Cranfield Health

Assessment of nanoparticle release and associated health effect of polymer-silicon composites

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Introduction

Rapid growth in development and application of nanotechnology has led to concerns regarding environmental exposure of nanomaterials. Little information is available on possible release of nanomaterials and nanoparticles (NP) from conventional and novel products and associated health effect.

this study focused on assessing the possible release of NP during the application stage of conventional and nanoproducts. NP release was monitored during drilling of polymer-silicon composites, and the toxicity of both the released NP and the raw silica nanomaterials that were used as fillers in nanocomposites was assessed in vitro using human lung epithelial A549 cells.

Methods

Monitoring of NP release from polymer materials subjected to drilling: the components of the polymer composites are listed in table 1**.** The release of NP from polyamide 6 (PA6)- and polypropylene (PP)- composites was comparatively quantified using a scanning mobility particle sizer (SMPS).

NP characterization: the size distribution and dispersion of NP in culture medium were determined by dynamic light scattering.

Cytotoxicity of NP: The toxicity of the dust NP and the raw SiO2 NP was assessed in vitro by membrane integrity (LDH) and viability (MTT) assays. Silica NP of size 7 nm (Si 7) and H2O2 (200 µM) were used as positive controls. Cells without any treatment were used as negative control.

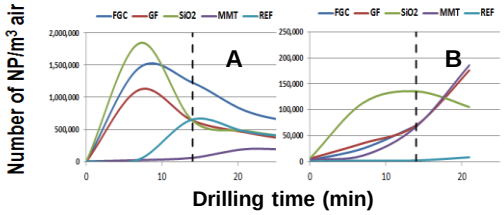
Results

PA6/PP-silicon composites	Filler materials
PA6/PP(REF)	
PA6-MMT	Dellite 43B
PA6-SiO2	AEROSIL® 200
PP-MMT	Dellite 72T
PP-SiO2	AEROSIL® 974
PA6/PP-FGC	FGC
PA6/PP-GF	FG

Table 1. Components of testing polymeric materials

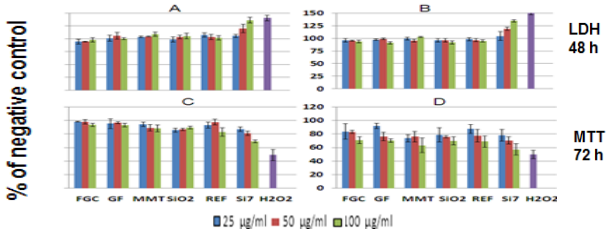
The PA6 and PP were reinforced with 5% of glass fibres (GF), SiO2 NP (Aerosil 200 or Aerosil 974), organically modified montmorillonite (MMT, Dellite 43B or Dellite 72T), or foam glass crystal (FGC). Among the reinforcement materials SiO2 NP and MMT are nanomaterials and the rest are microsized materials.

Figure 1. NP release from testing polymeric materials



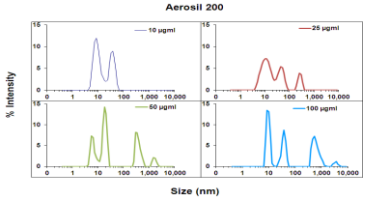
The level of NP release from PA6-materials (A) is higher than that from PP-materials (B) .

Figure 2. Assessment of dust NP cytotoxicity in vitro



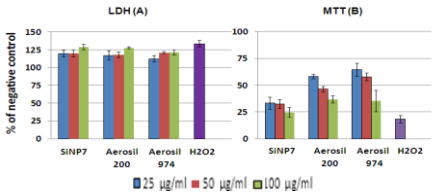
All the dust NP showed little toxicity effect. A.C: NP from PP materials; B. D: NP from PA6-materials.

Figure 3. Representative size distribution of SiNP



SiNP was dispersed in culture medium at concentrations as indicated. The concentration dependent size distribution of SiNP was detected by DLS .

Figure 4 Assessment of SiNP cytotoxicity in vitro



SiNP induced-cell membrane damage was determined by LDH assay at 12 hours (A) and loss of cell viability was determined by MTT assay at 72 hours (B).

Conclusions

We demonstrated that polymeric products can generate NP under certain application scenarios, suggesting that 1) NP release from polymer composites could be altered by different reinforcement materials; 2) working with polymer composites under certain conditions could risk inhalation of high level of polymer NP, although which exhibit low toxicity; 3) SiNP appeared to be toxic in the chosen in vitro system. Further study of the effect of novel filler materials on NP release from final polymer products and the effect of released NP on environment and human health will inform safety design and and minimization of negative impact of materials.

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