EVALUATION OF RISK TO HUMAN HEALTH BASED ON THE SURFACE AREA MONITORING DURING CLAY-NPs MELT COMPOUNDING

Carlos Fito, Carla Cots, Riccardo Concu
Packaging, Transport & Logistics Research Center (ITENE) Valencia, Spain
cfito@itene.com

Introduction

The use of clay nanoparticles in polymers to produce polymer nanocomposites (PNC) by melt compounding raises many questions and generates concerns due to the fragmentary scientific knowledge of the potential exposure risk for workers to airborne nanoparticles. In this regard current research indicated that clay-NPs can produce adverse health effects [1]. Simultaneously, several studies show a substantial release of nanoparticles from synthetic polymers [2].

This study assessed the potential exposure risk for workers to airborne clay nanoparticles during the extrusion process of Polylactic Acid (PLA) and nanoclays. To this end, the study explored the particle number concentration and the particle surface area deposited in the alveolar (AL) and trachea-bronchial (TB) sections of the respiratory tract

Experimental Design

Materials and Equipment

Model nanocomposite systems consisting of layered nanoclays (closite) and Polylactic Acid (PLA) were employed in this study.

The experimental design was based on the application of Real-time measurement instruments to monitorize the variations during the melt compounding process of the human lung-deposited surface area of particles (reported as µm2/cm3) corresponding to tracheobronchial (TB) and alveolar (A) regions of the lung and total number concentration (reported as Particles/cm3).

Measurements were taken starting with the warm-up of the twin screw extruder and continued until nanocomposite compounding was completed.

Particle Measurement

The concentrations of airborne nanoparticles were measured by the Condensation Particle Counter (CPC- Model 3007, TSI) in the range from 10-1000 nm, and the Philips Aerasense NP monitor (Nanotracer). To carry out the measurements a one-meter length tubing was connected to the air inlet of both instruments to reach the measurement location

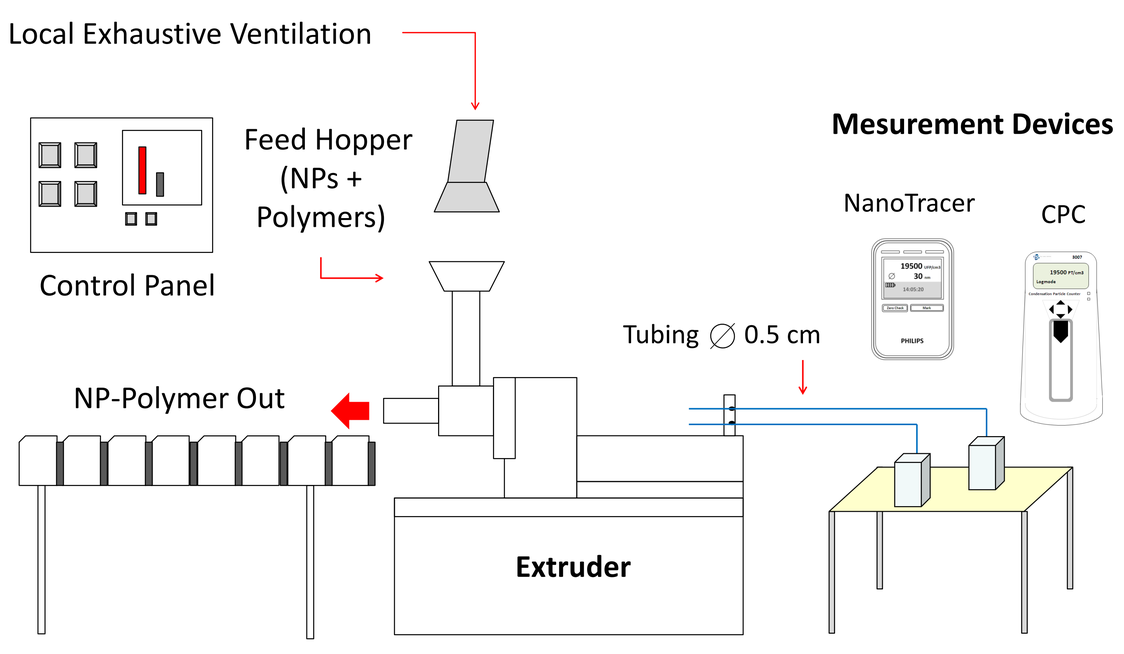

Figure 1. Scheme of the experimental design

Results

The following figures show the number and surface area concentration measured a) before the compounding process (background) and b) during the extrusion. The measurement duration was 10 minutes. Figure 2 shows the number concentration during the compounding compared to the background concentration.

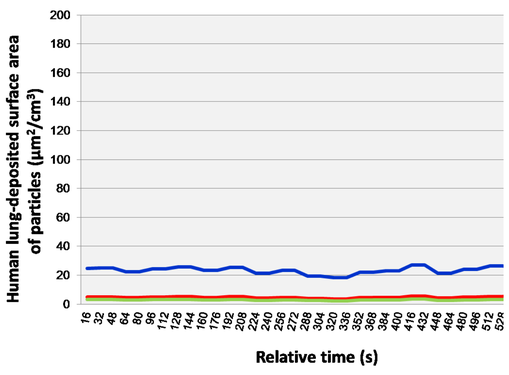

Figure 1a. Surface Area Concentration (Background)

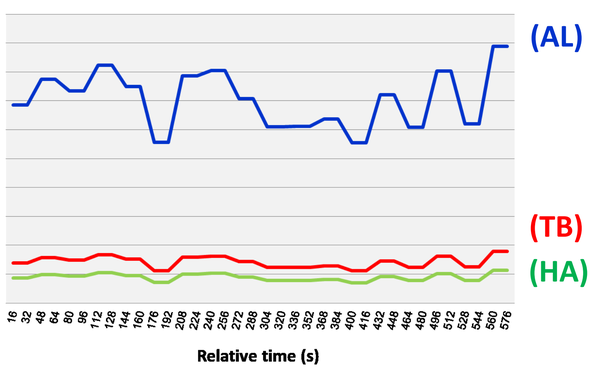

Figure 1b. Surface Area Concentration (Compounding)

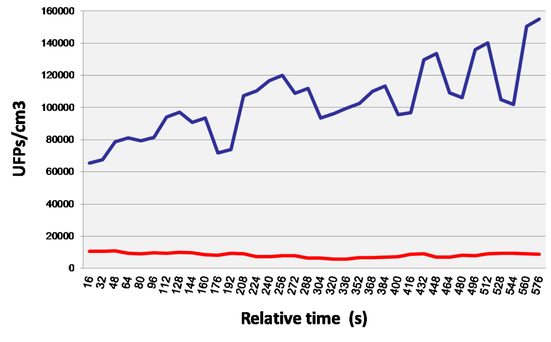

Figure 2. Number concentration (Compounding)

Table 1. Surface Area Concentration values (µm2/cm3)

	Alveolar (AL)		Trachea-bronchial (TB)		Head airway (HA)	
	Background	Compounding	Background	Compounding	Background	Compounding
Avg	23,52	**140,86**	4,75	**28,47**	3,00	**17,98**
Min	18,22	**110,88**	3,68	**22,41**	2,33	**14,15**
Max	26,97	**177,79**	5,45	**35,94**	3,44	**22,7**

Table 2. Number concentration values (UFPs(cm3)

	Number Concentration (UFPs/cm3)	
	Background	Compounding
Avg	8330	**103495**
Min	5720	**65630**
Max	10827	**155061**

Conclusions

The data collected show a **relevant increase in the NPs surface area concentration during the compounding process**. As it´s shown in figure 1b, the surface area deposited in the alveolar region is significantly higher than other regions, which implies a higher level of risks to workers exposed, considering that the gas exchange with the blood occurs in the alveolar region of the lung, being likely the translocation of NPs into the blood stream. In summary, the main conclusion are:

- Quantitative on-line measurements indicate a relevant increase on both number concentration and surface area concentration during the compounding process
- This study demonstrates conclusively that the compounding of polymers and nanoclays can release large quantities of nanoparticles into the air, with an average peak concentration during the compounding process greater than 100.000 particles / cm3
- Fraction deposited in the alveolar region (AL) is significatevely higher than the concentration deposited on the trachea – bronchial (TB) and head airway region (HA) of the lung.

[1] Faheem Uddin. 2008. Metallurgical and Materials Transactions A 39(12): 2804-2814

[2] Hsu L, Chein H. 2007. Journal of Nanoparticle Research 9:157–63.

ACKNOWLEDGMENT

The research leading to these results has received funding from the European Union's Seventh Framework Programme managed by REA Research Executive Agency http://ec.europa.eu/research/rea ([FP7/2007-2013] [FP7/2007-2011]) under grant agreement nº 286362