GFORSS

GLOBAL FOOD REGULATORY SCIENCE SOCIETY

GFoRSS is a Disciplinary Organization of IUFoST, devoted to Food Regulatory Science

GFoRSS Capacity Building Program

Food Contact Materials: International Regulatory Framework

Introduction to Food Contact Materials and their Interactions with Food

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PR AgroParisTech

Chaire CoPack (Fondation AgroParisTech) – UMR SayFood (AgroParisTech, INRAE, Université Paris-Saclay) – UMT SafeMat (LNE/AgroParisTech)

February 22, 2022

Virtual Event

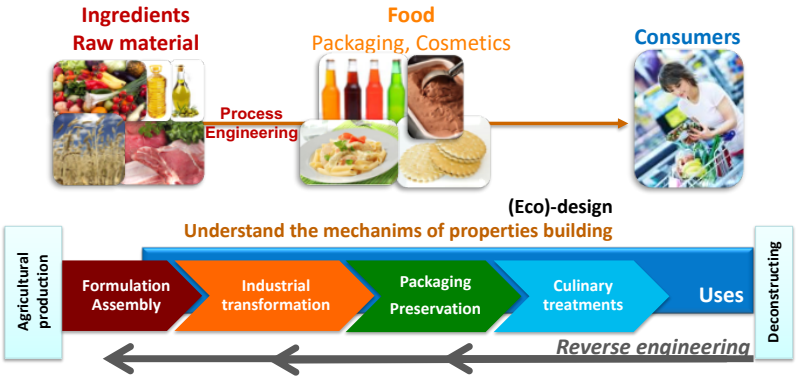
UMR SayFood / Chaire CoPack / UMT SafeMat

SayFood
Food & Bioproduct Engineering

AgroParisTech
INRAE
université PARIS-SACLAY

Research unit for Food and Bioproducts Engineering

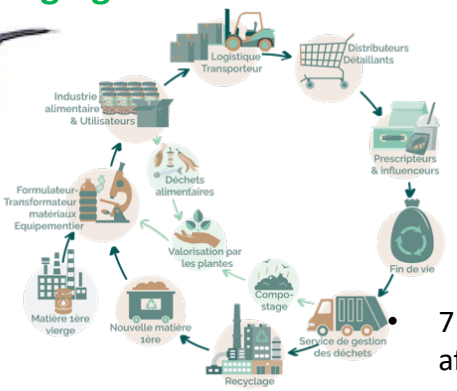
130 employees + 50-60 post-docs, PhD students, master students



- Mechanistic and dynamic understanding of the development of the functionalities of complex systems from renewable resources under the influence of process conditions
- Consideration of user expectations, sustainability criteria and innovative design objectives

Sustainable design of Packaging

Chaire CoPack
Co-construisons des emballages responsables



Fondation AgroParisTech

- 7 patrons + 5 affiliated members
- **Chair of patronage (non profit organization)**
  - Co-design of sustainable packaging taking into account the stakeholder needs at each link of the supply chain

Safe design of Packaging

UMT SAFEMAT SÉCURITÉ DES EMBALLAGES

LABORATOIRE NATIONAL DE MÉTROLOGIE ET D'ESSAIS LNE

Research and development unit for safety of plastic food packaging

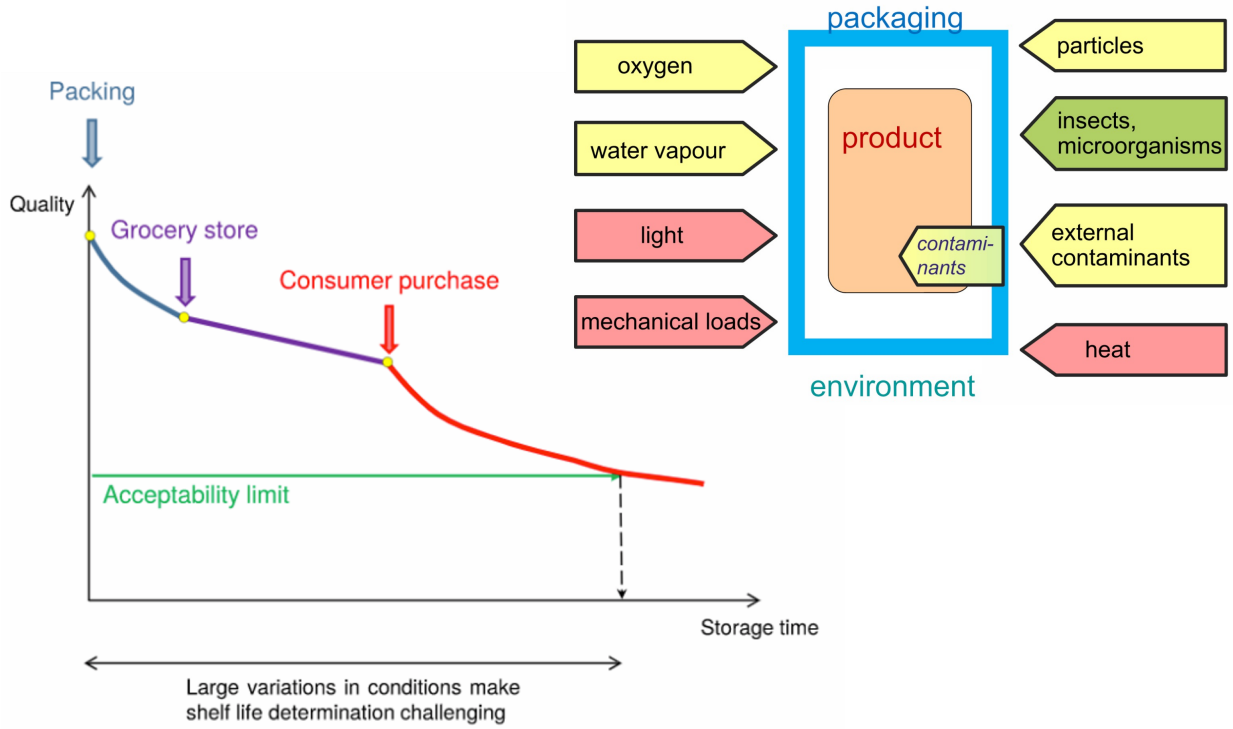
- Develop predictive mathematical models for safety evaluation along the supply chain
- Expertise for industrials and authorities

Outline

- Introduction to food packaging
- Focus on plastics
- Food/packaging interactions – quality and safety of foods
- Food packaging in the circular economy
- New challenges for safety

Packaging is an active partner of the supply chain

Agricultural products are seasonal and produced far from most consumers.

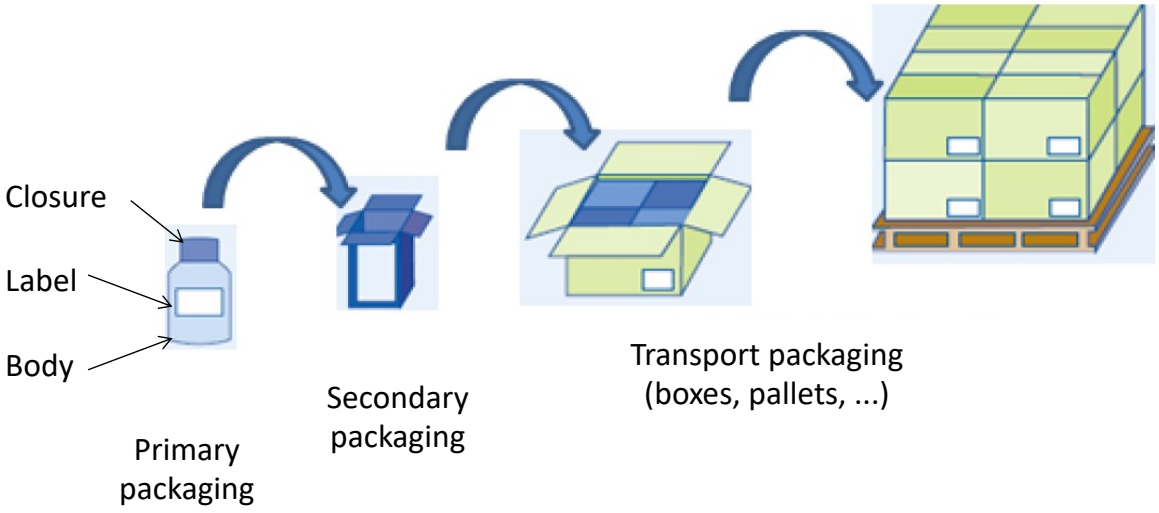


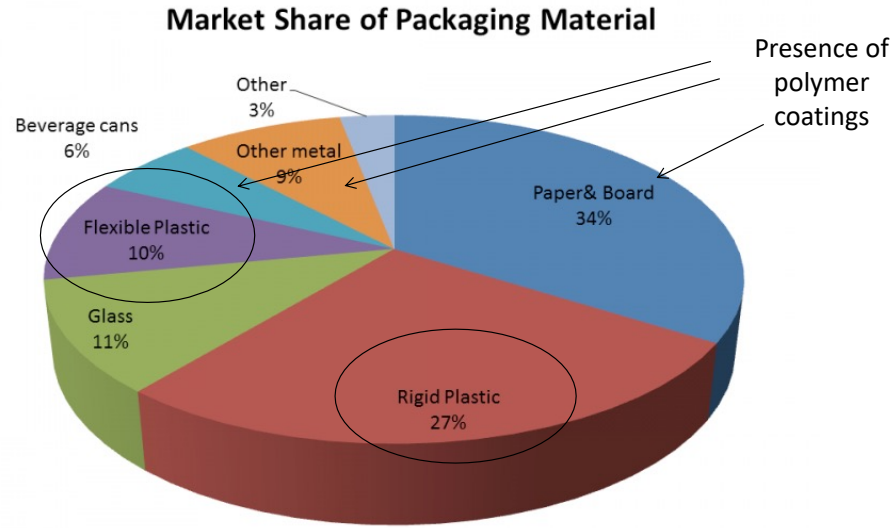
Functions of Packaging

- Transport
- Portionning
- Conservation
- Communication

- **Protection against mechanical impact**
- **Protection** against microbial, chemical, and physical **contamination**
- **Protection** of sensorial quality
- **Communication, presentation, selling**
- **Easy use** of packed food
- **Decreasing ecological footprint** the total service offer

Packaging system





https://www.foodpackagingforum.org/food-packaging-health/food-packaging-materials ; 15/10/2018

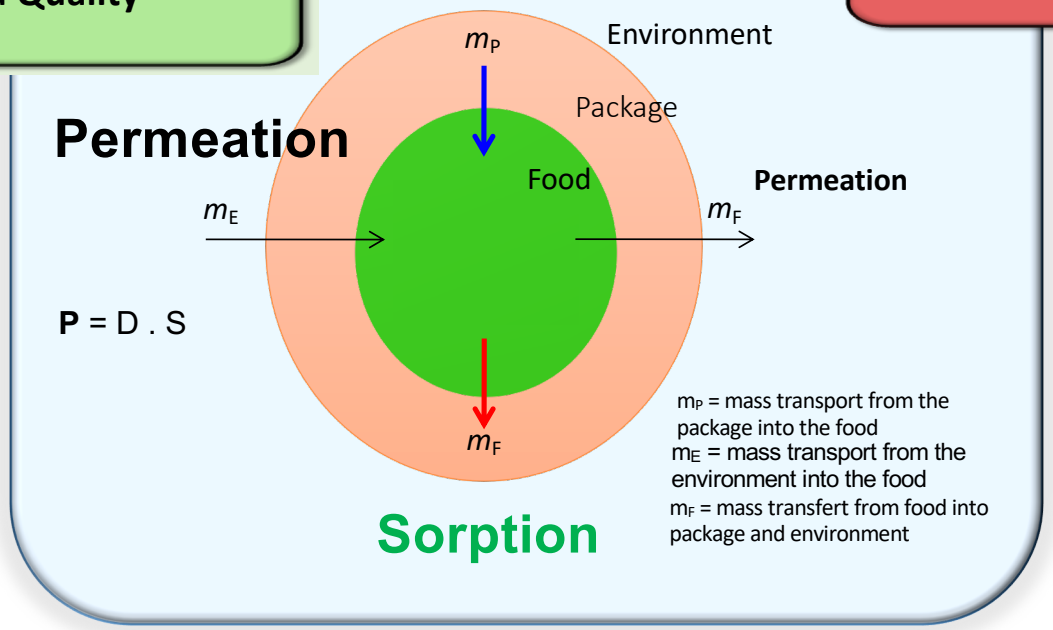
Interactions between food and packaging

UMT SAFEMAT MATÉRIAUX AU CONTACT DES ALIMENTS

Food Quality

Migration

Food Safety Concern



P = D . S

m_P = mass transport from the package into the food
m_E = mass transport from the environment into the food
m_F = mass transfert from food into package and environment

- modifications of the aroma composition
- decrease of intensity
- unbalanced flavour
- plasticizing effect

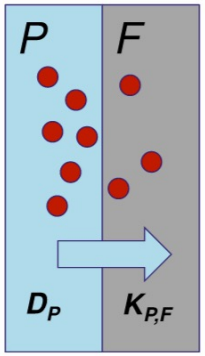
Transport mechanisms in polymers

Migration → Diffusion process

- **Diffusion is the rate limiting step**
  - Free volume of the polymer
  - Size of the migrant
  - Temperature
- **Equilibrium value determined by partition coefficient**

Fick's second law of diffusion:

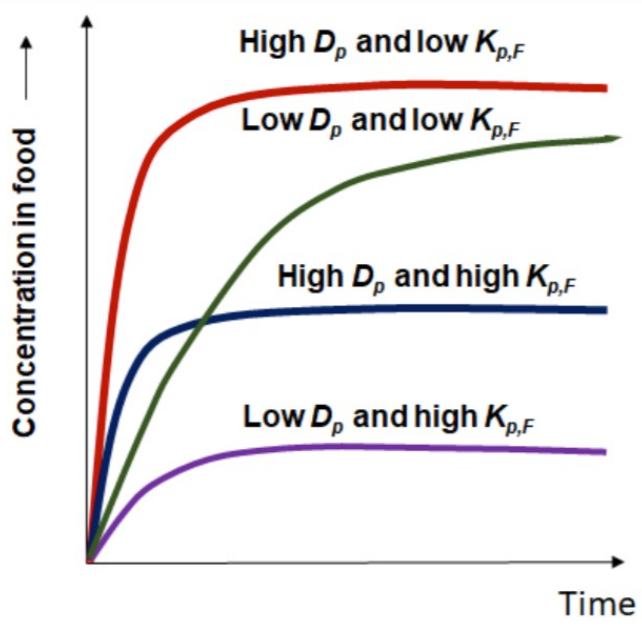
$$\frac{\delta c}{\delta t} = D\frac{\delta^2 c}{\delta x^2} \quad (1)$$



P - polymeric material (film, sheet)
F - contacting medium (food simulant)

Partition coefficient:

$$K_{P,F} = \frac{c_{P,\infty}}{c_{F,\infty}} \cdot \frac{\rho_p}{\rho_F}$$



Evaluation of migration – assessment of exposure

- Migration experiments
  - Immersing strips
    - Polymer of known thickness and surface area in food simulant (double side contact)
    - Measure of concentration of migrant in the food simulant
  - Migration cell
    - Single side or double side contact of a given surface with the food simulant
    - Measure of concentration of migrant in the food simulant

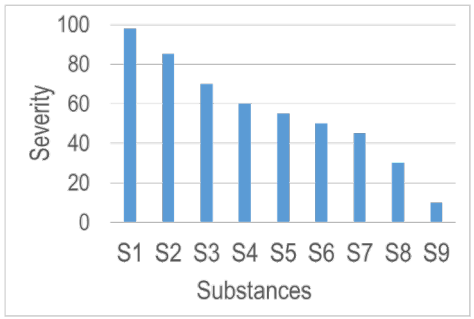
Difficulty : Analytical chemistry, time consuming

- Migration modeling
  - General requirements and assumptions
    - Plastic material assimilated to a polymer film of constant thickness in contact with a food simulant of finite and constant volume
    - Migrant distributed homogenously in the film
    - No boundary resistance for mass transfer
    - Interaction between polymer and food is neglectable and no swelling occurs
    - Partition coefficient is constant

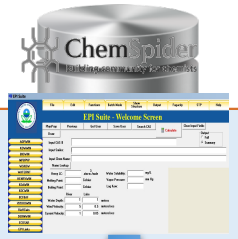
Difficulty : Availability of data

Migration modeling – FMECA tool

Substances	Description	Quantity
S1	UV-stabilizer	10
S2	UV-stabilize	20
S3	Antibiocide	5
S4	Antibiocide	1
S5	Mineral oil	4
S6	Mineral oil	6
S7	Solvent	5
S8	Solvent	5
S9	Photoinitiator	10



databases



- Nomenclature
- Formula
- M
- P_v^{sat}
- C_P
- K_i,
- D_{fuller}, $D_{Piringer}$

Simulation

$C_{i,F}$

FMECA

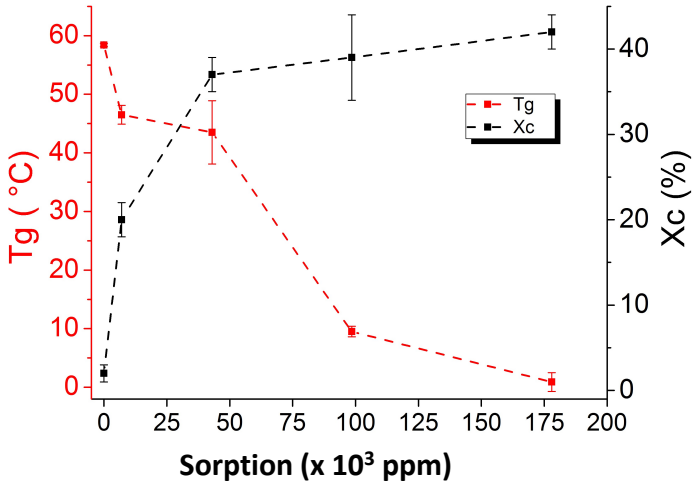
(Failure Modes, Effects, and Criticality Analysis)

- Severity
- Criticality

Nguyen P-M et *al.* , AIChE J. 2013, 59 (4), 1183
"FMECAengine" open-source project https://github.com/ovitrac/FMECAengine

Issues associated to interactions food/packaging

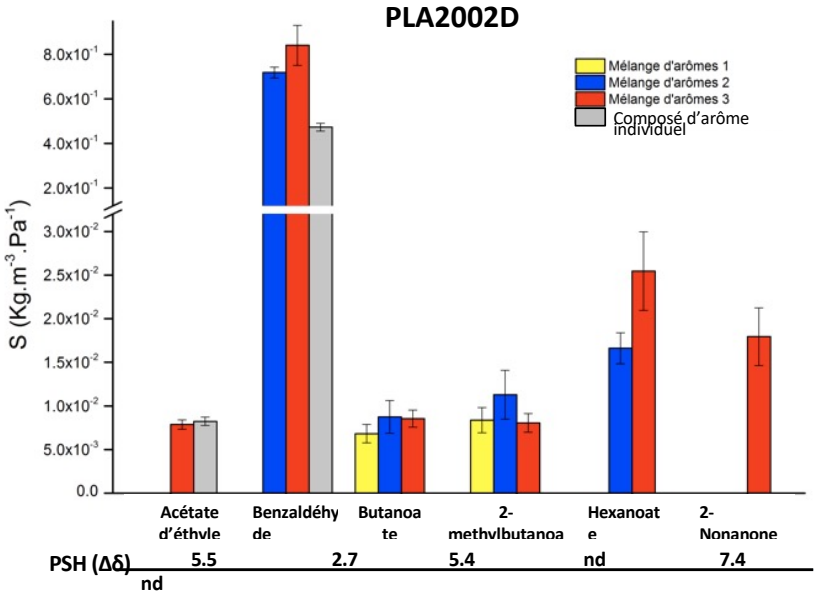
- **Morphological changes of the polymer**



Decrease of Tg and induced crystallization of PLA

Colomines G, Ducruet V, Courgneau C, Guinault A, Domenek S, Polymer International. 2010, 59, 818-826.

- **Aroma scalping caused by sorption**

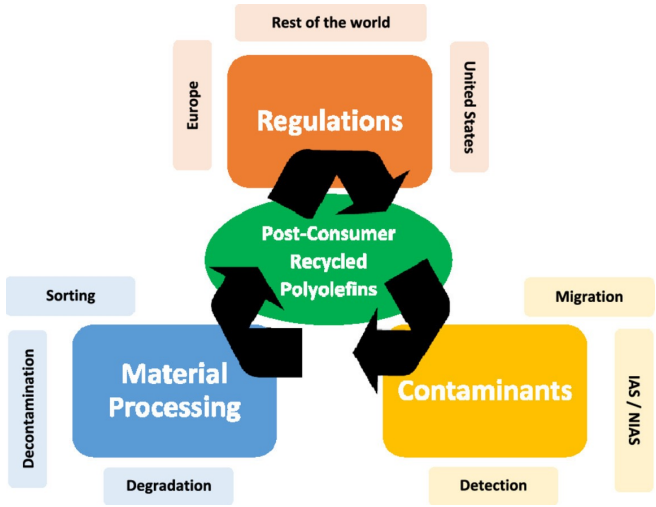


Synergistic sorption of aroma compounds in PLA

Salazar, R.; Domenek, S.; Courgneau, C.; Ducruet, V., *Polym. Degrad. Stab.* **2012,** 97, (10), 1871-1880.

Plastics in the circular economy - recycling

Contaminants – challenge for recycling



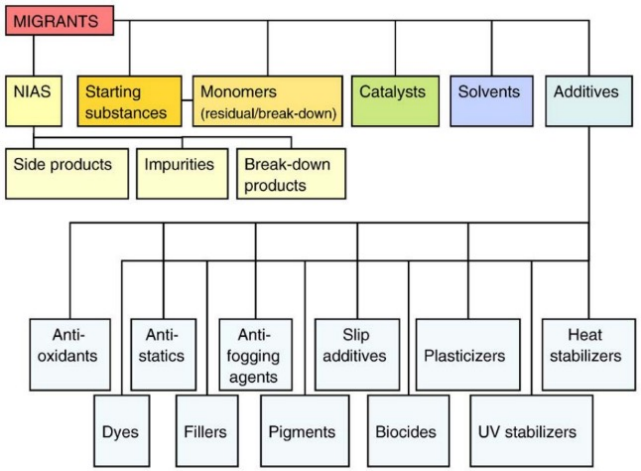
Resources, Conservation and Recycling Volume 167, April 2021, 105422

Table 1. Examples of Minimum Concentrations of Contaminants in a Surrogate Cocktail

Contaminant	Concentration
Chloroform (volatile polar)	10% v/v[a]
Toluene (volatile non-polar)	10% v/v
Benzophenone (non-volatile polar)	1% v/v
Tetracosane or Lindane (non-volatile non-polar)	1% w/w[b]
Copper(II) 2-ethylhexanoate (heavy metal)	1% w/w
Balance: 2-Propanol (as solvent for Cu(II) 2-ethylhexanoate) Hexane or Heptane (as overall solvent for cocktail)	 10% v/v 68% v/v

Use of Recycled Plastics in Food Packaging (Chemistry Considerations): Guidance for Industry – FDA – July 2021 - https://www.fda.gov/media/150792/download

Challenge – non targeted analyis of contaminants

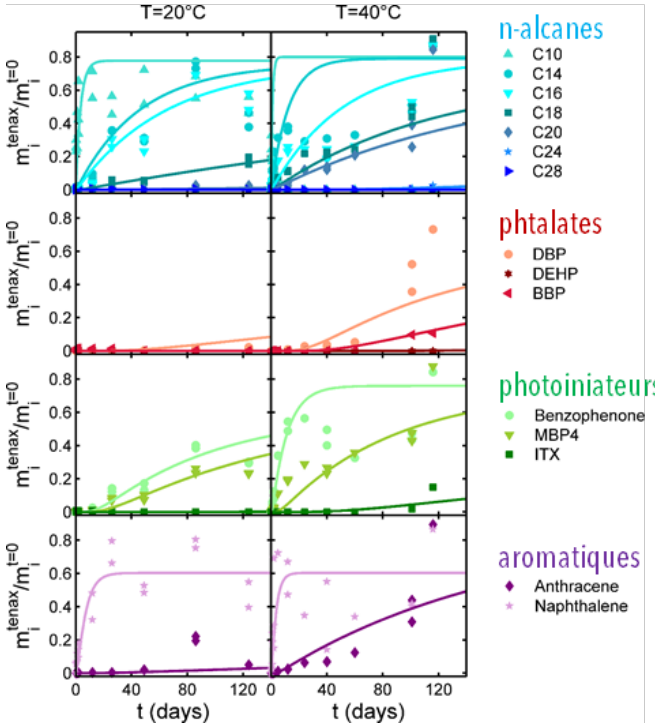


Muncke, 2009

Random unknown → **Systemic known**

Life cycle	New sourcing	Degradation products	Reactives and products
- Contact with the environment - Contact with food - Recycling and reuse - Misuse	- Formulation with by-products - Biocomposites - Biodegradable polymers	- Degradation of the polymer - Degradation of additives	- Polymers and oligomers - Catalyst residues - Solvents - Impurities

Confirmed risks for paper and plastic



Nguyen et al., Food Additives and Contaminants. **2017,**34,1703-20

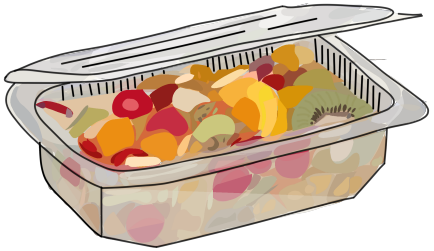
Table 4: EU legal requirement for safety assessment of plastics substances under selected regulations

Plastics substance type	EU 1907/2006 REACH[5]	EU 10/2011 plastic FCMs[6]	EU 282/2008 Recycled plastic FCMs	EU 1272/2008 CLP[7]
Monomers	✓	✓	✓	✓
Polymers	X	✓[8]	✓[9]	✓
Catalysts	✓	✓	✓	✓
Polymerisation agents	✓	X	X	✓
Polymer stabilisers	X[10]	✓	✓	✓
Solvents	✓	X	X	✓
Other additives	✓	✓	✓	✓
Colourants, pigments	✓	X	X	✓
NIAS[11]	X	✓[12]	✓[13]	X

✓ Risk assessment is required X Risk assessment is not required

A circular economy for plastics – Insights from research and innovation to inform policy and funding decisions, Jan 2019, EU Commission

Conclusion – new challenges for safety



- Risk assessment and management of unknown substances – development of methods for the prediction of exposure
- Ignorance of acceptable exposure limits (acute toxicity, endocrine disruption taking into account cocktail effects)
- Assessment of migration / exposure below analytical detection limits
- Assessment of functional barriers
- Traceability of recycled materials, containers and their decontamination
- Management of cross-contamination during collection, sorting, recycling
- Analysis of NIAS throughout the life of the container – taking into account the aging of materials

Modelling approaches for evaluation of migration

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UMT SafeMat: https://www.contactalimentaire.fr/fr/unite-recherche-developpement
Chaire CoPack: https://www.chairecopack.fr/
UMR SayFood: https://www6.versailles-grignon.inrae.fr/umr-sayfood/

Further reading:
online lectures on Food Packaging: https://fitness.agroparistech.fr/fitness/lectures/