Evaluation of data and recommendation on measurement technique and sampling protocol for determining concentrations of engineered and incidental nanoparticles

Date: 22 March 2012, ICOH2012

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Aim

- To generate and evaluate relevant data to establish appropriate assessment and control methods and identify and prioritize exposure levels;
- To suggest control measures in line with observed exposures scenarios;
- To develop a simple risk assessment tool/checklist to assist managers in the process of health hazard identification and risk prioritization

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Establish appropriate assessment and control methods

- **Introduction**
  - **Describes**
    - **Participants (& invitation to interested parties)**
    - **Material Selected For Studies**
    - **Approaches & measurement Methods for exposure assessment in work environment.**
    - **Planned research.**

Participants

- **Main project participants**
  - **Mintek, a South African State Owned Enterprise (SoE) synthesizes gold nano-particles**
  - **Eskom, a South African SoE mainly operate coal-powered power stations**
  - **CSIR, a South African SoE synthesizes various nano-particles**
  - **NIOH, a South African SoE conducting exposure assessment.**
- **Interested contributors are welcome to contact**

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Material Selection

- To start with, the synthesis process of gold nano-particles is studied first

Material Selection: Au NPs

Test Material	Mean Core Dia.	Capping Agent	By whom	Catalytic activity	Production method
# 1	14 nm	Citrate	Mintek	CO oxidation	Chemical reduction
# 2	40 nm	Citrate	Mintek		

Au NPs: Major Commercial Uses

- Currently used for Lateral flow diagnostics and Catalysis; Expected to be also applied in Therapeutics (e.g., cancer) and Imaging

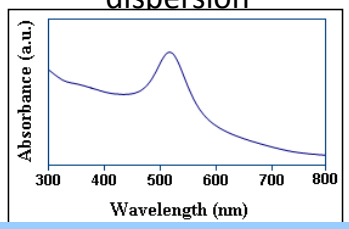
AU NPs' Physicochemical Properties Surface Chemistry

- Multilayer of citrate ions.

Physicochemical properties agglomeration/aggregation/dispersion

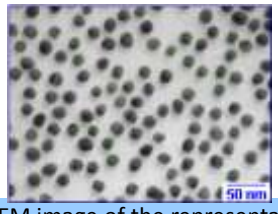
- UV/Vis
- TEM

agglomeration/aggregation/ dispersion



UV/Vis. spectrum of the 14 nm gold nanoparticles. The typical absorption peak of the 14 nm should be between 520- 524 nm.

14 nm Au TEM image



- The TEM image of the representative 14nm gold nanoparticles is given

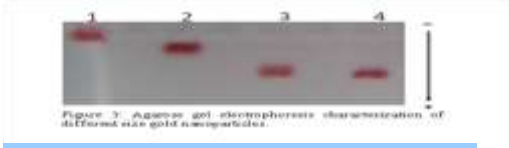
AU NPs' behaviour in solutions

- The sharp UV/Vis. absorption spectrum and TEM image clearly indicate that the 14 nm gold nanoparticles do not aggregate in solution

Physicochemical Properties Surface Charge

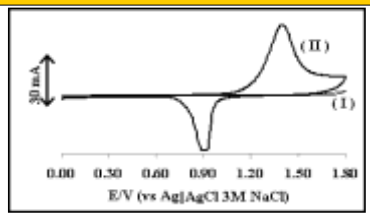
- LM 20 Zetasiser used.
- Measuring -34.8mV.
- This value is sufficient to keep the particles from interacting with each other and therefore maintain a stable particle size

Physicochemical Properties Surface Chemistry



- Gel Electrophoresis: separates Au nanoparticles based on size, shape and charge where particles migrate differently depending on molecular weight and charge.

Physicochemical Properties Redox Potential



- Cyclic voltametry was used.
- CV generally responds to a variety of factors such as pH, solvent, ligand and even if the nanoparticle is bare – it still resembles the bulk gold patterns

Physicochemical Properties Octanol/Water Partition Coefficient

- An average of Log P_{ow} = -2.0 at about 25 ° C using the UV-vis Spectroscopy

Occupational Human Exposure

– Source Emission/Ambient
- Inhalation.
- At point of synthesis.
- Area away from point of synthesis.

Exposure Characterisation in Research Lab

- Walk-Through Survey
  - For possible emission ID
  - Determine frequency & duration of each operation
  - Determine ventilation: General & local exhaust
  - Determine containment breaches in process points

Sampling Strategy

- Background readings.
- Source specific area sampling
- Source specific personal sampling

P-TRAK Ultrafine Particle Counter 8525

Met One HHPC - 6 Airborne Particle Counter

	Background Particle Counts - Met One HHPC - 6 Airborne Particle Counter	Background Particle Counts - TSK P TRAK, 8525
Synthesis Areas		
Location A: Fume Hood (1)	44017	14649
Location: B: Bench (2)	38329	12588
Location: C: Fume Hood (3)	36224	12861
Location D: Bench (4)	31702	11349
Non-synthesis Areas		
Location E: Fume Hood (5)	40212	11478
Location F: Bench (6)	34321	10435
Location G: Bench (7)	27163	9066
Location H: Freezer (8)	31323	9427
Location I: Between Benches (9)	23445	8031
Location J: Between Bench and Far wall (10)	26842	7813
Location K: In corner of Lab next to "Binder" Machine (11)	23303	7414
Location L: Next to Balances (12)	27061	7534
Location M: Electrophoresis Area (13)	27037	6644
Location N: Unused Fumehood (14)	27399	7431
Applications Areas		
Location O: Microwave (15)	31503	8247
Location P: Bio Imaging System Area (16)	29929	8342
Location Q: De-Ioniser Bench (17)	27595	7664
Location R: Entrance of Lab (18)	29998	5998
Location S: Electro Chemistry Room (19)	2575	537
Location T: Diagnostics Room (20)	2897	528
Location U: Tissue Culture Room (21)	3801	709
The inter-leading corridor		
Location V: Corridor Outside Lab (22)	32290	8209

- These two instruments give the counts of the particles without their characterization.

Collection of particles for characterization

Nano ID

- Selects a wide-range sampler: 2 nm up to 20 µm.
- Particles are collected simultaneously and separated into 12 size channels.
- It can give:
  - The size-resolved structure,
  - Mass resolved size distributions,
  - Morphology,
  - Chemical composition of captured particles.
  - Determines the concentration of the Engineered Nanoparticles against a background of naturally occurring aerosols and other anthropogenic aerosols produced from processes such as combustion.
  - For example, engineered nano-silver has been detected at levels of 2 ng/m3 against a background aerosol concentration of > 40 µg/m3

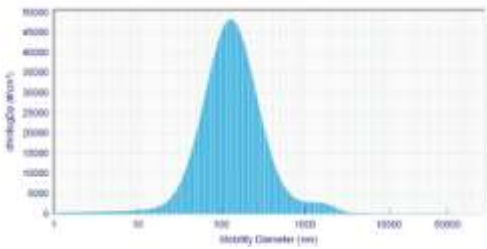
Physicochemical properties

- Aerodynamic diameter
- Particle number
- Size
- Surface area

Instrument used

- **TSI Scanning Mobility Particle Sizer** (SMPS), MODEL 3080, for particle number size distribution:
  - **Differential Mobility Analyzer** (DMA) coupled in series with a CDC
    - DMA, MODEL 3081= selects particle size interval of sampled aerosol
    - **Condensation Particle Counter** (CPC), MODEL 3772 = counts particles exiting the classifier
      - Particles neutralised @ DMA inlet with radioactive sources (Kr85, Am241) to reach charge equilibrium
      - Electric Field Scanning to different particle sizes selected for particle size distribution
- APS 3321 (**Aerodynamic Particle Sizer**)

The histogram shows a combined data from a TSI APS (Model 3321) and TSI SMPS (consisting of an Electrostatic Classifier, Model 3080 and Condensation Particle Counter, Model 3372)



Physicochemical properties (cont.)

- Chemical analysis
  - ICP-MS
- Size and agglomeration stage
  - TEM
- Surface properties/Ligands
  - FT-IR
  - NMR
- Surface activity
  - ESR

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- Thank you for your attention