ANSI-Nanotechnology Standards Panel
Break-out Group Report

1. Name of Break-out Group: Morphological, Geometrical, and General Terminology

2. Date of Report: September 29, 2004

3. Scope of Break-Out Group: The general language to define nanostructured materials will be discussed here. Whether it is practical to define the term 'nano' in any formal way, as well as general terms to describe the composition, quality and form of nanostructured materials will be discussed.

4. Facilitator: Donald E. Marlowe

5. Scribe: Dr. John Small

6. Break-out Group Participants: Append a list of participants in the discussions.

These issues and questions are posed specific to the scope of this break-out group.

I. Brainstorming session related to nomenclature standardization

1. What are the most critical nomenclature issues that require discussion and resolution?

1. **Characterization metrology/measurement test methods**
2. **Risk management/ Assessment/Communication**
3. **Description of characterization properties**
4. **Toxicity Effects/Environmental Impact**
5. **Applications**

(See attachment A for a detailed list under)

- **Exposure**
- **Application**
  - Characteristics and Metrology/Measurements
- **Personal Protection Requirements**

- **Bioresistance**
- **Origin/Source**
- **Industrial Handling Guidelines**
- **Characteristics – description of properties**
  - Chemical
  - Physical
  - Biological
  - Structural
  - Matrials Forms
- **Environmental Impact**
- **Toxicity Effects**
- **Functionality**
- **Matrix**
- **Interrelationships**
  - Risk Assessment Procedure (includes risk communication)
- **Development Stage**
- **Process of Manufacturing**
  - Tools for processing
- **Interrelationships**
  - Interaction with other materials
- **Risk Communication…Risk Assessment**
  - Risk Management

II. Discussion of implementation questions

1. What standards work is underway; who is involved and is any group or individual considered the "leader"?

1. **European Nano Forum, Nanoforum.org**
2. **IUPAC and ACS: characteristics**
3. **NSF**
4. **IEEE**
5. **ASTM**
6. **AVS**
7. **ACS**
8. **European Community Health and Protection**
9. **Vocabulary on scanning probe microscopy – ISO TC 201**
10. **UK: PAS - developing standard for nanoparticulars – vocabulary for nanoparticulates**
11. **NIST special publications – covers nano, micro and macro: 960-1 – particle size characterization, 960-3 – dispersions and …,**
12. **Source for vocabularies:**
    - **www.phatomsnet.com**
    - **nano.org.uk**

2. Are any stakeholders missing from this group?

1. **Biologists**
2. **Labor organizations**
3. **NGOs – environmental organizations**

3. Are there any cross-cutting issues with other break-out groups? If so, please identify.

1. **Do we need a more complete classification system first**
   a. **Hierarchical**
   b. **Can we afford to limit our initial discussion to less than 100 nm particles**
2. **What can we do to focus on making it a success?**
3. **Do we really need a NT specific terminology**
4. **International use/development**

4. What are the possible impediments to the generation and acceptance of a universal nomenclature?

1. **Getting international acceptance of what we do**
2. **Better definition of success: single standard; developed in x years**
3. **Is any SDO broad enough to do this**

5. Provide recommendations on appropriate venues in which to address the needs identified and any individuals or organizations who should be contacted to serve as project leaders.

III. Brainstorming broader issues of nanotechnology standardization needs

1. Are there other areas in nanotechnology that would benefit from standardization? Top items are underlined.

1. **<u>Standard test methods</u>**
   a. **<u>Characterization methods</u>**
2. **Calibration methods**
   a. **Certified Reference Material (CRMs) – vs. SRM, which is a CRM sold by NIST**
3. **<u>Public perception/issues (look into: NAS Futures Initiative – Celia was there)</u>**
4. **Accreditation of third-party testing/inspection**
5. **Need an SDO for Risk Management Standards: vis a vis ISO 1497**

6. **<u>Better Evaluation tools for cellular damage, toxicity as a function of exposure</u>**
7. **<u>Tox Testing Methods</u>**
8. **Process Standards for Manufacturing**
9. **Exposure Control for workers**
10. **Standards Linkage Between Sectors – Vertical Linkage**
11. **Waste Management**
12. **Legal Liability/Risk**
13. **Regulations in General, e.g., labeling of products**
14. **Patent issues**

2. Are there stakeholders in these areas that should be involved in future discussions? Please identify.

IV. General Comments
1. Comments/observations/suggestions
2. Thoughts on next steps
3. Is there a need for a future meeting of this break-out group?

Attachment A: Critical Issues

1. **Characterization metrology/measurements**
2. **Risk management/ Assessment/Communication**
3. **Description of properties**
4. **Toxicity Effects/Environmental Impact**
5. **Applications**

(1) Characterization metrology/measurement

1. statistical significance
2. measurement uncertainty / variablility
3. metrology
4. tools/instruments
5. scale/scaling effects
6. techniques
7. measuring environment/measuring tools
8. tools for characterization eg spms
9. standards and CRM's for calibration
10. shape
11. Aspect Ratio
12. Metrology how do you measure shape
13. Size
14. Particle size characterization
15. Aggregation
16. Agglomeration
17. Zeta potential
18. Hydroxylation
19. Realistic particle size standards
20. Surface area
21. Surface energy
22. Dispersivity
23. Airborne concentration
24. Number concentration
25. Mass concentration
26. Surface area concentration
27. Light scattering or absorbance
28. Size-selected attributes of all of the above properties

(2) Risk Management, Assessment and Communication

1. Environmental
2. Exposure
3. Workforce
4. Use balanced risk/benefit approach
5. Relationship to environmental impact assessment
6. Hazard identification

7. Exposure assessment
8. Dose-response assessment
9. Risk characterization
10. Containment Procedures
11. Persistence (life time)
12. Threshold levels
13. Health
14. Perception vs scientific evidence
15. Nanotechnology the term
16. Range of the Domain for Nanotech
17. Free species vs trapped or immobilized (composite)
18. Toxicology
19. End of life issues
20. Distributive considerations (how risk is distributed through the affected population)
21. Stage of Development (research, precommercial, commercial)
22. Control technology
23. Benefit vs Risk
24. Lay vs expert characterizations
25. Communication to regulators
26. Public sector communication

(3) Description of Properties

1. Naturally occurring versus engineered.
2. For complex species, need to distinguish different “polymorphs”, e.g., CNTs.
3. Size
4. Physical: size, shape, surface characteristics, morphology
5. Porosity: open, closed, size
6. Magnetic
7. Bioactivity
8. Surface area
9. How do you convey a description of a structure: analytically (space group, atomic positional parameters), by name?
10. Adventitious versus engineered.
11. Solid, liquid, gas
12. Free-flowing or confined
13. Surface functionality
14. Discrete nanoforms (particles, tubes, rods) versus nanostructured bulk materials (nanostructured or patterned surfaces, nanoporous materials, nano organized macrosystems)
15. Crystalline – amorphous
16. Solubility
17. Differentiate body structure from surface structure
18. Statistical distribution
19. Electrical and electronic
20. Composites

21. Get consensus on most important properties
22. Need to include: shape, features (physical) and relevant "functional" behaviors (conductivity, optical, magnetic)
23. Surface structures/functionalities
24. Aspect ratio
25. Inorganic, organic, hybrid
26. Behavior over time?
27. Optical
28. Thermal
29. Chemical Characteristics – Stability in ambient; Physical characteristics – optical electronics magnetic, etc; Biological characteristics – reactivity towards biochemicals; Structural characteristics – morphological polymorphism
30. Characteristics – define shape by words, analytically
31. Characteristics chemical: activity, composition, reactivity
32. Characteristics: Differentiating name chemicals with different sizes; same chemical – different forms nanotubes of different durability
33. Differentiating same form of different chemical sic nanotube from cost
34. Consistency issue
35. Biointerface
36. Standards
37. Functionalized structures from basic structures
38. Nano engineering devices
39. Structure or hierarchical scales
40. Physico – chemical characterization: size and distribution; shape; composition; crystallinity; surface: coating, charge, porosity (fractal dimension); solubility: acid, H20, base; aggregation: what medium: air, water, de-aggregation

(10) Environmental Impact

1. Benefits
2. Standards
3. Energy; Energy Conservation
4. Land
5. Air; Air Quality (Clean Air Act)
6. Water; Water quality
7. Pollution prevention
8. Disposal/Life cycle issues (production, use, release, medium, persistence)
9. Total impact: manufacture; use; end of life
10. Solid/hazardous waste (CERCLA/RCKA)
11. Risk Management: Risk Identification (Health, Bio, Environmental – Toxicity, Bio accumulation), Risk Assessment, Risk Communication (Investor, Business, Legal)
12. Waste streams (Clean water act)
13. Degredation mechanisms decontamination
14. Long term soil health
15. Disposal, Fate, Exposure
16. Relationship to risk management process

17. Toxicity Monitoring
18. Model/Route of exposure: inhalation; dermal; ingestion
19. Measures of exposure, e.g., mass surface area, number of particles
20. Distributive considerations: discussion of risk across populations
21. Use balanced risk/benefit approach
22. Waste minimization
23. Green chemistry

Toxicity Effects – Item 11

1. Bioavailability
2. Levels: ppb, grams
3. By-products
4. Safe worker exposure - TLV
5. Reproductive/developmental; oral; inhalation; dermal
6. Toxicity: acute vs. chronic; in vivo vs. in vitro; does response relationship – what are the relevant doses – human vs. animal vs. environmental; susceptibility issue: children, diseased, old/mature or exposure medium/route: inhalation, external, ingestion
7. Toxic effects: Long term toxicity; short term toxicity; pathogenicity; bio-interaction
8. Health issues (what are workers inhaling?)
9. Decomposition products
10. What happens when they break down?
11. Determine if/where existing toxicology tests are inadequate
12. Degree of particle aggregation
13. Size effects
14. Bioaccumulation
15. Reactivity towards biochemicals (DNA, proteins)
16. Exposure forms – breathing, ingesting
17. Particle size
18. Process safety
19. Routes of exposure
20. Mode/route of exposure: inhalation, ingestion, dermal
21. Mixed exposure: inhalation/dermal/ingestion; multiple chemicals/materials; combinations with other stressors, such as exercise, diet, high temperature; high altitude

Applications – Item 13

1. Efficacy or performance, i.e., Does it work? How can you tell/assess?
2. Agriculture and food
3. Hierarchical assembly
4. Degradation of host or matrix resulting in the release of nanoparticles (in a nanocomposite material)
5. Free versus bound nano particles
6. Interaction/interactive with other products: free-standing, devices

7. Medical therapeutic
8. Water purification
9. Education and Training: K-12 through grey
10. Drug delivery
11. Sensors
12. Scaling Effects
13. Applications: Medical, Therapeutic, drug delivery (cancer, etc.), diagnostic