



## Ecoefficiency indicators for development of nano-composites

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# Ecoefficiency indicators for development of nano-composites

Stig Irving Olsen and Alexis Laurent

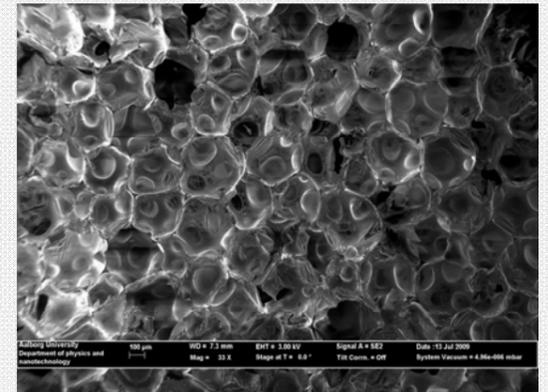
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## Development of nano-composite foams, strong and light

⇒ 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

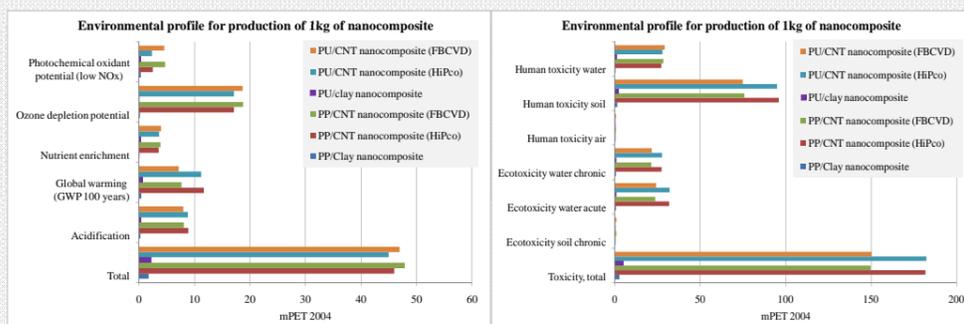


## Recommendations for technology development

### 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



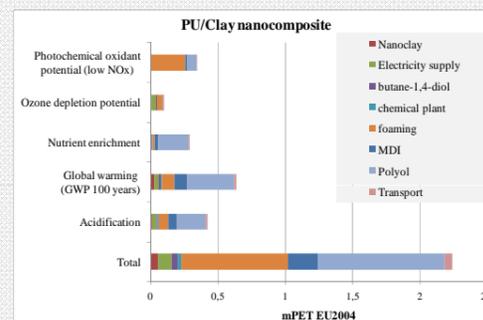
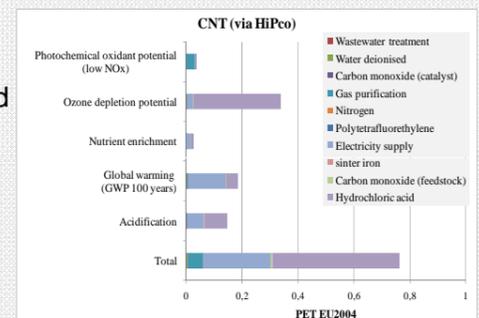
Overall environmental impacts (non-toxic and toxic impacts) per functional unit

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



- Production of the **nanoclay composite in PU** (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)