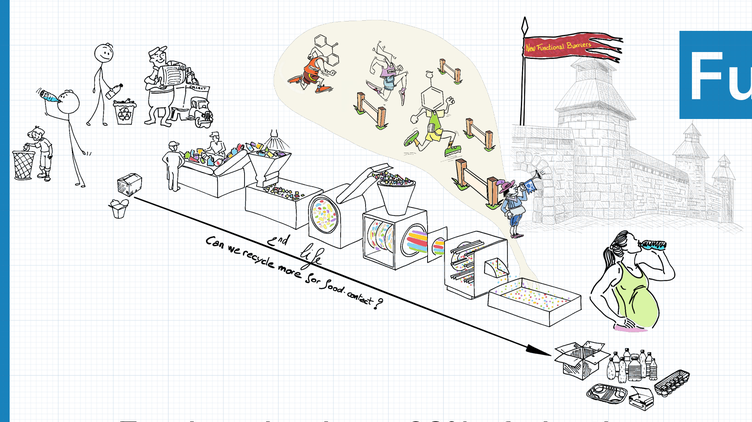
Assessment of functional barriers for the generalized use of recycled plastics for food contact



- Food packaging = 30% of plastic uses
- Food packaging > 60% of plastic waste
- Only PET can be currently recycled mechanically for food contact in the EU
- Plastic streams need to be carefully selected and decontaminated for direct contact with food,
- Can we use more recycled materials (PP, HDPE, cardboard) behind functional barriers while keeping the final product ?

Functional barriers: enablers for authorizing new recycled materials

Recycled for food contact (PET) — Could be recycled for food contact (polyolefins: PP, HDPE, LDPE)

Recycling difficulties - any purpose (variable according to regions/countries): feasible → Very difficult

1	2	3	4	5	6	7
PET Polyethylene terephthalate	**HDPE** High density polyethylene	**PVC** Polyvinyl chloride	**LDPE** Low density polyethylene	**PP** Propylene	**PS** Polystyrenes	**Other** Plastics
Beverages, jars, clothing, carpets, products cosmetics...	Detergents, snacks, corks, toys, barrels, garden furniture, garbage cans...	Door/window frames, gutters, electric ducts, CC...	Films, bags, bubble wrap, flexible bottles, electrical insulation...	Rigid closures, food boxes, coolers, tarpaulins, diapers...	Cups, egg cartons, trays, yoghurt pots, toys, electrical insulators...	Nylon/polyamide fabrics and films, CD, parts …
11% (>15%)	**14%** (~15%)	**5%** (<3%)	**20%** (32%)	**19%** (~20%)	**6%** (~10%)	**24%** (~5%)

% plastic wastes in 2015 - (% food packaging wastes, Plastics Europe 2016)

Example of barrier performances achieved during the European project Banus (ref. P7-SME-2013-606572). Packaging trays with recycled PP were used for the pasteurization of foie gras (60 min at 80°C followed by refrigerated storage). Results are shown for an initial contamination level of the recycled PP of the order of 1000 mg·kg-1 .

thickness 1.5 mm	chloroform (mg·kg^{-1})	toluene (mg·kg^{-1})	hexylcyclobenzene (mg·kg^{-1})	benzophenone (mg·kg^{-1})
PP/EVOH/PPcont(30%)/EVOH/PP	35	51	15	24
PP/EVOH/PPcont(40%)/EVOH/PP	37	62	20	32

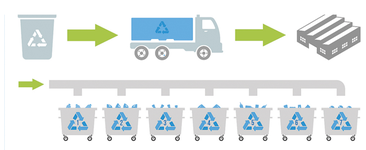
EFSA sets acceptable migration to be below $0.15\ \mu g \cdot kg^{-1}$ for adults.

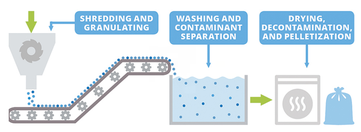
Goals

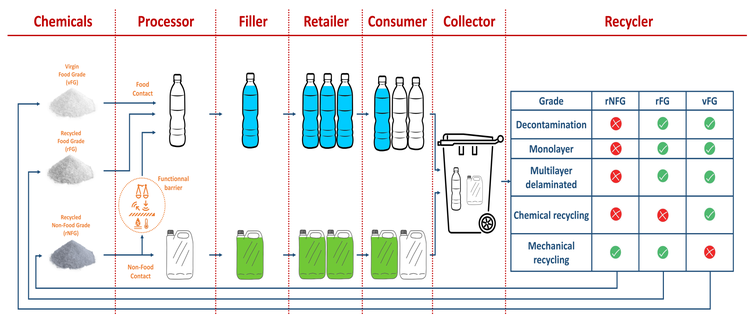
Promote a return to Food Grade

Allow the recycling of polyolefins (light plastics) intended for food contact. Priority to PP and HDPE. Provide a significant barrier to mineral oils from recycled paper and cardboard used for direct or indirect contact (secondary and ternary packaging).

Type equation here.



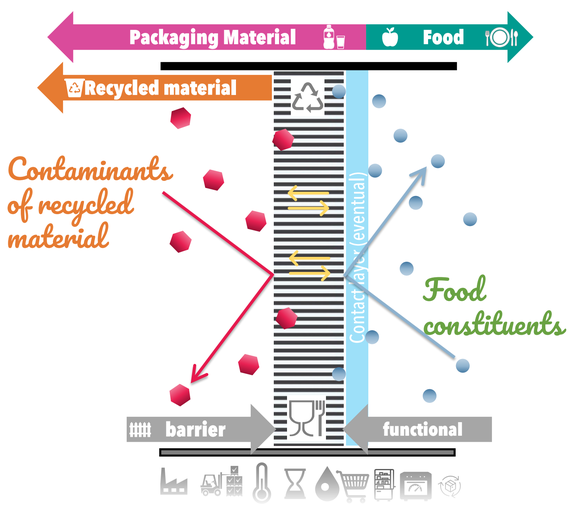




Grade	rNFG	rFG	vFG
Decontamination	✗	✓	✓
Monolayer	✗	✓	✓
Multilayer delaminated	✗	✓	✓
Chemical recycling	✗	✗	✓
Mechanical recycling	✓	✓	✗

Develop the functional barrier (FB) concept

The concept of functional barrier has been insufficiently explored in the past. It is not an absolute barrier and its properties need to be optimized to allow safe and robust use for mass applications. The barrier layer can be placed behind a food compatible contact layer.



Develop good manufacturing practices and support the evolution of European regulations

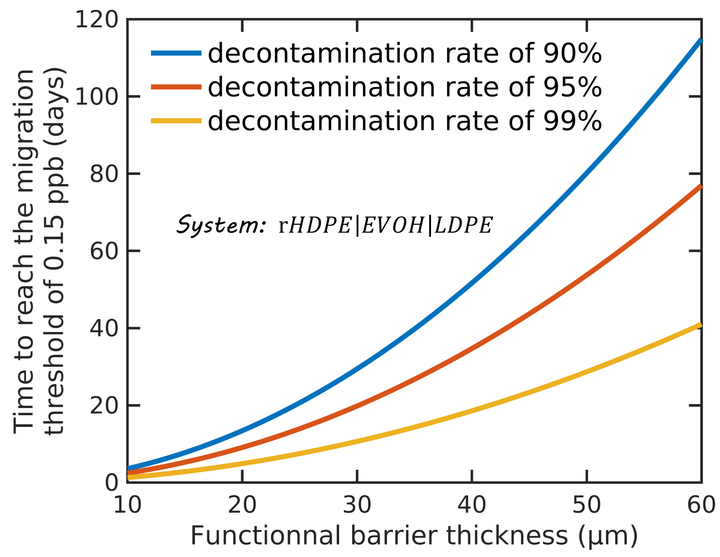
European regulations require ad-hoc risk management procedures, material traceability procedures, quality procedures and good manufacturing practices.

Some practices or technologies will have to be submitted to the European Food Safety Authority.

Breakthrough

FB can replace some decontamination level for some period of time. An optimal solution exists for each case if time-equivalence has been established.

Example with EVOH layer as FB and LDPE as contact layer for recycled HDPE.



Tasks

T1. Reference material production

- **Polyolefin films (PP, HDPE, LDPE)** of different thicknesses with model sub<stances in different concentrations mimicking recycled materials
- **Functional barriers** only on inert porous support or in the form of films when possible.
- **Materials with functional barrier** (plastics and cardboard).

T2. Materials and functional barriers characterization

- **Crystallinity, density, porosity/tomography (cardboard)**
- **Characterization of laminated/coextruded/coinjected structures of films and articles** (thickness profiles)
- **Defects in plasma barriers (SiOx, carbon)**

T3. Direct/indirect characterization of deposits

- **Samples of "worst case" containers on the market**
- **Reproduction of contamination scenarios in the laboratory.**
- **Analytical chemistry (GC-MS), chemometrics**

T4.Thermodynamic characterization of mass transfer (mutual diffusion, soprtion and their activation)

- **Sorption isotherms for model solutes and water**
- **Diffusion and activation coefficients** for homologous solutes (solid and molten states)
- **Physical and chemical aging effects**

T5. Modeling and molecular theories

- **Prediction of activity coefficients at the atomic scale** in the framework of the Flory-Huggins theory
- **Prediction of diffusion coefficients** in the framework of free volume theory
- **Consideration of plasticization effects** by water and food constituents

T6. Risks assessment

- **Integration of shaping conditions in FMECAengine, FMECAengine3D**
- **Probabilistic modeling**
- **Risk prioritization, best practices**

Contact

Natacha DAOUD, IPC
natacha.daoud@agroparistech.fr

Olivier VITRAC, INRAE
olivier.vitrac@agroparistech.fr

INDUSTRIAL PhD THESIS (CIFRE)
With the Centre Technique de la Plasturgie et des Composites (IPC)

UMT SAFEMAT SAFETY OF PACKAGING

UMT SAFEMAT ACTIA 17-09 "Safety of Food Contact Materials"
https://www.contactalimentaire.fr/fr/unite-recherche-developpement/unite-mixte-technologique-actia-safemat

Edition: 23/09/2021