Development of a Multi-Criteria Decision Analysis Tool to Support Selection of Nanomaterial Studies

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GOAL (*in light of increasing data*):

“…determining which information is most relevant to the nanoscale science and engineering community.”
Hazard assessment studies of nanomaterials are proliferating

- How can we efficiently identify **high quality** studies to meet our research needs?

Source: http://icon.rice.edu/report.cfm
Studies measure and report a range of parameters and characteristics.

Particle characteristics

Data quality/presentation

Study design

Images from NCL, 2007

What characteristics or criteria define a study as “high quality”?

Can we develop a tool that allows us to efficiently identify studies that meet these criteria?
Project Objective:
Develop a tool that uses Multi-Criteria Decision Analysis (MCDA) to identify studies that meet defined characteristics

- MCDA provides a framework to assist decision makers in choosing the best alternative from a range of alternatives amidst conflicting and competing criteria.

- Can identify:
  - Single most preferred option (study) or group of options (studies)
  - Rank options
  - Distinguish acceptable from unacceptable possibilities
What will the MCDA tool do?

- Identify the “best” study (or studies) based on study criteria identified as important by the “stakeholders” (researchers, policy makers, etc.)
- Integrated with the Nanomaterial-Biological Interaction (NBI) data repository
Project Status

1. **Initial phase**—
   - Seek stakeholder input
   - Develop test version of Tool
   - Establish feasibility of concept

2. **If proof-of-concept established, proceed with development**
   - Refine
   - Program beta version of tool
   - Integrate with databases
Initial Phase: Specific steps

1. Identify stakeholders and goals
2. Identify criteria that define a “quality” study
3. Build a decision framework
4. Rate studies based on criteria
5. Weight relative importance of criteria
6. Integrate results into test version
Identify stakeholders and goals

- Who will use the tool?
- How will they use the information?
- What are their decision criteria for defining a study as useful/not useful; high quality/low quality?
Identify criteria that define a “quality study”

- Physical/chemical properties
- Study design
- Environmental behavior
- Biological response
- Data quality/reliability

Study
Quality/ extent of characterization varies between studies

- Call to develop standardized characterization criteria for hazard identification of nanomaterials

<table>
<thead>
<tr>
<th>Material characterization</th>
<th>In vitro testing</th>
<th>In vivo testing</th>
<th>Environmental fate</th>
<th>Data quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle size/ Distribution</td>
<td>Protocol</td>
<td>Protocol</td>
<td>Persistence</td>
<td>Peer review</td>
</tr>
<tr>
<td>Shape</td>
<td>Cell line</td>
<td>Species</td>
<td>Mobility</td>
<td>Independence</td>
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<td>Composition</td>
<td>Culture medium</td>
<td>Age/ life stage</td>
<td>Bioavailability</td>
<td>Replicates</td>
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<td>Surface chemistry</td>
<td>Assay</td>
<td>Gender</td>
<td>Biomagnification</td>
<td>Positive controls</td>
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<tr>
<td>Surface charge</td>
<td>Concentration</td>
<td>Exposure route</td>
<td>Transformation</td>
<td>Negative controls</td>
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<td>Solubility/Dispersibility</td>
<td>Protein binding</td>
<td>Dose</td>
<td></td>
<td>Variability</td>
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<tr>
<td>Aggregate/Agglomerate</td>
<td>Time</td>
<td># of Subjects</td>
<td></td>
<td>Error</td>
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<tr>
<td>Surface area/Specific surface area</td>
<td>Endpoint</td>
<td>Target organ/endpoint</td>
<td>Data presentation</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Duration</td>
<td></td>
<td>Statistics</td>
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<td>NOAEL/LOAEL</td>
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<tr>
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<td>Pathology/ Chemistry</td>
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</tbody>
</table>

- Which criteria are *most important*?

Source: Oberdörster et al. 2005. Particle and Fibre Toxicology. 2:8; ISO TC229.
Establish relationships between decision criteria and alternatives

Goal

Select “quality” study

Criteria

Particle well-characterized

Relevant exposure

Data quality

Subcriteria

Size distribution

Composition/surface-coatings

Highly pure

Relevant species

Relevant exposure route

Repeated exposure

Standard protocol

Use of controls

Descriptive statistics

Alternatives

Study 1

Study 2

Study 3

Study 4
Weight the relative importance of criteria

Which do I consider more important…?

• Size distribution well characterized …or… better characterized surface chemistry?

• Standardized protocols…or…More replicates?

• Repeated dosing…or…Relevant exposure pathway?
### Weight the relative importance of criteria

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<tr>
<th>Criteria</th>
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<th>Subcriteria</th>
<th>Wt</th>
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<td>Particle well-characterized</td>
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<td>Size-distribution well-characterized</td>
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<td>Composition/surface-coatings well-characterized</td>
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<tr>
<td>Relevant exposure</td>
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<tr>
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<td>Use of controls</td>
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<tr>
<td></td>
<td></td>
<td>Descriptive statistics</td>
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</tbody>
</table>
Rate studies

• Mine databases of nanomaterial studies
Rate studies

Assessments may be factual or subjective

Images from mavimo.org; 3dchem.com; esd.orl.gov; thorax.bmj.com; ocregister.com; mattk.com; opticsplanet.com; Oberdorster et al., 2005; topnews.in
## Rate studies

<table>
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<tr>
<th>Subcriteria</th>
<th>Study 1</th>
<th>Study 2</th>
<th>Study 3</th>
<th>Study 4</th>
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1 = worst, 5 = best
## Integrate results

<table>
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Moving forward…

• Determine stakeholder priorities and define key criteria
• Integrate data and develop test version of Tool
• Establish Proof-of-Concept
  • Refine
  • Develop
Questions?

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