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Ecoefficiency indicators for development of nano-composites

Olsen, Stig Irving; Laurent, Alexis

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Ecoefficiency indicators for development of nano-composites

Stig Irving Olsen and Alexis Laurent

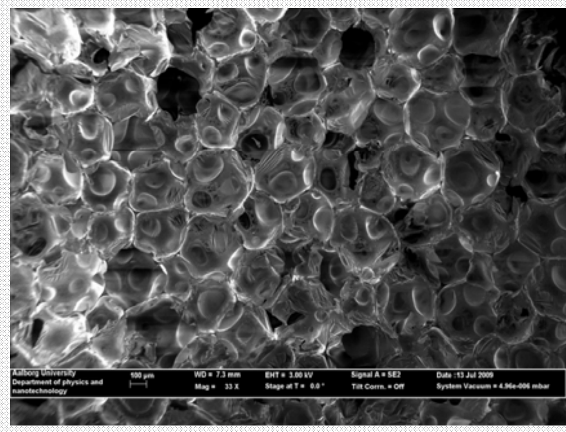
Department of Management Engineering, Technical University of Denmark (DTU), Lyngby, Denmark

Development of nano-composite foams, strong and light

⇒ **Replacement of structural material in wind turbine blades or boats**

- Matrix of polyurethane (PU) or polypropylene (PP) with carbon nanotubes (CNT) or nanoclays as fillers
- Different production pathways of CNT
- Different polymerisation and foaming processes

⇒ **Which environmental aspects are important to consider in the development of the nano-composites ?**



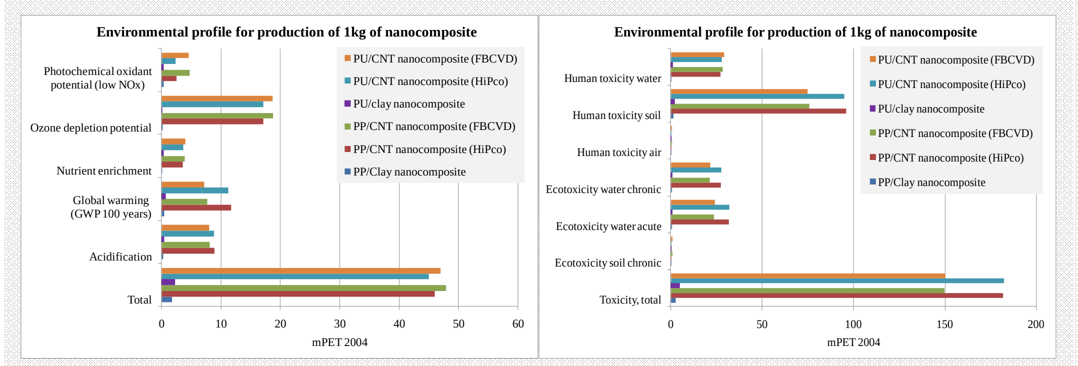
PU foam with 0.5% multiwall carbon nanotubes

Recommendations for technology development

OBJECTIVES AND METHODS

- Use of **LCA** to identify environmental "hot spots" in a life cycle based comparisons of different production pathways
- Only **cradle-to-gate** since use and disposal are still very uncertain
- Functional unit: **1 kg of nanocomposite with 5 wt% nanofiller**
- Systems: **PU/CNT** (in-situ polymerization), **PP/CNT** (in-situ polymerization), **PU/clay** (bulk polymerization), and **PP/clay** nanocomposites (bulk polymerization)
- Literature data sources
- LCIA follows EDIP methodology
- CNT produced either by Fluidized bed chemical vapour deposition (**FBCVD**) or High pressure carbon monoxide (**HiPco**)
- Nanoclays functionalized with quarternary ammonium salt obtained from tallow (by-product of agriculture)

RESULTS



Overall environmental impacts (non-toxic and toxic impacts) per functional unit

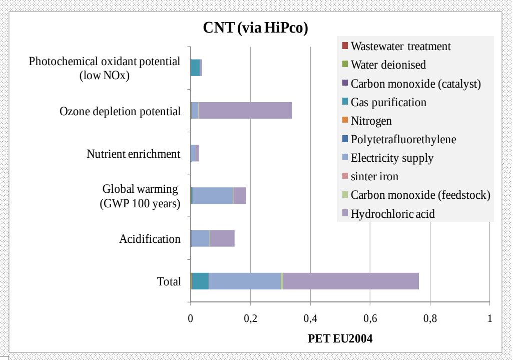
Main conclusions

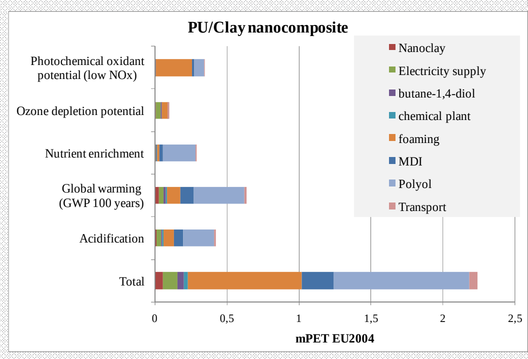
- **Environmental impacts {CNT composites} » Environmental impacts {nanoclay composites}**
- The contribution of **CNT nanofiller** in product is **85% and 96%** for non-toxic and toxic impacts, respectively. The same figures for **nanoclay** are **3% and 13%,** respectively
- Energy {HiPco} » Energy {FBCVD}

➔ **Higher GWP and toxic impacts for HiPco process**

Which processes cause the most environmental impacts?

- Production of <u>CNT by HiPco</u> process (opposite graph):
  ⇒ **Electricity consumption** and production of **hydrochloric acid** (for refining CNTs)
- Production of <u>CNT by FBCVD</u>
  ⇒ **hydrochloric acid** and **aluminium oxide** production





- Production of the <u>nanoclay composite in PU</u> (opposite graph):
  ⇒ **Polyol production** and the **foaming process**
  ⇒ **Production of nanoclay is of minor importance**

Uncertainties

- **Functionality of foam not considered**, eg. strength etc.
- Inventory uncertainties:
  ⇒ Database and literature **data may not be fully representative** of the specific processes to be developed
  ⇒ Inconsistencies in **data for CNT** (2 modes of production)
  ⇒ No knowledge on **emissions of nanoparticles** => Not assessed!

CONCLUSION AND PERSPECTIVES

- **Nanoclays perform significantly better than CNT from an environmental perspective**

➔ **Be cautious with the use of CNT**

- **PP foams are slightly better than PU foams**
- **Further work needed** to:
  - Refine the functionality of the foams (strength) to ensure consistent comparison
  - Identify actual processes and specify data
  - Include use and disposal
  - Work on exposure to nanoparticles during the whole life cycle

References: *Kushnir and Sandén (2007); See and Harris (2006); Healy et al. (2008); Roes et al. (2007); Verdejo et al. (2008); Yoo et al. (2006); Pattanayak et al. (2005); Koval'chuk et al. (2008); Joshi (2008); Musumeci et al. (2007)*

For further information, please contact Stig Irving Olsen (siol@man.dtu.dk)