SCIENTIFIC **SERVICES**

SAFENANO

EUROPE'S CENTRE OF EXCELLENCE ON **NANOTECHNOLOGY HAZARD AND RISK**

Lithium-Ion Batteries and Carbon Nanotubes

Helping Business with Risk, Regulation and Responsibility

Background

SAFENANO has contributed to a lifecycle analysis study of CNT-containing lithium-ion batteries, to identify critical stages where there may be potential for the release of CNTs, and to give a qualitative assessment on the subsequent exposure inhalation risk posed.

The lifecycle study has identified the following groups that could be at risk exposure inhalation to CNTs :

- production personnel involved with ***powder handling*** and ***processing*** of CNTs, including ***maintenance*** and ***cleaning***.
- personnel working at ***recycling*** facilities.
- personnel working at ***waste disposal*** premises, or in the immediate vicinity.

Risk, Regulation & Responsibility

The use of carbon nanotubes (CNTs) in the manufacture of lithium-ion secondary batteries continues to grow as manufacturers seek to exploit their unique physical and chemical properties.

A clear barrier to growth is the significant risk presented to business from :

- uncertainty that remains regarding the potential ***toxicity*** of these innovative raw materials.
- uncertainty regarding current ***regulation*** on nanomaterials coupled with the problem that many CNTs are supplied with MSDS data corresponding to graphite.
- results from recent studies[1,2] which have indicated that some CNTs may manifest ***asbestos-like*** pathogenic effects through inhalation exposure.

Regulators in the United States[3] and Europe[4] continue to introduce further measures to regulate CNTs. Manufacturers and importers must therefore exercise appropriate duty of care measures and prepare for further regulatory compliance.

Who can help?

SAFENANO is a recognised **leader** in the **characterisation, exposure assessment** and **toxicology** of **particles.** We can help you identify, understand and address the potential risks from manufactured nanomaterials to your employees, your customers and the environment. Using a best practice approach SAFENANO can provide you with a basis for responsible stewardship to help meet your duty of care responsibilities.

1 – Poland, C et al. "Carbon nanotubes introduced into the abdominal cavity of mice show asbestos-like pathogenicity in a pilot study"; Nature Nanotechnol, vol, 3, no.7, pp. 423-428.
2 – Porter DW et al. "Mouse pulmonary dose- and time course-responses induced by exposure to multi-walled carbon nanotubes"; *Toxicology.* 2010 Mar 10;269(2-3):136-47.
3 – Unites States EPA - "Toxic Substances Control Act Inventory Status of Carbon Nanotubes"; FR Doc E8-26026.
4 – European Commission - Removal of exemption status of carbon and graphite from REACH Amended Annex IV and V.

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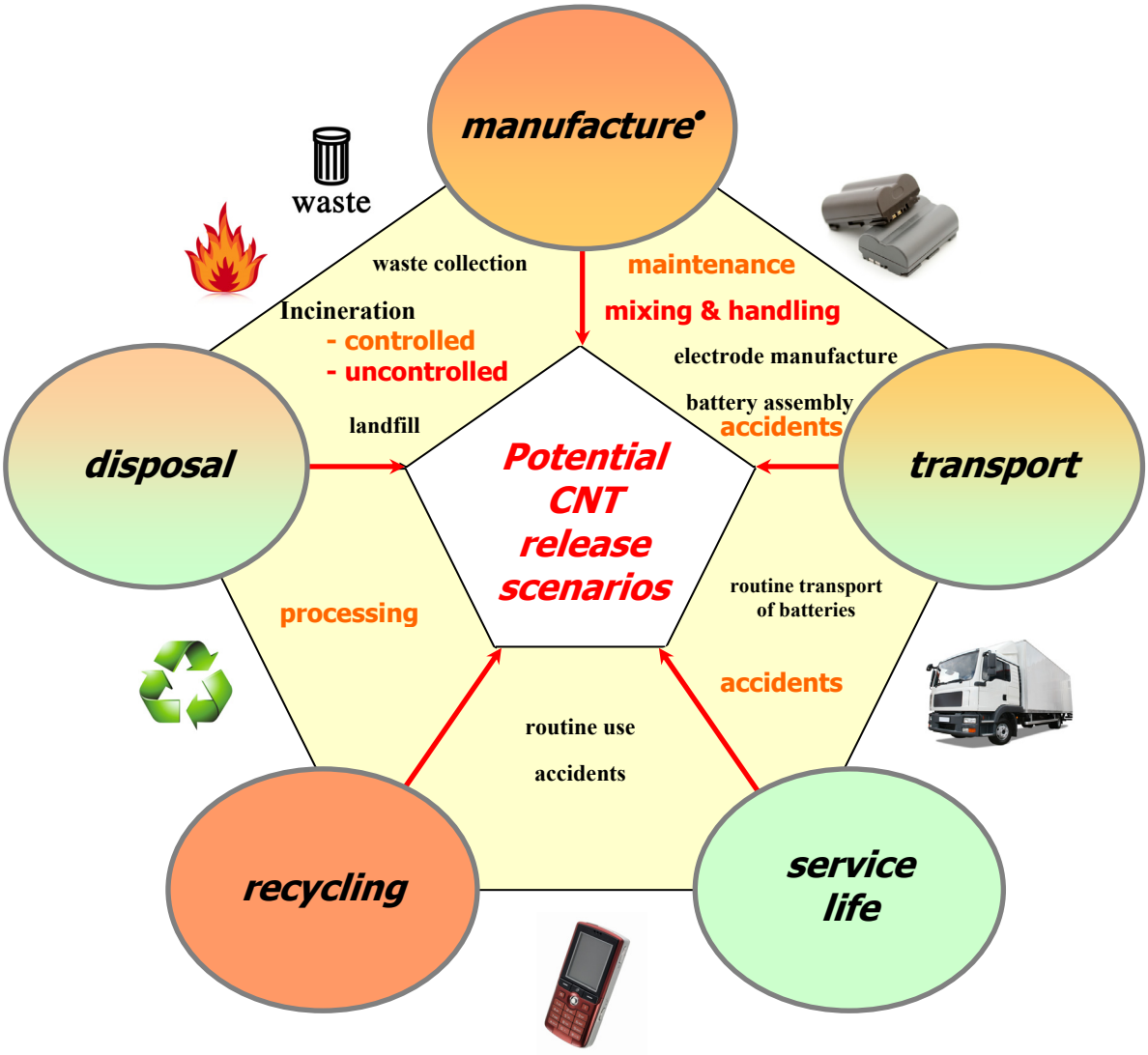
Lifecycle Analysis of Lithium-Ion Re-chargeable Batteries

The lifecycle analysis below provides information to help identify potential for inhalation exposure to carbon nanotubes used in lithium-ion batteries, allowing you to evaluate the potential risks to your business.



Analysis of the manufacturing stage assumes that the carbon nanotube material has been manufactured and supplied by a third party as a raw material i.e. the potential exposure inhalation risk resulting from the primary manufacture of carbon nanotubes has not been considered in the above LCA. However, detailed information on the commercial scale production of CNTs and associated release scenarios and exposure inhalation risks are documented in the full report.

The full report " ***NANOLIFECYCLE – A Lifecycle Assessment Study of the Route and Extent of Human Exposure via Inhalation for Commercially Available Products and Applications Containing Carbon Nanotubes*** " is available on the SAFENANO website, www.safenano.org

Lifecycle Analysis of CNT Containing Lithium-Ion Batteries

Lifecycle Stage	Potential Release Scenarios
Manufacture	**Electrode Manufacture** Potential inhalation exposure risk to CNTs exists during bulk handling activities involving CNTs (spraying, handling, mixing etc).
	Potential inhalation is possible under conditions where exposure to powder dust is conceivable.
	Disposal of any CNT containing waste generated or particulate emissions released during equipment maintenance may present an inhalation exposure risk
	Accidents Accidents involving CNT containing pre-cursors, prior to encapsulation, may generate particulate emissions of CNTs, CNT composites or their aggregates. This could lead to secondary sources of aerosolisable CNT containing material from dried spilled or residual material.
	Battery Assembly Assembly will include fixing the electrode into the casing. This is not anticipated to release free CNTs under normal conditions
	Welding of the battery casing is also not anticipated to release free CNTs under normal conditions
Transport	**Accidental Exposure to High Temperature and Substantial Mechanical Force** These are the principal factors to consider. Such situations may have the potential to release measurable CNTs when large quantities of batteries are involved.
	Routine transport Would not be anticipated to present an inhalation exposure risk
Service life	CNT release from the battery would either require the battery to be physically opened or subjected to high temperatures. Both scenarios are seen to be unlikely and therefore the risk is seen to be negligible.
Recycling	**Manual Processing** Dismantling, mechanical shredding, milling and sorting have the potential for release of CNTs into the workplace atmosphere and exposure to the workforce. Control measures in place in automated facilities may be sufficient to prevent exposure.
	Thermal Processing Pyrolysis or smelting, for example, may generate particulate emissions of CNTs, CNT composites or their aggregates. It has been reported that thermal processing of batteries does not eliminate CNTs. They are seen to transfer into granulate interstage products (e.g. cobalt fraction) where these are have been considered a major source of CNT emission as handling would take place outside of a controlled environment.
Disposal	**Uncontrolled Incineration** Uncontrolled incineration (e.g. uncontrolled fires) is unlikely to destry the CNT and may therefore present a risk of potential exposure.
	Controlled Incineration Incineration conditions (>850^{o}C) are likely to destroy CNT materials. However, some densely packed CNT inside the metallic casing may not be exposed to oxygen during incineration. Under reductive conditions, SWCNT may reform into MWCNT at around 2200^{o}C. Therefore cylindrical cells, which enter the slag, can still contain some CNTs.
	Landfill Batteries disposed of either through land filling or wrongly disposed are likely to corrode over time. It is unknown whether CNTs will migrate into soil / water environments. Inhalation exposure potential is considered to be low.

Potential Risk : - low - medium - high

Multidisciplinary expertise …

Our expertise covers occupational hygiene and health, laboratory services, toxicology, ecotoxicology, review of existing data or knowledge and training provision. We offer first class client care from start to finish, using an approach that ensures each customer has access to our multidisciplinary scientific team via a single point of contact.
As recognised leaders in the field, our authoritative reports are guaranteed to be independent, and can be trusted by you, your employees, insurers and investors

Our approach is professional, with an emphasis on delivering multidisciplinary solutions tailored to your needs

Our services span six interconnecting areas :

The **SAFENANO Team** …

In addition to its extensive in-house expertise through the IOM, **SAFENANO** has access to a multidisciplinary consortium of internationally recognised researchers through SnIRC – the Safety of Nanoparticles Interdisciplinary Research Centre. SNIRC was formed in 2004 to address nanoparticle risk issues, and is based on long-standing collaborations between the IOM, Edinburgh, Aberdeen and Edinburgh Napier Universities and the Central Science Laboratory (CSL).

The combined expertise of the IOM and SnIRC provides **SAFENANO** clients with a unique and extensive wealth of experience in particle toxicology, exposure, ecotoxicological and human studies/epidemiology.

Members of the **SAFENANO** team are actively involved in advising government agencies such as DEFRA and NIOSH on the potential risks of nanotechnology to health, and management of these risks.

SAFENANO has also been heavily involved in the writing of landmark reports and papers such as BSI PD 6699-2 " **Good practice guide to safe handling and disposal of nanoparticles** " the Nature paper " **Safe handling of Nanotechnology** " and the DEFRA report " **EMERGNANO** ".

Who to **Contact** …

To discuss how SAFENANO's comprehensive and responsive approach can provide the support you need to stay safe with nanotechnology, contact:

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