Measurement of dustiness of bulk materials that contain or release nano-objects or submicrometer particles and usage for mitigating exposure

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What is dustiness?

- Dustiness
  - Propensity of bulk material to release particles in response to mechanical stimulus

- Conventional dustiness methods
  - EN15051
  - Health related dustiness mass fraction (e.g. respirable, thoracic, inhalable) expressed in mg/kg
  - Rotating drum and Continuous drop - Accepted standards for micrometer-size particles

- New Measurands:
  - Can dustiness of powders containing nanoparticles be adequately characterised by their mass fraction only?
  - N/mg; m²/mg, size-distribution data?
Absence of a harmonized approach limits use of dustiness methods

Five European Standards developed by CEN/TC 137 WG3 committee members:

- Measurement of dustiness of bulk materials that contain or release nano-objects or submicrometer particles – Part 1 to 5: General guidance and requirements; Rotating drum method; Continuous drop method; Small rotating drum method; Vortex shaker method.

In support, pre-normative research conducted by CIOP-PIB (Poland), HSL (UK), IGF (Germany), INRS (France), NRCWE (Denmark), TNO (Netherlands) and under the lead of INRS to:

- Develop and test a harmonized approach for measuring dustiness for bulk materials
- Assess the repeatability and reproducibility for a given test method
CEN mandate work - Pre-normative research

Rotating drum (RD)  Continuous drop (CD)  Small rotating drum (SRD)  Vortex shaker (VS)
Respirable, thoracic and inhalable dustiness mass fraction (mg/kg): Separate testing (EN 15051-1 and EN 15051-2)

Number-based dustiness index of respirable particles in particle size range from ~ 10 nm to ~ 1 μm (1/mg)

Number-based average emission rate of respirable particles in particle size range from ~ 10 nm to ~ 1 μm (1/mg·s)

Number-based particle size distribution as $dN/d\log d_i$

Morphological and chemical characterization of the particles including NOAA
Dustiness mass fraction (mg/kg) (EN15051-2) and Number based dustiness index (N/mg)

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Primary size (nm)</th>
<th>SSA (m²/mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TiO₂ (1)</td>
<td>~5-10</td>
<td>350</td>
</tr>
<tr>
<td>TiO₂ (2)</td>
<td>~15-25</td>
<td>90</td>
</tr>
<tr>
<td>TiO₂ (3)</td>
<td>21</td>
<td>50</td>
</tr>
<tr>
<td>CaCO₃ - Surface modified for printing ink (1)</td>
<td>15-40</td>
<td>&gt;40</td>
</tr>
<tr>
<td>CaCO₃ (2)</td>
<td>15-40</td>
<td>Not specified</td>
</tr>
<tr>
<td>SiO₂</td>
<td>31</td>
<td>~300</td>
</tr>
<tr>
<td>BaSO₄ (1)</td>
<td>~37</td>
<td>40</td>
</tr>
<tr>
<td>BaSO₄ (2)</td>
<td>~37</td>
<td>40</td>
</tr>
<tr>
<td>TiO₂ (4)</td>
<td>~200</td>
<td>9</td>
</tr>
</tbody>
</table>
CEN mandate work – Pre-normative research

- Comparaison of number-based dustiness indices for a dustiness method X in relation to rotating drum:
  - Methods are not correlated.
  - VS provides significantly greater number of dustiness indices than other methods.
  - VS method uses more energy (vibration).

- ELPI / ELPI+ particle size distribution:
  - In general, monomodal distribution observed.
  - In some cases, bimodal distributions observed.
  - Highest aerodynamic equivalent diameter mode between ~ 1 μm and ~ 2.5 μm.
  - Four methods produce aerosols of similar particle size.
Dustiness and risk assessment

- Important determinant for worker exposure
- Used to rank bulk materials / powders
- Requested input parameter in control banding tools to evaluate and control the risk of exposure to nanomaterials in powder form
- Data have been recommended for nanomaterials exposure assessment by the OECD
- Starts to be of use in risk assessments
Conclusion

- Harmonised dustiness test methods - Important step for dustiness to be used in risk assessment
- New measurands proposed
- Rotating drum: good repeatability and reproducibility for new measurands (e.g. number based dustiness index, particle size distribution)
- Dustiness mass fraction (respirable, thoracic and inhalable) relevant for nanomaterials
- Five parts standards to be published in 2019 (CEN TC 137 WG3)
Thank you for listening

Questions?

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