



[Guidance](#)

[Regulation](#)

[Governance](#)

[Standards](#)

[Resources](#)

[Key Links](#)

[Multimedia](#)

[FAQs](#)

[Glossary](#)

[News](#)

[News Articles](#)

[Events](#)

[Feature Articles](#)

[In the Know](#)

[Newsletter](#)

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[About SAFENANO Services](#)

[SAFENANO RiskMap](#)

[Risk Assessment & Regulatory Compliance](#)

[Workplace Exposure Monitoring](#)

[Laboratory Services & Analysis](#)

[Hazard Assessment & Toxicology](#)

[Research to Support Innovation](#)

[Resources](#)

[Research](#)

[Our Expertise](#)

[Collaborate with Us](#)

[Horizon 2020](#)

[Innovate UK](#)

[Projects](#)

[Focus Areas](#)

[Nanosafety & Risk Assessment](#)

[Consultancy & Reviews](#)

[Regulatory Development](#)

[Standards Development](#)

[State-of-the-Science Reviews](#)

[Contact Us](#)

In the know...on food packaging

[Home](#) >

[News](#) >

[In the Know](#) >

In the know...on food packaging

[News Articles](#)

[Events](#)

[Feature Articles](#)

[In the Know](#)

[Newsletter](#)

Nanotechnology in the food packaging industry

Nanomaterials are increasingly being used in the food packaging industry due to the range of advanced functional properties they can bring to packaging materials. Nanotechnology-enabled food packaging can generally be divided into three main categories (Silvestre et al.



- *improved packaging* - whereby nanomaterials are mixed into the polymer matrix to improve the gas barrier properties, as well as temperature and humidity resistance of the packaging;
- *“active” packaging* - illustrated by the use of nanomaterials to interact directly with the food or the environment to allow better protection of the product. For example, silver nanoparticles and silver coatings can provide anti-microbial properties, with other materials being used as oxygen or UV scavengers; and
- *“intelligent/smart” packaging* - designed for sensing biochemical or microbial changes in the food, for example detecting specific pathogens developing in the food, or specific gases from food spoiling. Some “smart” packaging has also been developed to be used as a tracing device for food safety or to avoid counterfeit.



Ensuring consumer safety...

In terms of consumer safety, it is important to evaluate the potential migration of packaging constituents into food and to assess their potential hazard for a comprehensive risk assessment. However, to date very few studies have been published regarding the effects of nanomaterials upon ingestion, or the potential interaction of nanomaterial-based food contact materials (FCMs) with food components (Silvestre et al. 2011). In Europe, the legislation currently applies an overall migration limit of 10 mg constituent per dm² surface area to all substances that can migrate from FCMs to foodstuffs (Commission Regulation (EU) No. 10/2011). For a litre cubic packaging containing 1kg of food, this equates to a migration of 60 mg of substance per kg of food. However, with the exception of a few materials specifically listed in Annex 1 of the legislation, nanomaterial risk assessment has to be performed on a case-by-case basis (Silvestre et al. 2011; Commission Regulation (EU) No. 10/2011).

Research on migration potential...

Echegoyen et al. (2013) studied the migration of silver from three different types of nanocomposites into food simulants, including an analysis of the form of silver migrating (ions or particles). Their results showed that silver migrated into food simulants and that acidic food presented the highest level of migration. Moreover, heating was observed to increase migration, with microwave heating inducing more migration than a classical oven. The authors suggest that migration of silver could occur through two different mechanisms: the detachment of silver nanoparticles from the composites, or the oxidative dissolution of silver ions.

Cushen et al. (2013) studied the migration of silver and copper from nanocomposites, used for their anti-microbial properties in food packaging. The authors showed that the percentage of nanofiller in the nanocomposites was one of the most critical parameters driving migration, more so than particle size, temperature or contact time. The authors developed a model to study migration of particles from food packaging. This model was a good predictor of the level of migration of nanosilver and to a lesser extent of nanocopper into food stuff and, when further developed and validated, could potentially be of benefit to industry by reducing the time and costs usually associated with migration studies.

More recently, the migration and toxicological profile of an organo-modified clay polylactic acid nanocomposite to be used as a FCM was evaluated. Migration studies indicated that less than 10 mg per dm² of the nanocomposite migrated in water, under the conditions of the experiment (Maisanaba et al. 2014a). Further analysis of the food simulant indicated that the levels of metals measured were below the permitted values. In addition, the authors evaluated the potential toxicity of migration extracts both in vitro and in vivo. Assessment of the potential cytotoxicity of the migration extracts in vitro, on two cell types representative of the digestive system and their ability to induce DNA mutations, did not reveal any evidence of in vitro toxicity compared to control (Maisanaba et al. 2014a). Furthermore, exposure of rats to the same migration extracts for 90 days in drinking water did not show evidence of toxicity in terms of oxidative stress, inflammation, clinical biomarkers and histopathological analysis (Maisanaba et al. 2014b).

Future directions...

These studies indicate the potential for nanomaterials to migrate from FCMs into foodstuffs, with the rate of migration potentially associated with the percentage of nanofiller present in the composite material. There remains a need for further migration and toxicological studies in order to ensure safe development of nanotechnologies in the food packaging industry.

SAFENANO is currently involved in research to assess the toxicological impact and migration potential of nanomaterials in packaging through the [EU FP7 NanoSafePack project](#). For further information on SAFENANO's Hazard Assessment & Toxicology Testing Services, [click here](#).

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