POLYMER NANO AND SUBMICRO COMPOSITES RISK ASSESSMENT

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1. Introduction

Nanotechnology has been exponentially developed in the last years bringing promises to create improved and new materials (Gupta, 2011). The terminology "polymer nanocomposite" describes a compound in which one or more constituent materials at nanoscale size are completely dispersed in the polymer (Aitken, Chaudhry, Boxall, & Hull, 2006). The nanoparticles typically used are generally inorganic such as clays, carbon nanotubes or chemical additives. In general, almost all types and classes of nanocomposite materials lead to new and improved properties when compared with their equivalents, macro and micro composites (Šupová, Martynková, & Barabaszová, 2011; Zou, Wu, & Shen, 2008). Nanocomposites global market is estimated that would be worth $3000 billion by 2015, since nanomaterials are increasingly playing a decisive role in diverse market sectors (Kiliaris & Papaspyrides, 2010). However, the new technologies rise is normally related with new human and environmental risk factors (Beaulieu, 2009). The production, processing and handling of nanoparticles can expose workers by inhalation, ingestion and absorption through the skin. Exposure can also occur for final consumers who use products sold in the market, often without taking great precautions (Crosera et al., 2009; Gupta, 2011). Thus, with the rapid growth of nanotechnology based products, researchers, manufacturers, regulators and consumers are increasingly concerned about potential safety impacts that these products could have (ISO, 2011).

To determine how to prevent and/or control the risks associated with the nanomaterials, it should be first studied the existing legal texts. Until now there is no specific national legislation for nanomaterials, but recently, it started to appear some ISO, ASTM and BSI related standards. Most of these related regulations approved by the European Community can be interpreted as applying to nanomaterials the same procedures that have been applied to chemicals (based on existing laws and regulations for these products) (Amoabediny et al., 2009; INRS, 2011; Kaluza & al, 2009; Lövestam et al., 2010; MESD, 2006). Though, taking into account the special issues associated to nanotechnologies, specific legal texts or eventual revision of the existing ones is urgently required (Lövestam et al., 2010).

2. Objectives

The present research project aims to study the national legislation relative to nanoparticles and its suitability to analyse polymer nano and submicro composites risk assessment during their production in a laboratory. The project has been developed in the Institute of Mechanical Engineering and Industrial Management (INEGI).

3. Methodological approach

The nano and submicrocomposites were produced by mixing an unsaturated polyester polymer matrix with $Mg(OH)_2$ (15ηm) and Al_2O_3 (45ηm**)** nanoparticles, and SiO_2 (>300ηm) submicroparticles. Both manual stirring and ultrasound sonication techniques were used in the mixing process. The risk assessment involved in the manufacturing process was made by studying the legislation and using simple qualitative analysis based on ISPESL (Istituto Superiore per la Preven-zione e la Sicurezza del Lavoro, Italy) and NanoSafe ("online" research, performed by the Swiss team) methodologies (Giacobbe, Monica, & Geraci, 2009; Groso, Petri-Fink, Magrez, Riediker, & Meyer, 2010).

4. Results and discussion

During the composites production it was observed that particles pass through different "states" during the composites production: in the pre-production (stage 1), particles are at powder state; in the production (stage 2), particles are dispersed in a resin/solution; and, at last, in post-production (stage 3) the particles are inserted into the solidified resin matrix. Using the qualitative methods it was obtain the results contained in Table 1 and 2.

Table 1 - ISPESL method results

Particles	**Factors**										**Σ factors**	**Corrective Factor**	**Risk Assessment**	**Total Risk Level**
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**				
Al_2O_3	1	1	2	1	1	1	1	2	1	1	12	2	24	Medium
$Mg(OH)_2$	1	1	2	1	1	1	1	2	1	1	12	2	24	Medium
SiO_2	1	1	1	1	1	1	1	2	1	1	11	2	22	Medium

The selected qualitative methods application had convergent and consensual results. It is considered that the most critical operation in the whole composite production process is the particles manipulation in powder state, in which lack of safety procedures (e.g.: inappropriate containers), organizational aspects (e.g.: information and training absence), or preventive maintenance (e.g.: cracks in the containers) may lead to typical exposure scenarios.

Table 2 - Nanosafe method results

Particle	Stage	Process	State	Description	Risk level
Al_2O_3, $Mg(OH)_2$ and SiO_2	1	Not fully isolated	Powder	Use >10 mg Tend to cluster	2
	2	Not fully isolated	"Liquid"	Can release dry particles Process not fully isolated Powder Use >10 mg Tend to cluster	2
	3	Not fully isolated	"Solid"	Can release dust Powder Use >10 mg Tend to cluster	2

5. Conclusion

The risks are a key issue to consider especially in the early stages of any new technology. By studying proactively emerging technology potential risks, one can prevent future problems. The risks are inherent to any technology and nanotechnology is not exempt.

Within this scope, in this study the inherent risks associated to the main production stages of three different nano/microcomposites were assessed. The particles exposure scenarios during the different manufacturing processes were also identified and characterized. The experimental study was conducted in a laboratory environment (small scale) but provided an overview of the measures that could be implemented to improve the safety levels during polymer nanocomposite production on a large scale. The results obtained with the qualitative methods were globally convergent: in all the cases a medium risk level was attained.

However, in most at the cases, qualitative analyses are not enough; for a proper risk assessment, qualitative analysis must to be complemented with suitable quantitative methods. So there is a need for a standardized sampling instrument with a particle analysis gauge wide range, in order to allow obtaining more reliable data about the nanoparticles dimensions and chemical composition. With the currently legislation applicable to nanoparticles it is possible to implement prevention and protection generic measures. These measures should be adopted as soon as possible to ensure responsible development of nanoparticles manipulation and use. Current knowledge about the nanoparticles toxicity is insufficient and the scientific preliminary assessments show that there are enough suspicions that nanoparticles can have harmful effects on human health. Thus more research work is needed to fill existing gaps. Until further information, nanomaterials should be considered as risky materials.

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