PhD thesis offer 2021 | Funded within the collaborative project ANR FoodSafeBioPack ANR-20-CE21-0009 2021-2024)
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Mass transfer supporting the safety of recycled paper & board for food contact

SUMMARY

A Ph.D. thesis in chemical engineering/materials science is open at the University of Paris-Saclay (UMR 0782 SayFood between AgroParisTech and INRAE) to characterize and model the transfer of potentially toxic residues from recycled paper and cardboard to food. The work prepares the conditions for the safe use of recycled cellulosic materials for food contact and thus prepares the programmed end of single-use plastic packaging. The thesis is part of a collaborative project funded by the French National Research Agency (ANR).

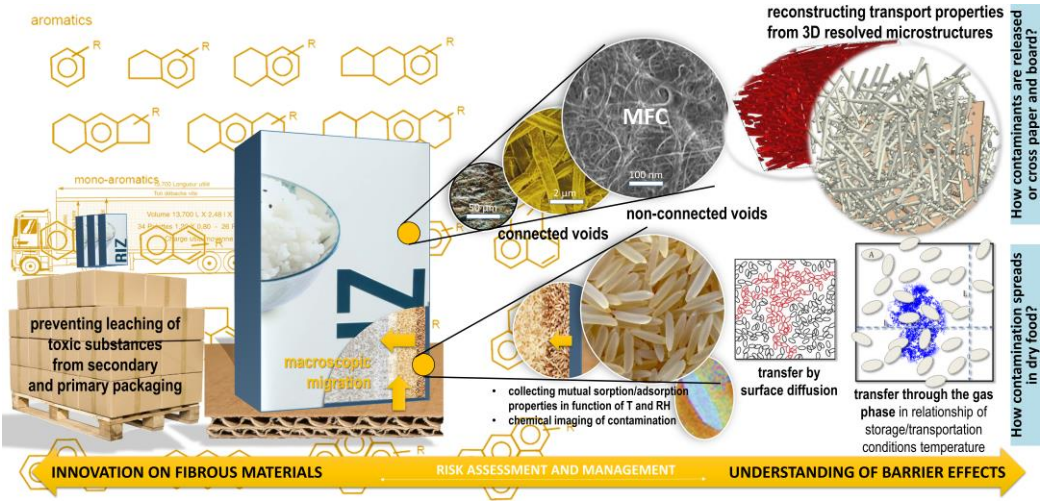

Illustration of the goals of the collaborative project FoodSafeBioPack "Evaluating and managing the migration of contaminants from cellulosic materials" (Coord. INRAE/Olivier Vitrac)

PLACES OF WORK

INRAE, Université Paris-Saclay, UMR 0782 SayFood « *Paris-Saclay Food and Bioproduct Engineering Research Unit* » (formerly UMR 1145 GENIAL).

Our campus until September 2022	Our new campus on the campus of the University of Paris-Saclay
	
AgroParisTech site de Massy , 1 rue des Olympiades, 91300 Massy, France	AgroParisTech-INRAE campus , boulevard Gaspard Monge, 91120 Palaiseau, France

The work will be carried out within the Joint Technological Unit (UMT ACTIA 17.09) SafeMat "Safe Materials for Food Contact" between AgroParisTech/INRAE and the French National Reference Laboratory (LNE).

WORK DESCRIPTION

Context. **PREPARING OUR POST-PLASTICS FUTURE.**
During the last decade, the opinion about disposable food packaging shifted from technological progress to the chamber of horrors: the first source of chemicals in food, a source of microplastics, a cause of marine litter, a drain of non-renewable resources, and source of CO_2. The demand for biobased, biodegradable, recyclable, and recycled materials is skyrocketing. It is driven by consumers and comprehensive policy in Europe encouraging the circular economy and the phasing out of single-use plastic packaging, as recognized in the Directive (EU) 2019/904 on the reduction of the environmental impact of certain plastic products. As the unique biobased source that is both recyclable and degradable, cellulosic fibrous materials offer an economically and technologically viable solution to the environmental problems posed by single-use plastics. However, substituting massively plastic with recycled cellulosic materials does not address unresolved issues such as the migration of harmful mineral oils [1] and the lack of harmonized regulation between the seventeen groups of materials defined in the EU. The FoodSafeBioPack project (see project summary) addresses project several of the most critical issues: assessing the level of mineral oil contamination of foodstuffs on the French market, understanding the mechanisms of substance transfer, developing an effective barrier to mineral oils from cellulose microfibers (MFC), and proposing a reasoned approach to manage the risks of substance transfer from paper and cardboard. Similar approaches have been developed for plastics [2]. Migration modeling has been accepted globally (EU, USA, China) for evaluating in a few minutes instead of days the compliance of materials in plastic in contact with food [3]. The possibility of mass transfer without direct contact of substances with and across layers complicates the use of recycled and non-decontaminated materials [4, 5].

Goal of the thesis. The project sponsors two complementary Ph.D. works: one to develop 3D models of the fibrous network (recycled material and MFC) from X-ray nano- and microtomography experiments and another one on the study of mass transfer across fibrous networks (this thesis offer). Mass transfer descriptions will support the optimization of the MFC barrier layer at the finest scale according to the conditions of contact (dry, oily, time×temperature, relative humidity). At the coarsest scale, the results will support the modeling of the risk of contamination of food products [6].

Research hypotheses. The Aromatic mineral oils with more than two rings are the most concerning because they are possibly carcinogenic. The detection limits with conventional analytical techniques are too high [7, 8] to highlight the causality (sources, the contamination routes) and the mechanisms (evapo-condensation, surface diffusion, mass diffusion). The PROJECT FOODSAFEBIOPACK (2021-2024) has started to collect packaged food on the market with recycled paper and board to constitute a database of food×materials applications and desorbable substances (mineral oils, from printed areas, adhesives, plastics). The database will produce reference materials with optimized formulations for macroscopic quantification and chemical imaging at a microscopic scale.

Proposed approach and methodology. Mass transfer models will be developed based on reference measurements of thermodynamical and transport properties in materials and a selection of foods using an automatic cosorption balance, enabling measurements at controlled relative humidity (RH) and temperature (from ambient to 130°C). Reference mass transfer kinetics will be collected using migration and permeation cells, enabling to adjust the quality of the contact with paper and board and the circulation of air. Chemical imaging (confocal fluorescence/Raman, FTIR-micro ATR) will be used to evidence the route followed by typical contaminants to reach foods. Mass transfer models on 3D digitized

structures will rely on several multiscale techniques, including Langevin Dynamics [9], Kinetic Monte-Carlo [10, 11], and conventional continuum models with effective properties [12].

Keywords. Porous media, mass transfer, modeling, analytical chemistry, risk assessment, food safety

PROFILE & CONTACT

Profile sought. General engineering degree or master 2 in process/chemical engineering, physics in porous media physical chemistry of polymers or physical chemistry. Skills in analytical chemistry, numerical analysis, modeling, and programming will be appreciated.

Funding: The Ph.D. student will be enrolled (3 years doctoral contract) by INRAE (French National Institute for Research in Agriculture, Food and Environment).

Starting date: October 2021

Contact. Please send a CV, cover letter, and a summary of previous research works.

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Doctoral School. ABIES (Université Paris-Saclay) – suggested disciplines

- Food processing sciences, sanitary security and risk, animal health and public health,
- Engineering sciences applied to living matter and the environment.

COLLABORATIVE RESEARCH PROJECT FOODSAFEBIOPACK

Funded by the French National Research Agency | Ref. ANR-20-CE21-0009 | 2021-2024 | on-line description

Our societies are at a crossroads between several alternatives. The end of single-use plastic packaging is scheduled in France and Europe. Cellulosic materials such as paper and cardboard are today the only viable bio-sourced alternative, biodegradable, and already 70% recycled, which can reach a mass market. However, the contamination of recycled cellulosic fibers with a fraction of carcinogenic substances from printing inks and solvents has become a major concern for consumer health. The German (2017, 2019) and French (2019) authorities have activated the precautionary principle to reduce our exposure to these substances. The situation can be described as critical because the transfer to food can occur without contact through the plastic layers. Both primary and secondary packaging (American crate) and transport packaging are sources of contaminants. Current analytical techniques can hardly assess the

level of contamination of food products on the market because of their lack of sensitivity and the presence of food constituents hindering their detection.

The FOODSAFEBIOPACK project offers THREE significant contributions. (1) The transfer conditions will be exhaustively qualified by food type and modality for packaged foods sampled from the market by using a new design of migration cells enabling humidity control, freezing, and oven heating. (2) The relationships between the structure of fibrous assemblages, the structure and composition of foods, and the transfer mechanisms of complex mixtures of substances from printing inks will be investigated from the nanoscale (20 nm) to the macroscopic scale using novel nano/micro-tomographic techniques, multispectral imaging and multiscale numerical simulations. (3) A preventive and comprehensive approach to the risk of contamination will be proposed thanks to a water-based deposition of microfibrillated cellulose (MFC). This technical solution not only preserves the recyclability and initial biodegradability of the materials but also greatly improves the barrier properties of the fibrous materials to liquids and gases to compete directly with plastic materials. The MFC layer sizing and risk assessment rules will be integrated into predictive tools compatible with the approaches already used to demonstrate compliance of plastic packaging (10/2011/EC) or to design food packaging.

The results and deliverables (28) will support the harmonization of regulations for paper and board for food contact in Europe, as well as future testing standards. The development of new types of eco-designed and safe packaging is within reach, especially as the wet deposition technology for MFCs is already patented by one of the partners. The cost is 2 to 4 times cheaper than a solution with a plastic layer. The structure-property relationships and computer-aided evaluation will allow the MFCs to be optimized for packaging, overpackaging, and dry or fatty foods.

The consortium involves four complementary partners. Two academic laboratories specialized in the study of material transfer and materials in contact with food (INRAe Massy, coordination) and the characterization and modeling of microstructures (University of Grenoble Alpes). The French national reference laboratory on materials in contact with food (LNE, Trappes) and the technical center for paper and board (Grenoble) will combine their experience and expertise to provide practical solutions to the food, paper & board, and retail sectors.

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