling methods is being assessed using a scanning mobility particle sizer and electron microscopy by generating nanoparticles of known concentration and size. NaCl particles with a mean diameter of about 100 nm have been generated in a test chamber. • Particle generation techniques for PPE testing The generation of airborne salt nanoparticles in a chamber is being investigated. The inward and outward concentrations of a dummy head undergoing mechanical breathing are being monitored using real-time instruments (e.g. scanning mobility particle sizer (SMPS)). A number of difficulties have to be overcome for a testing method based on salt to be validated, which includes the low concentration level of airborne salt in the chamber and the slow response from instruments like a SMPS. • Evaluation / Improvement of TEM image measurement and analysis (in progress). Image pro analysis software is being investigated for carrying out automatic and manual measurements on TEM images of nanoparticles. • Improvements of samplers for nanoparticles collection (in progress). A Sampling strategy for the characterisation of airborne nanoparticles by Scanning Electron microscopy (SEM) or Transmission Electron microscopy (TEM) has been drafted. An innovative filter assembly has been developed.

HSE/HSL Research Projects

Table 1 - Research

Description	Progress
<p>iii) The applicability of biological monitoring.</p> <p>iv) The investigation of whether the current method of dustiness testing is suitable for nanomaterials and if not to propose and investigate alternative options for particle dispersal and measurement.</p>	<ul style="list-style-type: none"> • A literature review of biological monitoring for nanoparticles has been undertaken and is currently being written up. An evaluation of the new biological matrix, the exhaled breath condensate, which may offer the possibility of monitoring both chemical and particle exposure, will be starting. Work is currently underway learning the technique and conducting preliminary analyses. • The work to date has been on investigating whether the kit currently used to assess dustiness is suitable for nanoparticles. Several nanopowders (e.g. carbon black; newly purchased and old TiO₂; CeO₂) have been tested in the conventional dustiness equipment. The biological fractions were collected onto metal foams and a filter for gravimetric analysis. A P-track probe was introduced in the drum to measure the number of particles generated with time. The powders exhibited different dustiness behaviour from very low to measurable levels. Experiments on a new range of nanopowders (including cerium oxide, aluminium oxide, and carbon nanofibres) have been carried out with NIOSH (USA). NIOSH has been using a compressed air dustiness tester. Very interesting results were obtained showing behaviour differences between very 'fluffy' low-density powders and more compact materials as well as between dustiness testers. A way forward was agreed including the measurements of (i) size distribution using a scanning mobility particle sizer (SMPS) and (ii) mass using gravimetric analysis. • Progress was presented in August 2007 at 3rd International Symposium on OH implications of nanomaterials in Taiwan. • Recent work has seen modification of the standard drum by inserting a stainless steel sampling tube through the entry filter on the axis of the drum and samples taken at the end of the drum assessed in a Scanning Mobility Particle Sizer (SMPS). Tests have been carried out using titanium dioxide and cerium oxide.

HSE/HSL Research Projects

Table 1 - Research

Description	Progress
<p>2. Fire and Explosion The development of testing kit for explosive properties of nanoparticles</p>	<ul style="list-style-type: none"> • Explosion severity An explosion test vessel has been manufactured and is being installed within a fume cupboard. This will be used to measure the rate of pressure rise and the maximum explosion pressure. The design is based on the 20 litre sphere but has internal volume of 2 litres. The vessel has been designed as a pressure vessel and has been pressure tested and certified. The equipment that forms the dedicated data logging and control system has been purchased and is being assembled. The control software is being prepared. The software will be of similar appearance to the software used with the 20 litre sphere apparatus, to ease transition for operators familiar with the existing system. The fume cupboard has been fitted with a HEPA filter and now requires the airflow to be rebalanced or upgraded. Filters have been installed to the fume cupboard sink and the glove box will be modified to enable the enclosure to be inerted with argon gas. • Ignition energy The measurement of the minimum ignition energy (MIE) of the dust cloud of standard dusts is done using the Kuhner MIKE3 apparatus. The dispersion ring components that will enable non-oxidised nanopowders to be dispersed as dust clouds are being modified. A chamber has been manufactured that allows the material to be loaded and sealed in a glove box and then transferred to the MIE apparatus. • Qinetiq have donated a large mass of old nano aluminium that will be used to compare results from the standard and new kit. A full risk assessment is being completed.
<p>3. In vitro Toxicology Assays The project aims to develop a human blood based assay. The endpoints being covered include immunotoxicity, blood coagulation, oxidative stress and cell death.</p>	<ul style="list-style-type: none"> • A two-stage assay for testing the toxicity of manufactured nanoparticles has been developed and optimised, building on the work of the first year of the project with the human blood assay. In the first stage, the toxicity of nanoparticles is evaluated in a range-finding assay using human skin and respiratory epithelial cells, which mimic

HSE/HSL Research Projects

Table 1 - Research

Description	Progress
	<p>critical portal-of-entry tissues for nanoparticles. This preliminary screen tests a wide range of doses with the aim of informing the choice of doses to be tested in the second stage, the human blood assay; it also allows familiarisation with handling the nanoparticles. A single endpoint is used in this first stage (cell death), and initial data have been generated with two nanoparticles: rutile and anatase forms of titanium dioxide. Data have shown that the Hoechst/PI assay for cell death is considerably more sensitive than the LDH assay. These TiO₂ nanoparticles are now being tested in the human blood assay. The endpoints for this assay have been optimised and consist of: blood coagulation, myeloperoxidase (MPO, an indicator of cell activation and stress), inflammation (through release of cytokines) and cell death.</p> <p>Further forms of titanium dioxide (e.g. with and without coatings) are being purchased for testing, and further nanoparticles will be obtained through collaboration with interested companies.</p>

HSE/HSL Research Projects

Table 1 - Research

Literature Review into the explosion hazards associated with nanoparticles	HSL project completed May 2004. Published at http://www.hse.gov.uk/research/hsl_pdf/2004/hsl04-12.pdf
Explosion properties of nanometric aluminium and nickel powder	Project completed. Results used to inform further investigation. http://www.hseresearchprojects.com/ProjectSearch.aspx?id=1736
Review of the occupational hygiene implications of the manufacture and use of nanoparticles.	IoM project completed September 2004. Published at http://www.hse.gov.uk/research/rrhtm/rr274.htm
Health effects of particles produced for nanotechnologies	HSE toxicology review completed 2004. Published at http://www.hse.gov.uk/horizons/nanotech/healtheffects.pdf
Review of the adequacy of current regulatory regimes to secure effective regulation of nanoparticles created by nanotechnology	HSE review. Published at http://www.hse.gov.uk/horizons/nanotech/regulatoryreview.pdf
Report on possible <i>in vitro</i> approaches to nanotoxicology	HSL project. Published as part of the NRCG Research Report at http://www.defra.gov.uk/environment/nanotech/research/reports/progress-report061019.pdf
Nanoparticle Occupational Safety & Health (NOSH) Consortium	A multi-partner international project. Completed 2007. Outline summary, including details of papers, published at http://www.hse.gov.uk/horizons/nanotech.htm

HSE/HSL Research Projects

Table 2 – Research Proposals

Description	Progress
<p>Effectiveness of current control measures It is proposed that the project will include; a review of control measures currently used for the production, handling and end use of nanoparticles. The most common control systems will be identified and have their performance assessed. This will focus on capture or containment of nanoparticles (using systems such as LEV, fume cupboards, laminar flow booths, glove boxes, etc) and include all parts of the system including leakage through seals and filters.</p>	<p>This would build on results obtained in the Nanosh project. Decision on HSE support for 08-09 due early 2008.</p>
<p>Control banding project HSE would like to form an international group to develop a Control Banding approach to exposure control.</p>	<p>Control Banding is being pursued through the OECD. It is proposed to set up an Expert Network as part of the work of OECD Nanomaterials Working Party 6 – Co-operation on Risk Assessment Approaches, to evaluate the usefulness of the Control Banding concept for controlling the risks of nanomaterial exposure in the workplace.</p>
<p>EU FP 7 bid - NMP-2007-1.3-5 HSL proposed continuation of the HSE NanoAlert bulletin, and involvement in NMP-2007-1.3-5: “Coordination in studying the environmental, safety and health impact of engineered nanoparticles and nanotechnology-based materials and products</p>	<p>HSE funding agreed in principle - EU decision awaited</p>

HSE/HSL Research Projects

Description	Progress
<p>EU-FP7 proposal Nanodevice The aims of the project that HSL would contribute to are:</p> <ul style="list-style-type: none"> i) To determine the important physical, chemical and toxicological characteristics of nanoparticles to determine the generic relationships (if any) between measurement matrices and health effects. ii) To develop and explore relevant workplace scenarios in which the resultant instruments would have to be used. iii) Communication and use of results 	<p>HSE funding agreed in principle - EU decision awaited</p>
<p>*To investigate the ability of nanoparticles to penetrate human skin Outline proposal – The ability of nanoparticles to penetrate through intact human skin is debated. We propose to establish the OECD test guideline method (no. 428) for “Skin absorption: <i>in vitro</i> method” at HSL and use it to resolve whether occupationally relevant nanoparticles can penetrate through human skin. Nanoparticles currently in-house and donated by industry will be used for validation of the approach.</p>	<p>Project proposed as part of the NanoTeam funding bid 08-09. Decision on HSE support due early 2008.</p>
<p>*To obtain basic toxicity data on the nanoparticles in human skin and blood. Alongside the skin penetration assay, the basic toxicity of the nanoparticles will be evaluated in the human blood assay (currently being optimised as part of the HSL project NanoChallenge) and in primary human skin cells.</p>	<p>Project proposed as part of the NanoTeam funding bid 08-09. Decision on HSE support due early 2008.</p>
<p>*To start a dialogue with DoH (and OGDs) using the cross-government network in which the NanoTeam participate We intend to approach OGDs including DH (HPA) and DEFRA with the hope that joint projects can be developed and pursued to move our understanding of the human health effects of nanoparticles forward.</p>	<p>Project proposed as part of the NanoTeam funding bid 08-09. Decision on HSE support due early 2008.</p>

HSE/HSL Research Projects

Description	Progress
<p>*NANOSAFE2 (Measurements in workplaces) additional funds from EU project due to partner withdrawal NANOSAFE2 is an existing EU FP6 project HSE/HSL participates in. There is the possibility of additional matched funding from the EU to be used by HSL to take measurements in industry. This would build on existing data gathering at UK Universities.</p>	<p>Project proposed as part of the NanoTeam funding bid 08-09. Decision on HSE support due early 2008.</p>
<p>*Investigation of the use of enclosures to estimate exposure to engineered nanoparticles in universities and industrial workplaces HSL to develop a measurement technique that encloses the process/instrument in order to avoid background natural nanoparticle contamination.</p>	<p>Project proposed as part of the NanoTeam funding bid 08-09. Decision on HSE support due early 2008.</p>
<p>*Assessment of emissions of particles from printers and photocopiers Initially a review of work in this area will be carried out to obtain the most up-to-date information. We will make use of a large clean air test cabin to determine the emission rates of particles from a range of printers and photocopiers.</p>	<p>Project proposed as part of the NanoTeam funding bid 08-09. Decision on HSE support due early 2008.</p>