Using time equivalence to design safe recycled food packaging with functional barriers

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Context & Goals

European "single-use" Directive 2019/904 and French "anti-waste" Law N°2020-105 have programmed the forthcoming end of single-use plastics, including food packaging. Still, plastics other than PET are not widely recycled for food contact due to safety concerns. Using recycled materials behind a virgin layer called functional barrier (FB) could resolve the issue under specific provisions. Still, neither the European regulation nor the FDA offer guidance concerning functional barriers evaluation and use. This study aims to give rules to risk assess FBs with non-authorized recycled materials in contact with food by seeking same protection with authorized virgin monolayers. This new approach goes beyond toxicological thresholds in order to discuss whether the use of a FB can overcome decontamination problems of recycled plastics other than PET or not.

Approaches

Mathematical modeling is the only viable method recognized by European and American agencies to evaluate recycled material under usage conditions. Compliant numerical diffusion models are used to simulate homologous aromatic solutes diffusion in relevant systems with recycled polypropylene and glassy virgin polymers known to have good barrier properties such as rPP/vPET or rPP/EVOH/PE multilayers. The conditions and parameters of the simulations are chosen under conservative assumptions and diffusion coefficients are extracted from validated data or measured independently by sorption or stacking experiments. The dimensionless approach of the problem makes it applicable to any type of plastic packaging, geometry, substance, application.

Main results

The feasibility of lowering decontamination behind a FB for materials difficult to decontaminate or with a less controlled origin is demonstrated: low molecular weight contaminants are easily removed but not stopped by the FB, whereas high molecular weight contaminants are persistent but easily stopped by a glassy layer. An optimal decontamination profile for PET and EVOH barriers is proposed and experimentally validated. Risk assessment and substance-dependency rules are identified for functional barriers and homologous organic contaminants. The thickness of the FB needs to be sufficient to accommodate food shelf-life and the storage of the material before use. Considering this, multicriteria optimization offers good prototype for food packaging combining maximized shelf life and minimized amount of virgin polymer.