Safe-by-Design Nanocomposite for Food Packaging Application

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Abstract:

The market of nanotechnologies is dominated by the food packaging area which amount more than 20% of the total nanotechnologies market in 2015. However, the wide-scale use of nanomaterials raises important questions about environmental and safety risks that could hinder their development. In the case of plastic materials intended to be in contact with food, the risk of contamination concerns not only the nanoparticles but also all the chemical additives added during the plastic processing. Indeed, the presence of nanoparticles is susceptible to modify the interactions between polymer and the additives with a possible change in their transfer properties and therefore on the food contamination. This project contributes in developing the next generation of safer and eco-designed nanocomposite packaging by filling the gap of knowledge in structure characterization, physical-chemical stability (interfacial interactions, breakdown products) and modeling of mass transfer properties of targeted nanocomposites in real usage conditions.

Exploratory Approach:

The analysis of the extant and extent of migration in the clay polymer nanocomposite (CPN) was performed through exhaustive investigation on the ability of such material to be used in contact with food including the global migration, specific migrations of the clay modifier and compatibilizer, oxygen permeability, migration of nanoclay in elemental and "nano-state" as well as the effect of nanoclay on the migration of a set of plastic processing additives with various size, shape and functionalities.

The results of this project lays the foundation for setting up a reverse engineering toolbox, by which, starting from functionality and safety requirements, follows by translating these requirements into material mass transfer properties (diffusivity and partition coefficient), the safe nanopackagings could be designed which are compliant with EU regulation.

Results Highlights:

Applied knowledge

The applicatory aspects of this project the safety issue of nanocomposites from various viewpoints, from which the following results are obtained:

- Compliance of the nanocomposite with EU regulations on food contact materials in terms of overall migration, specific migration of intercalants, modifier and the metallic elements
- Evaluation of benefit/risk balance induced by the NP inclusion on migration process of low molecular weigth molecules
- No clear evidence on the migration of nanoclay per se

Fundamental knowledge

The fundamental aspect of this thesis aims to determine the influence of nanoclay on thermodynamics and the kinetics aspects of migration, from which the following results were concluded:

- The affinity between polymer and food simulant proved to be determining factor of the partition coefficients of additives and apparent diffusion coefficients in both nanocomposite and pure polymer
- Additive size, shape and affinity to the polymer, has no significant effect on the efficiency of nanoclay to reduce the diffusivity of additives in polyethylene
- A new model based on Flory-hungins theory which allows to predict with relative accuracy the partition coefficients of organic migrants in PNC based on their values in the pure polymer was proposed

'Integrated Approach'