

> The fate of food packaging substances: cross-contaminations, migrations, etc. a main challenge for the 21st century

Olivier Vitrac, olivier.vitrac@agroparistech.fr

University of Paris-Saclay, INRAE, AgroParisTech

UMR 0782 SayFood "Food Processing and Engineering of Paris-Saclay"

UMT SafeMat "Safe Food Contact Materials" between AgroParisTech/INRAE and LNE

1 rue des Olympiades, 91300 Massy, France

EMBALLAGE ALIMENTAIRE

les défis du 21^{ème} siècle

Technologie de conservation de l'aliment, l'emballage a pour fonction de protéger, transporter et stocker les denrées périssables. Il contribue à réduire les pertes et gaspillages et lutte contre les risques sanitaires et microbiens. Toutefois, il est accusé de contaminer l'aliment et polluer l'environnement. Quels sont les défis à relever et que peut-on attendre des innovations?

DÉFIS



MATÉRIAUX

Consommation des ressources et de l'énergie non-renouvelables et sont issus de formulations complexes.

+90%
des plastiques
tous secteurs
confondus issus de
ressources fossiles

20%
consommation
mondiale de
ressources fossiles
d'ici à 2050



INNOVATIONS

MATÉRIAUX

Constitués de matières 1^{ère} renouvelables via un procédé de fabrication peu coûteux en énergie.

améliorer le rôle
de réduction des
pertes et
déchets

+ minimiser
l'impact
environnemental
négatif



USAGES

L'emballage est une source de contamination de l'aliment. Il reste suffisamment longtemps en contact avec l'aliment pour permettre la migration de substances.

Substances retrouvées dans les aliments
• BPA présent dans les contenants
• résidus d'encre d'impression



USAGES

Propriétés adaptées à la conservation de la qualité et de la sécurité de l'aliment.

Emballage
actif

atmosphère
interne modifiable
pour une meilleure
conservation

Emballage
intelligent

détecte et informe
les acteurs de la
chaîne sur la
qualité du produit



DÉCHETS

Biodégradation, collecte, tri et recyclage insuffisants, les déchets s'accumulent dans nos sols et océans.

72%
de plastique non
récupérés sur les
78M de tonnes
produits/an

14%
de plastique
recyclé sur les
28% récupérés et
4% perdus



DÉCHETS

Biodégradables ou recyclables à faible coût économique et environnemental qui doivent s'imposer sur le marché de l'emballage.

=

EMBALLAGES INNOVANTS

SYSTÈME ALIMENT/EMBALLAGE

La conception et le choix de nouveaux emballages reposent sur une approche privilégiant un ou deux aspects (ex. recyclabilité) au détriment de beaucoup d'autres (ex. aptitude à la conservation, consommation d'énergie, disponibilité concurrentielle des matières premières, acceptabilité par les consommateurs etc.) et sans intégration du système « aliment/emballage ».

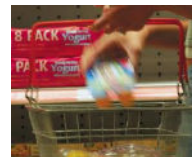
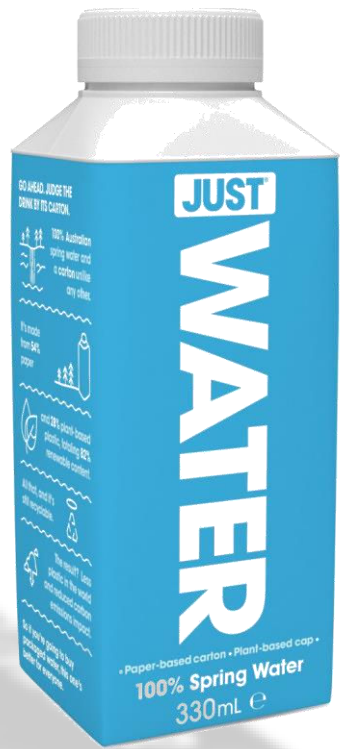
1964

La malbouffe
et les additifs,
progrès ou
danger pour
le futur ?

Archive INA

[https://www.youtube.com/
watch?v=aZcNza1xHSk](https://www.youtube.com/watch?v=aZcNza1xHSk)





INRAE

➤ Turn into
constructive
controversy





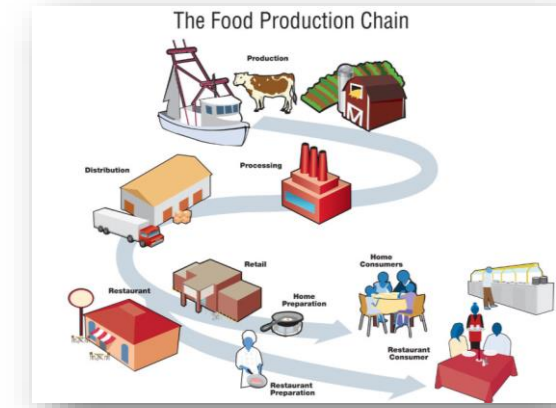
1950



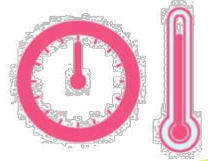
1980



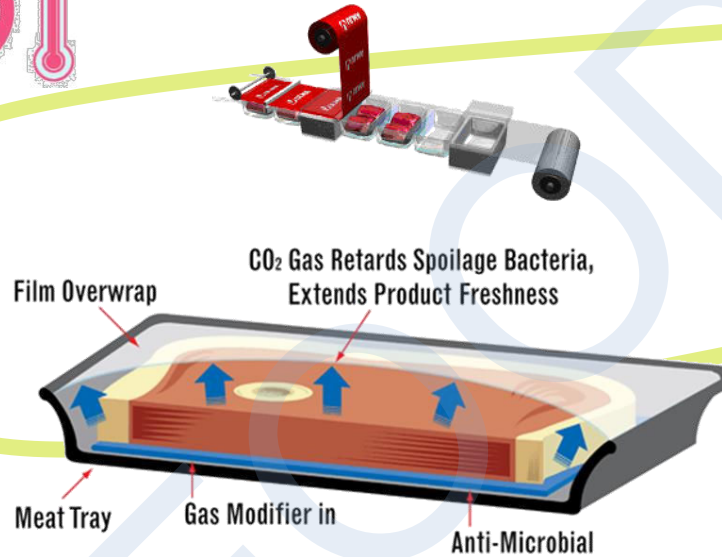
1990



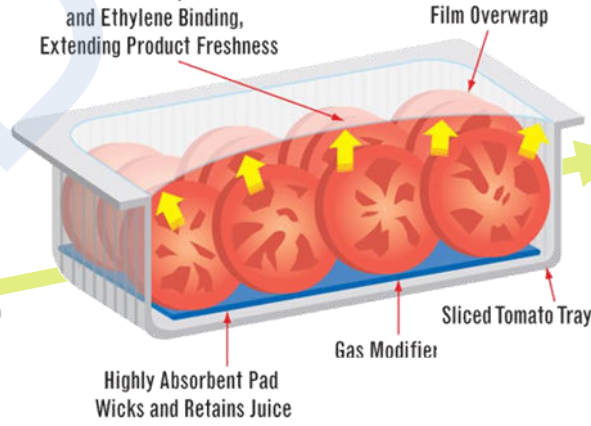
Ultrahigh Temperature



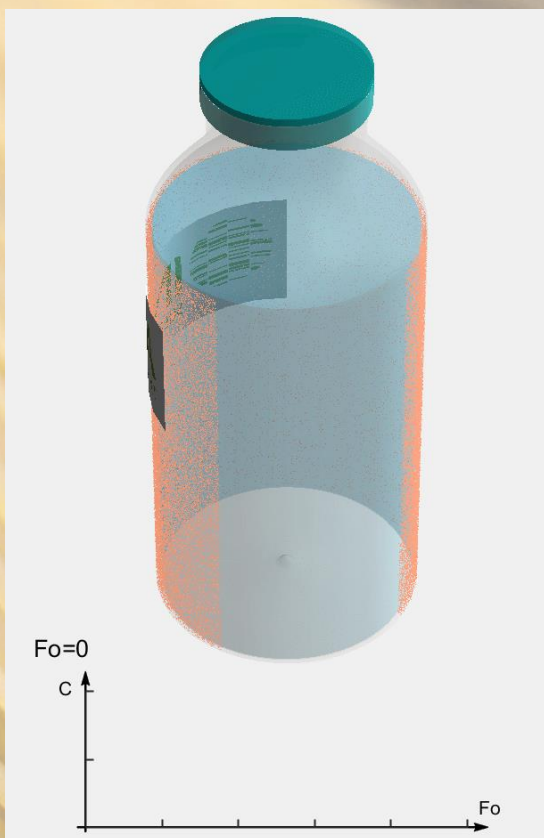
2000



CO₂ Slows the Respiration Rate and Ethylene Binding, Extending Product Freshness



Protective, active, intelligent, useful packaging



**Food
Packaging
Forum**

Workshop "Predicting the safety of food contact articles" - New science and digital opportunities

4 October 2018, Zurich, Switzerland

<https://www.foodpackagingforum.org/events/predicting-the-safety-of-food-contact-articles-new-science-and-digital-opportunities>



« Ce grand homme à mon avis mérite d'être préféré à tous les autres... il a établi une doctrine fondée sur des raisons physiques et palpables sans se servir des énigmes inintelligibles qui font tourner la tête plutôt que d'instruire »

François-Marie-Pompée Colonna – Abrégé de la doctrine de Paracelse et de ses Archidoxes – Paris, 1724.

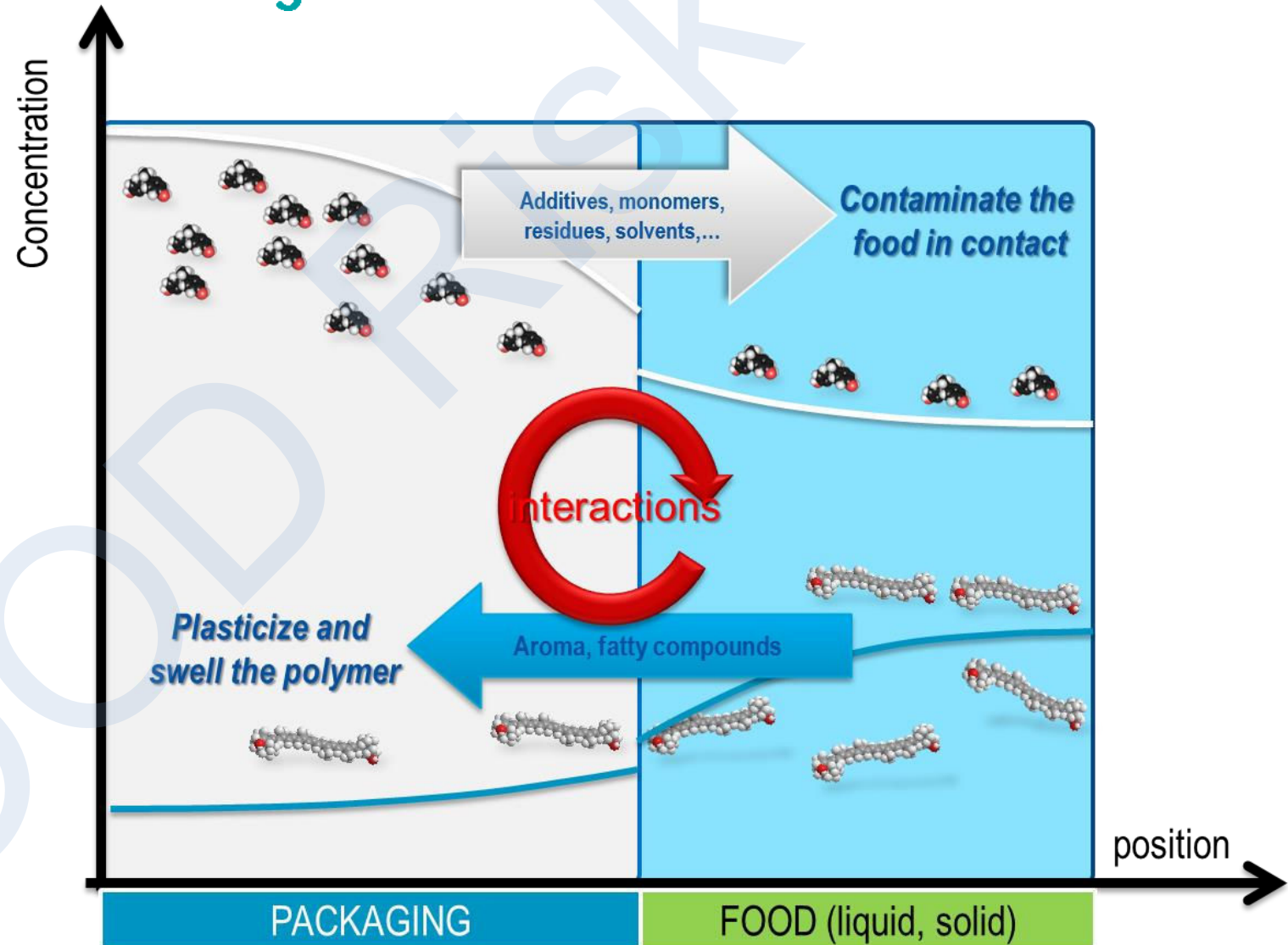
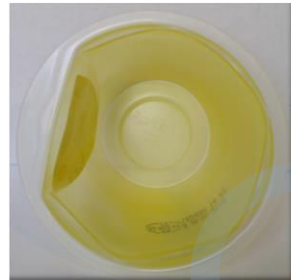
Contamination with contact

= migration

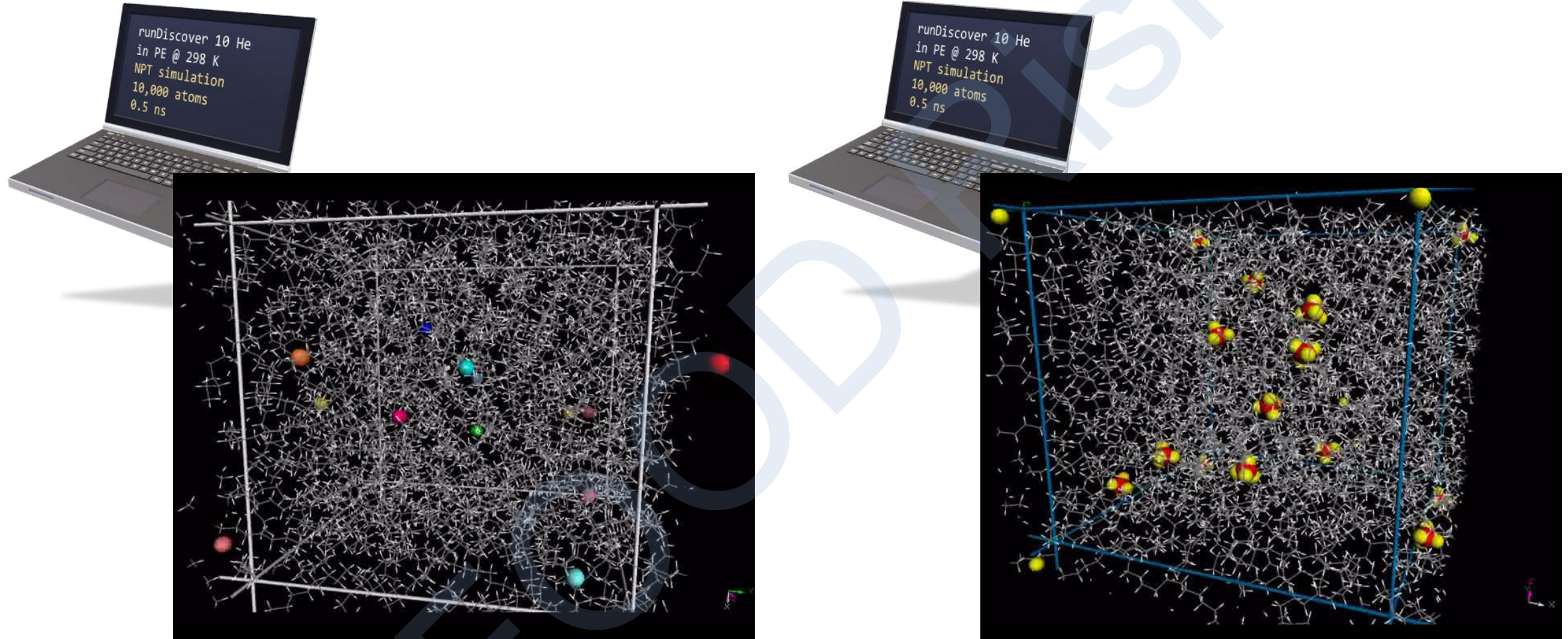
old routes = new issues

➤ The conventional description of migration

Observational evidences



➤ The kinetics of migration depends on the diffusivity of the substance



$$D \approx \frac{1}{6} \frac{\partial}{\partial t} \left\langle \left(x_{CM}(t) - x_{CM}(0) \right)^2 \right\rangle$$

➤ The conventional description of migration

The level of contamination depends essentially on the fatty character of the food in contact

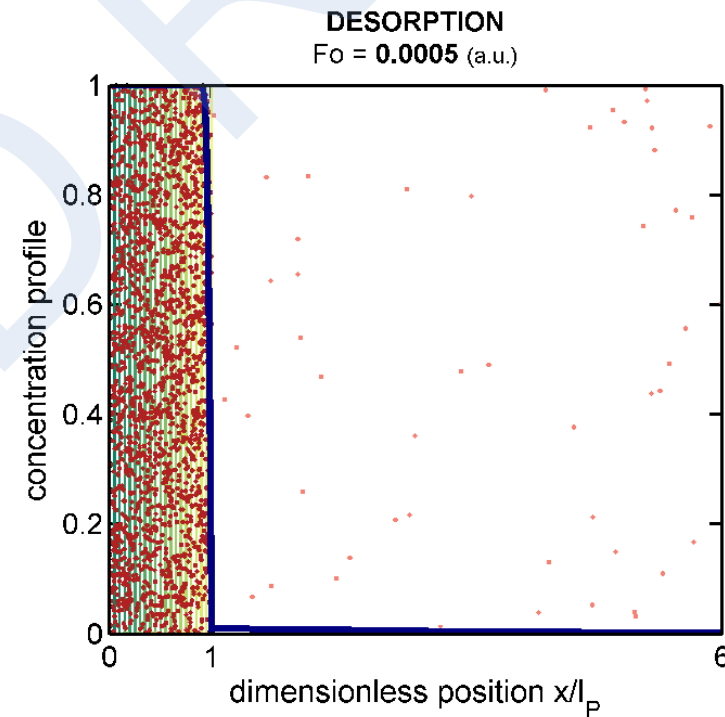
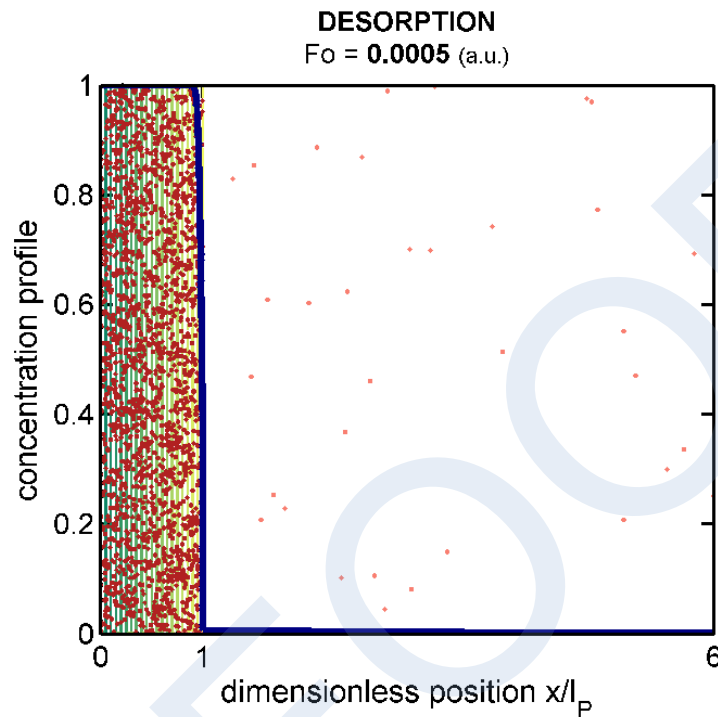
50 × more chemical affinity for P

50 × more chemical affinity for F

$K_{i,F/P} =$

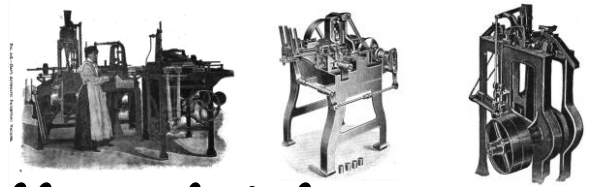
1/50

50



$$K_{i,F/P} = \frac{C_{i,F}^{eq}}{C_{i,P}^{eq}} = \frac{1}{1 - \text{crystallinity}} \frac{\gamma_{i,P}^v}{\gamma_{i,F}^v}$$

> Food inertia: a long history



Le règlement de 1908: « ...aucune substance alimentaire ne doit contenir de produit nuisible, produit chimiques... »

L'ART DE CONSERVER,

PENDANT PLUSIEURS ANNÉES,

TOUTES LES SUBSTANCES ANIMALES ET VÉGÉTALES;

Ouvrage soumis au Bureau consultatif des Arts et Manufactures, revêtu de son approbation, et publié sur l'invitation de S. Exc. le Ministre de l'intérieur.

PAR APPERT,

Propriétaire à Massy, Département de Seine et Oise, ancien Confiseur et Distillateur, élève de la bouche de la Maison ducale de Christian IV.

« J'ai pensé que votre découverte méritait un témoignage particulier de la bienveillance du Gouvernement ».

Lettre de S. Exc. le Ministre de l'intérieur.

A PARIS,

CHEZ PATRIS ET C^{ie} IMPRIMEURS-LIBRAIRES, QUAI NAPOLÉON, AU COIN DE LA RUE DE LA COLOMBE, N° 4.

1810.

INRAE

Food Risk – Jan 30-31, Nîmes - The fate of food pack

2020-01-16 / IHST / Olivier Vitrac

8^{me} ANNÉE. — N° 49 JUILLET 1910

LA CONSERVE ALIMENTAIRE

Bulletin mensuel de Vulgarisation Théorique et Pratique de Fabrication
PARAISANT LE 15 DE CHAQUE MOIS
Rédigé par un groupe de Fabricants-Industriels et de Chefs d'Emplois de cette Industrie



Nicolas APPERT
(1740-1841)

École Nationale d'INDUSTRIE ALIMENTAIRE

Nicolas Appert

COMITÉ DE DIRECTION
Bourse du Commerce
— Paris —

L'idée de la création de cette école dont nous avons été les plus fervents propagandistes vient d'être mise définitivement au point par un groupe de praticiens, de chimistes et d'agronomes distingués qui vont en assurer le fonctionnement.

L'enseignement sera tout à la fois théorique et pratique.

Dans la voie pratique, le Comité de Direction se propose, non pas d'organiser une usine de fabrication de conserves et de produits alimentaires divers, destinée à concurrencer l'industrie libre, mais de créer des laboratoires d'essais et d'enseignement que dirigera un praticien qualifié et où chaque fabricant pourra venir se documenter et concourir aux progrès de la science alimentaire.

Les essais théoriques seront dirigés par un technologue éminent, M. CROUVOIS, chef de laboratoire à l'Institut Pasteur.

Une très large place sera réservée, dans l'enseignement à la question des machines, appareils et ustensiles employés par l'industrie alimentaire. Un ingénieur diplômé, M. RAYMOND MONOT, des usines de Diétrich, est chargé d'organiser cette partie du programme.

M. MORÉAL DE BRÉVANS, le distingué sous-directeur du laboratoire municipal, a bien voulu se charger de l'enseignement si important de la chimie appliquée à l'alimentation.

Enfin M. ED. JACQUET, ingénieur-agronome, administrateur de l'école, occupera la chaire de professeur d'« Alimentation Commerciale ».

Ajoutons que notre bulletin transformé en revue bi-mensuelle à laquelle collaboreront désormais les personnalités ci-dessus, devient le Bulletin Officiel de l'école.

En un mot et suivant l'exemple d'autres pays, une Université nouvelle et bien moderne vient de naître en France, celle de l'Industrie Alimentaire. Cette industrie quitte ainsi, définitivement, le domaine empirique pour rentrer dans celui des sciences exactes, où elle avait

200 LA CONSERVE ALIMENTAIRE

sa place déjà marquée par les exigences et le progrès sans cesse grandissant de la vie contemporaine.

Pour le Comité de Direction :
Aug. CORTHAY.

Causerie Professionnelle

par Nicolas APPERT

Méfions-nous des Conservés Étrangères

Nous donnons ci-dessous la traduction d'un extrait du passage que M. Hamel consacre à la législation et l'inspection des conserves alimentaires au Canada, dans le traité qu'il publie en ce moment. (Modern practice of canning meats) :

« Comparés avec les règlements qui régissent l'inspection des conserves alimentaires aux États-Unis et en Europe, ceux du Canada sont encore à l'état embryonnaire.

Pour protéger les fabricants Canadiens contre la concurrence des États-Unis, il était nécessaire de créer une législation, au moins sur le papier.

« Je ne parle pas ici de l'inspection des viandes fraîches qui est soumise à un groupe de savants et de vétérinaires de valeur.

« Mais l'acheteur éclairé de conserves alimentaires quelles qu'elles soient, viandes, poissons, fruits ou légumes est loin d'avoir obtenu la même sécurité.

« Le règlement en date de 1908 qui régit l'inspection des conserves alimentaires nous dit :

Aucune substance alimentaire ne doit contenir de produit nuisible, produits chimiques, colorants ou antiseptiques, et plus loin on nous dit : Il sera fourni aux Inspecteurs par les soins du Ministère de l'Agriculture les noms des antiseptiques et colorants inoffensifs dont l'emploi est permis. L'addition de tout autre empêchera le produit de recevoir l'étiquette constatant l'inspection.

« Nous comprenons bien que les chimistes du Ministère sont là pour condamner tout produit alimentaire où l'analyse révélerait la présence d'un produit chimique dangereux, mais pour ceux qui sont au courant des discussions en cours entre les hygiénistes les plus distingués du monde entier au sujet de la plus ou moins grande nocivité de tel ou tel antiseptique, la satisfaction est maigre.

« Je répète que le fabricant de conserves en boîtes n'a pas besoin d'antiseptiques pour assurer la conservation indéfinie de ses produits. La stérilisation lui suffit.

« Pourquoi donc ne pas faire comprendre au monde entier que les mots « CANADA APPROVED » de l'étiquette signifient absence entière de substances nuisibles, aussi bien dans les conserves que dans les viandes fraîches.

« Que si quelques antiseptiques sont considérés comme inoffensifs par le Ministère de l'Agriculture, pourquoi ne pas faire connaître au public comme aux fabricants le nom de ce qui est permis et de ce qui est prohibé ?

« Le règlement de 1908 ne prend nullement en considération la qualité de la soudure employée, pas plus que celle de l'acide, et il semble que sur ce point les japonais sont bien en avance sur nous lorsqu'ils donnent les commandes pour leur armée.

« Pour en finir, il semble que des instructions plus complètes auraient été pour le plus grand intérêt du fabricant lui-même, en donnant au public consommateur une garantie parfaite de sécurité. La consommation en aurait été accrue en regagnant la confiance des consommateurs qui sont peu confiants dans les conserves, généralement sans raisons, d'ailleurs. »

G. T. HAMEL, ingénieur.

L'auteur faisant une œuvre purement technique et non de polémique est évidemment très modéré. Mais pour qui lit entre les lignes et pour nous qui savons combien sont rares parmi le personnel de l'inspection les gens compétents, toutes les places étant prises par les politiciens, nous ne nous sentons pas rassurés.



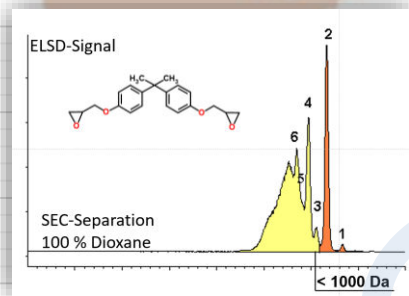
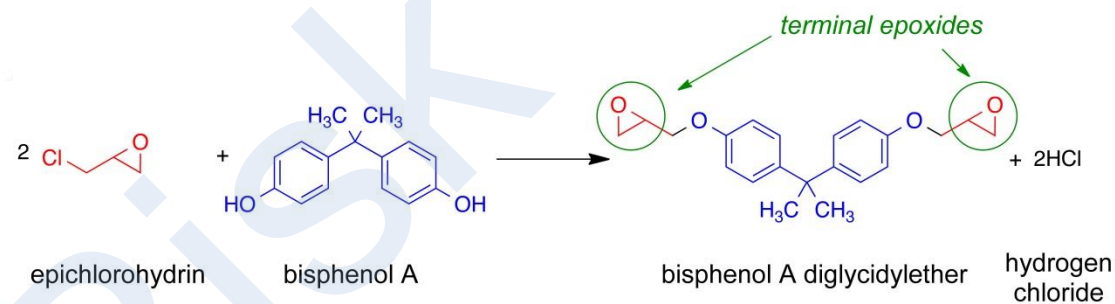
Google Trends / Bisphenol A: (Worldwide)

CANCO: Ensuring the safety of consumers:
can coatings for direct food contact.
Project QLAM-2001-00066.

M +1 Substances
(originated from the resin)

359	BADGE-H ₂ O
341	BADGE
643	BADGE(n=1)-H ₂ O
569	Cyclo-DIBADGE
625	BADGE(n=1)
927	BADGE(n=2)-H ₂ O
491	BADGE-tBuPh*
909	BADGE(n=2)
775	BADGE(n=1)-tBuPh
641	BADGE-2tBuPh
477	BADGE-H ₂ O-BuEtOH**
403	BADGE-EG*** (+)
459	BADGE-BuEtOH
509	BADGE-H ₂ O-tBuPh
577	BADGE-2BuEtOH
687	BADGE(n=1)-EG (+)
743	BADGE(n=1)-BuEtOH
609	BADGE-BuEtOH-tBuPh
971	BADGE(n=2)-EG (+)

* t-BuPh: tert-Butylphenol (chain stopper)
** BuEtOH: Butoxyethanol
*** EG: Ethyleneglycol
(+) Further confirmations are necessary



LOI no 2012-1442 du 24 décembre 2012



Current Biology 2018, 28,1



REGULATION 2018/213/EC



Bisphenol A Exposure Causes Meiotic Aneuploidy in the Female Mouse

Patricia A. Hunt,^{1,*} Kara E. Koehler,¹ Martha Susiarjo,¹ Craig A. Hodges,¹ Arlene Ilagan,¹ Robert C. Voigt,^{2,5} Sally Thomas,³ Brian F. Thomas,⁴ and Terry J. Hassold¹

¹Department of Genetics

²Animal Resource Center
Case Western Reserve University
Cleveland, Ohio 44106-4955

³Thoren Caging Systems
Hazleton, Pennsylvania 18201

⁴RTI International
Research Triangle Park, North Carolina 27709-2194

Summary

Background: There is increasing concern that exposure to man-made substances that mimic endogenous hormones may adversely affect mammalian reproduction. Although a variety of reproductive complications have been ascribed to compounds with androgenic or estrogenic properties, little attention has been directed at the potential consequences of such exposures to the genetic quality of the gamete.

Results: A sudden, spontaneous increase in meiotic disturbances, including aneuploidy, in studies of oocytes from control female mice in our laboratory coincided with the accidental exposure of the facility to an environmental source of bisphenol A. Bisphenol A was implicated as a potent disruptor of meiosis because of its known estrogenic properties and its widespread use in polycarbonate plastics and epoxy resins. To test this hypothesis, we were able to recapitulate the increase in aneuploidy by intentionally damaging cages with bisphenol A. In subsequent studies of female mice, we found that daily oral doses of BPA to control mice resulted in a similar increase in aneuploidy, demonstrating that low levels of BPA disrupt female meiosis. Our results demonstrated that the meiotic effects were dose dependent and could be induced by environmentally relevant doses of BPA.

Conclusions: Both the initial inadvertent exposure and subsequent experimental studies suggest that BPA is a potent meiotic aneugen. Specifically, in the female mouse, short-term, low-dose exposure during the final stages of oocyte growth is sufficient to elicit detectable meiotic effects. These results provide the first unequivocal link between mammalian meiotic aneuploidy and an accidental environmental exposure and suggest that the oocyte and its meiotic spindle will provide a sensitive assay system for the study of reproductive toxins.

Introduction

An estimated 10%–25% of fertilized human oocytes are aneuploid; thus, numerical chromosome abnormalities

are the leading cause of miscarriage, congenital defects, and mental retardation [1]. Because almost all such aneuploidy derives from meiotic errors, considerable effort has been directed at identifying factors that increase meiotic nondisjunction. A number of potential risk factors, including irradiation (e.g., [2, 3]), smoking or drinking (e.g., [4, 5]), oral contraceptives and fertility drugs (e.g., [4, 6]), and environmental pollutants/pesticides (e.g., [7]), have been suggested. However, significant effects have been small and difficult to verify or disputed, making positive associations hard to establish. In part, this may reflect difficulties in detection. For example, the extraordinary effect of maternal age on aneuploidy may obscure less obvious associations. Further, previous studies may have focused on the “wrong” population; that is, most utilized liveborns, although virtually all aneuploidy terminates in miscarriage. Thus, the contribution of environmental insults to meiotic chromosome errors remains unknown.

We recently experienced an inadvertent environmental exposure in our mouse colony to 2,2-(4,4-dihydroxydiphenyl)propane, or bisphenol A. Bisphenol A (BPA) is the monomer that is polymerized to manufacture polycarbonate plastic products and resins, such as those used to line cans containing food and beverages and those found in dental sealants. The exposure was accompanied by highly significant increases in meiotic abnormalities, including nondisjunction. Bisphenol A was implicated as a potent disruptor of meiosis because of its known estrogenic properties and its widespread use in polycarbonate plastics and epoxy resins. To test this hypothesis, we were able to recapitulate the increase in aneuploidy by intentionally damaging cages with bisphenol A. In subsequent studies of female mice, we found that daily oral doses of BPA to control mice resulted in a similar increase in aneuploidy, demonstrating that low levels of BPA disrupt female meiosis. Our results demonstrated that the meiotic effects were dose dependent and could be induced by environmentally relevant doses of BPA.

A Sudden Increase in Meiotic Abnormalities Is Correlated with Damage to Caging Materials

We recently reported meiotic studies of mouse mutants with defects in the alignment of the chromosomes on the first meiotic (MI) spindle [8]. This meiotic abnormality, which we have termed congression failure (Figure 1), is of particular relevance to humans because it is an age-related feature of human oocytes and has been postulated to be causally related to the well-known increase in aneuploidy associated with advancing maternal age [9].

In the course of meiotic studies of mouse oocytes conducted in 1998, we observed a sudden and dramatic change in congression failure levels. The first wave of follicles that initiate growth in the sexually immature ovary provides access to a large cohort of oocytes, and, typically, only 1%–2% of oocytes from control females exhibit congression failure at metaphase I [8]. However, in experiments conducted in August 1998, congression failure levels suddenly spiked, and approximately 40% of control oocytes exhibited this phenotype or more severe aberrations (Figures 1 and 2).

At the same time that these studies were being conducted, we were also using the animal facility to house

Replacement Bisphenols Adversely Affect Mouse Gametogenesis with Consequences for Subsequent Generations

Tegan S. Horan,¹ Hannah Pulcastro,¹ Crystal Lawson,¹ Roy Gerona,² Spencer Martin,² Mary C. Gieske,¹ Caroline V. Sartain,¹ and Patricia A. Hunt^{1,3,*}

¹School of Molecular Biosciences, Center for Reproductive Biology, Washington State University, Pullman, WA, USA

²School of Medicine, University of California, San Francisco, CA, USA

³Lead Contact

*Correspondence: pathunt@wsu.edu
<https://doi.org/10.1016/j.cub.2018.06.070>

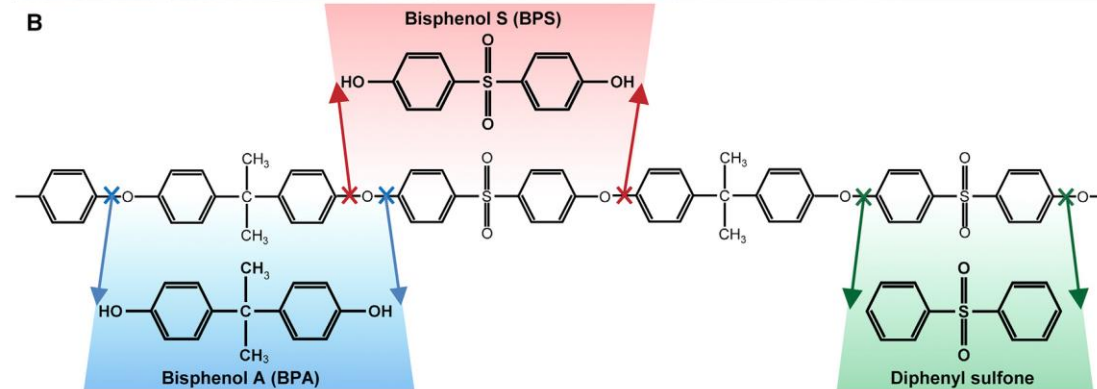
SUMMARY

20 years ago, accidental bisphenol A (BPA) exposure caused a sudden increase in chromosomally abnormal eggs from our control mice [1]. Subsequent rodent studies demonstrated developmental effects of exposure with repercussions on adult health and fertility (e.g., [2–9]; reviewed in [10–17]). Studies in monkeys, humans, fish, and worms suggest BPA effects extend across species (e.g., [18–30]; reviewed in [31–33]). Widespread use has resulted in ubiquitous environmental exposure to BPA and human BPA exposure. To test the hypothesis that BPA exposure resulted in “BPA-free” products, we replaced polycarbonate cages with BPA-free polycarbonate cages. Surprisingly, we found that naturally similar bisphenols to BPA, bisphenol S (BPS) and bisphenol AF (BPAF), also caused an increase in meiotic abnormalities [34–41]. We report here studies demonstrating that BPS and BPAF also cause changes mirroring our previous findings with BPA and implicating exposure to these replacement bisphenols as a cause of the increase in aneuploidy (replacement) from damaged polysulfone cages. Like with BPA [1, 2, 5], our data show that exposure

Results and Discussion

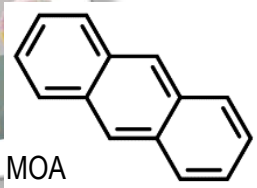
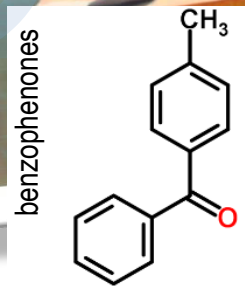
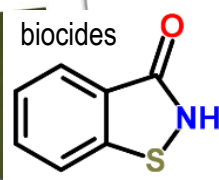
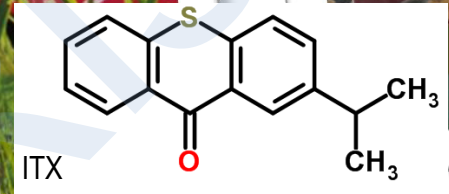
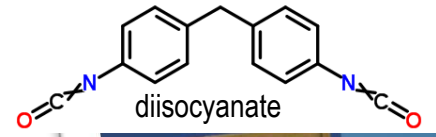
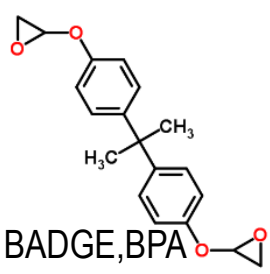
In the course of meiotic studies in male and female mice, we observed variation in meiotic recombination (measured by the number of MLH1 foci in pachytene stage meiocytes), with levels in some controls reaching values characteristic of BPA-exposed animals [2, 5]. Although the change in pooled data was subtle, variation among litters was striking (Figure 1). Given our previous experience with BPA leaching from polycarbonate cages and water bottles [1], damaged materials were an obvious suspect. When white residue was evident on the surface of some polysulfone cages in our facility (Figure 2A), we suspected that exposure to chemicals leaching from the damaged polymer was eliciting

the increase in meiotic abnormalities. The residue was comprised of BPA and diphenyl sulfone (Figure 2B). To test this hypothesis, we suspected that these were the contaminants, we performed liquid chromatography–tandem mass spectrometry (LC/MS/MS) analysis of a methanol extraction of damaged cages. The analysis demonstrated the presence of both BPA and diphenyl sulfone (Figure 2C–2F). Because polymeric aromatic ethers, like BPS and BPAF, cannot undergo nucleophilic substitution to generate an unsubstituted aromatic ring at the reaction site, degradation results in the formation of a phenolic group.



*Correspondence: pah13@po.cwru.edu

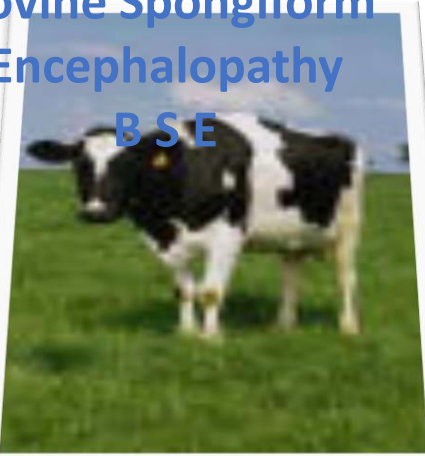
⁵Present address: Lab Products, 742 Sussex Avenue, P.O. Box 639, Seaford, Delaware 19973.



Food and Feed borne crises throughout the food chain

Bovine Spongiform
Encephalopathy

BSE



Sudan red

Dioxins



Chloramphenicol

CAP



Cotoxins



destroy consumer's confidence in food

But what about food packaging



Nonylphenol
NP

?



Semicarbazide/SEM



Organic solvents/
residues



Bisphenol A diglycidyl ether
(BADGE)

Italian police seize contaminated Nestle baby milk

22 Nov 2005 16:45:09 GMT

Source: Reuters



(Adds Tetra Pak comment in paragraph 11)

By Massimiliano Di Giorgio and Isabel Strassheim

ROME/ZURICH, Nov 22 (Reuters) - Italian police seized around 30 million litres of baby milk produced by Swiss food giant Nestle <NESN.VX> on Tuesday after tests showed it was contaminated with traces of ink used in the packaging.

Nestle said the chemical substance was not harmful, but announced it was recalling the infant food in four European countries, including Italy, because of the problem, which related to Tetra Pak cartons.

Italian Agriculture Minister Gianni Alemanno demanded tests to see if babies given the contaminated milk over a prolonged period faced health risks.

"It is incredible that such defenceless

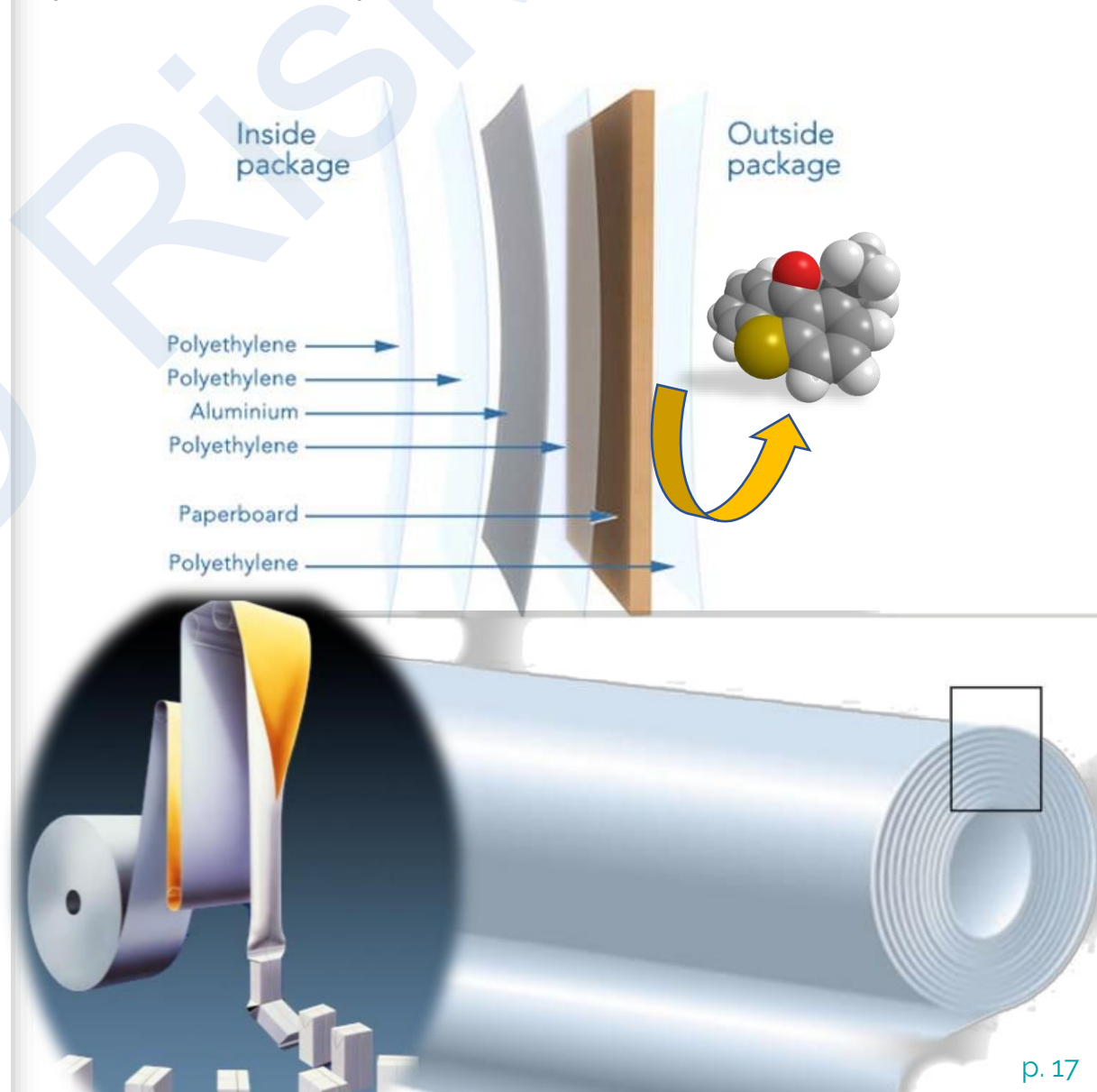
[← PREVIOUS](#) | [NEXT →](#)

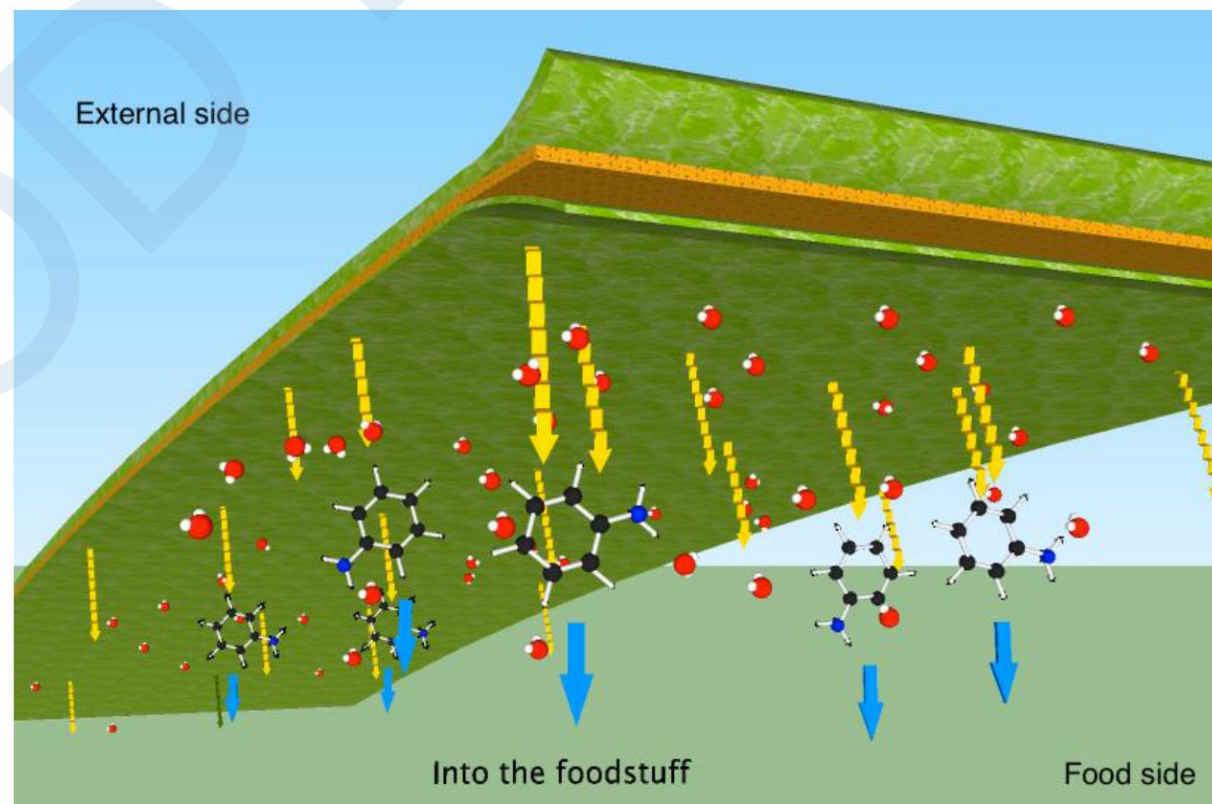
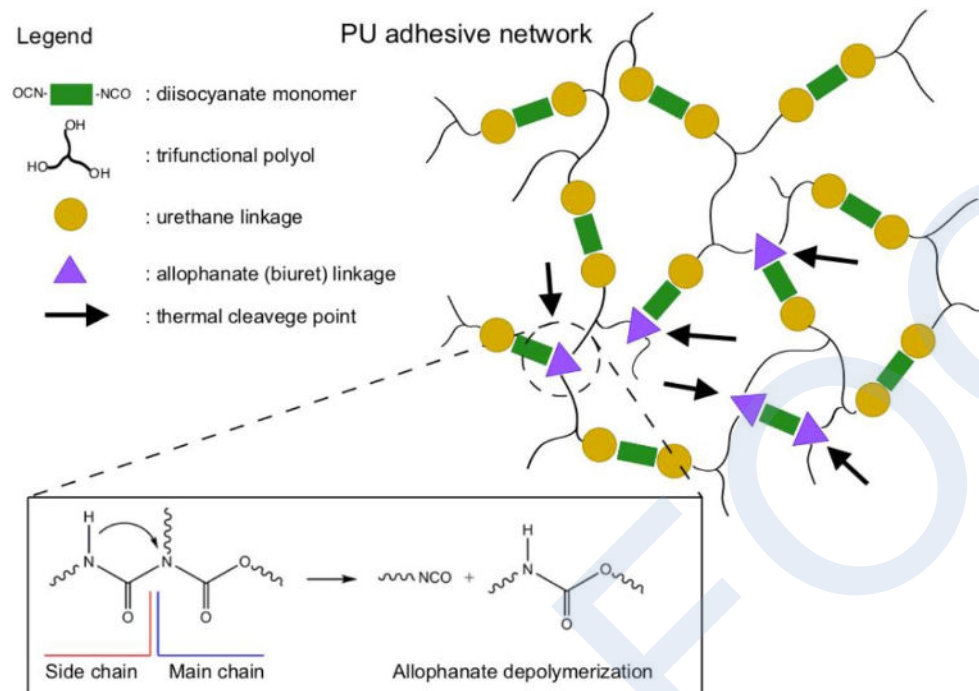
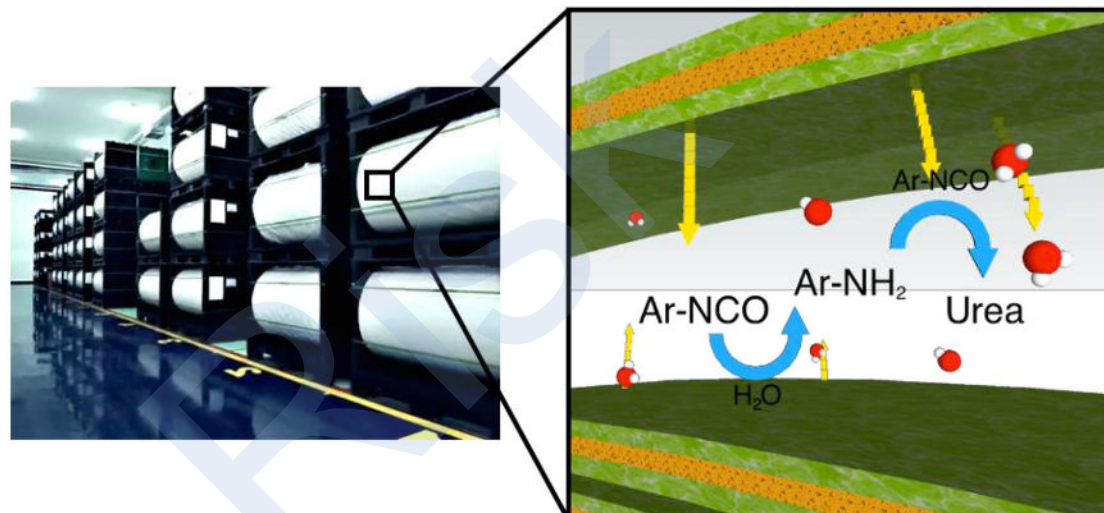
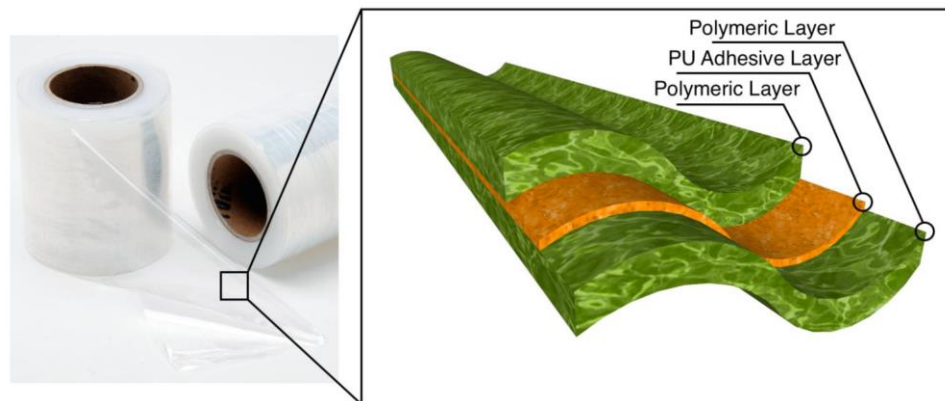
Forest Ranger officials check a package of baby milk made by Swiss food group Nestle in a supermarket in Italy November 22, 2005. Italian police seized around 30 million litres of baby milk produced by Nestle on Tuesday after tests showed traces of ink, and the company said it was recalling the infant food in four European countries. REUTERS/HO

beings as babies should face such serious risks in a product as widely used as milk," Alemanno said in a statement.

Italian officials said they had already seized about 2 million litres of Nestle baby milk earlier this month after finding traces of isopropylthioxanthone (ITX), an ink component used in the offset printing process of the Tetra Pak cartons.

"It is incredible that such defenseless beings as babies should face such serious risks in a product as widely used as milk"







CHEMICAL SAFETY
Contaminants
Residues of Veterinary Medicines
Hormones in Meat
Pesticide Residues
Food Contact Materials
Legislation
Authorisations
Non-harmonised
Consultation

Food Contact Materials



RELATED LINKS

- [Food Contact Materials Database](#)
- [Multi-language versions of brochures and guidance](#)

RELATED DOCUMENTS

- [EU guidelines on conditions and procedures for the import of polyamide and melamine kitchenware originating in or consigned from China and Hong Kong](#)
- [EU Guidance to the Commission Regulation \(EC\) No 450/2009 on active and intelligent materials and articles intended to come into contact with food](#)

QUICK LINKS

- Rapid Alert for Food and Feed (RASFF)
- Health and food audits and analysis
- European Food Safety Authority (EFSA)
- Better Training for Safer Food (BTSF)
- E-News
- Events
- Videos

Food comes into contact with many materials and articles during its production, processing, storage, preparation and serving, before its eventual consumption. Such materials and articles are called **Food Contact Materials (FCMs)**. Food contact materials are either intended to be brought into contact with food, are already in contact with food, or can reasonably be brought into contact with food or transfer their constituents to the food under normal or foreseeable use. **This includes direct or indirect contact.** Examples include:

- containers for transporting food
- machinery to process food
- packaging materials
- kitchenware and tableware

The term **does not cover fixed public or private water supply equipment.**

FCMs should be sufficiently inert so that their constituents neither adversely affect consumer health nor influence the quality of the food. To ensure the safety of FCMs, and to facilitate the free movement of goods, EU law provides for binding rules that business operators must comply with.

The EU Rules on food contact materials can be of general scope, i.e. apply to all FCMs or apply to specific materials only. EU law may be complemented with Member States national legislation if specific EU rules do not exist.

The safety of FCM is evaluated by the **European Food Safety Authority (EFSA)**. At EFSA's website you can search for [opinions on substances to be used in food contact materials](#).

The safety of Food Contact Materials is tested by the business operators placing them on the market, and by the competent authorities of the Member States during official controls. Scientific knowledge and technical competence on testing methods is being maintained by the **European Reference Laboratory for Food Contact Materials (EURL-FCM)**. Its website provides guidelines and other resources concerning the testing of food contact materials.

Principles for EU legislation

Union legislation on food contact materials at EU level aims to:

- Protect consumers' health
- Ensure the effective functioning of the internal market

Contacts

- SANTE-fcm@ec.europa.eu
- National authorities [EN](#) [FR](#) [IT](#) [ES](#) [PT](#) [NL](#) [DE](#) [PL](#) [CZ](#) [SK](#) [HU](#) [SI](#) [BG](#) [RO](#) [GR](#) [CY](#) [EL](#) [MT](#) [LU](#) [BE](#) [IE](#) [UK](#) [SE](#) [NO](#) [DK](#) [FI](#) [EE](#) [LV](#) [LT](#) [PL](#) [CZ](#) [SK](#) [HU](#) [SI](#) [BG](#) [RO](#) [GR](#) [CY](#) [EL](#) [MT](#) [LU](#) [BE](#) [IE](#) [UK](#) [SE](#) [NO](#) [DK](#) [FI](#) [EE](#) [LV](#) [LT](#)
- European professional organisations
- European Reference Laboratory on Food Contact Materials (EURL-FCM)
- European Food Safety Authority

Training

For government officials engaged in food and feed safety inspection of selected countries training on food contact materials is provided free of charge under **BTSF**. Also refer to the **European Training Platform for Safer Food**.

Legislation

I. General legislation

The framework Regulation

Regulation (EC) No 1935/2004 provides a harmonised legal EU framework. It sets out the general principles of safety and inertness for all Food Contact Materials (FCMs).

The principles set out in Regulation (EC) No 1935/2004 require that materials do not:

- Release their constituents into food at levels harmful to human health
- Change food composition, taste and odour in an unacceptable way

Moreover, the framework provides:

- for special rules on active and intelligent materials (they are by their design not inert)
- powers to enact additional EU measures for specific materials (e.g. for plastics)
- the procedure to per FCMs involving the E
- rules on labelling inc bottle, or a soup s information, please i contact materials.
- for compliance docu

Regulation on Good Manu

Regulation (EC) No 2023/21 so that the specifications for

- premises fit for purpose
- documented quality premises, and
- selection of suitable s the safety and inertn

Good manufacturing rules : materials, although the pro

II. EU legislation

In addition to the general cellulose film, plastics (in materials — are covered by starting substances used to

Plastic Materials

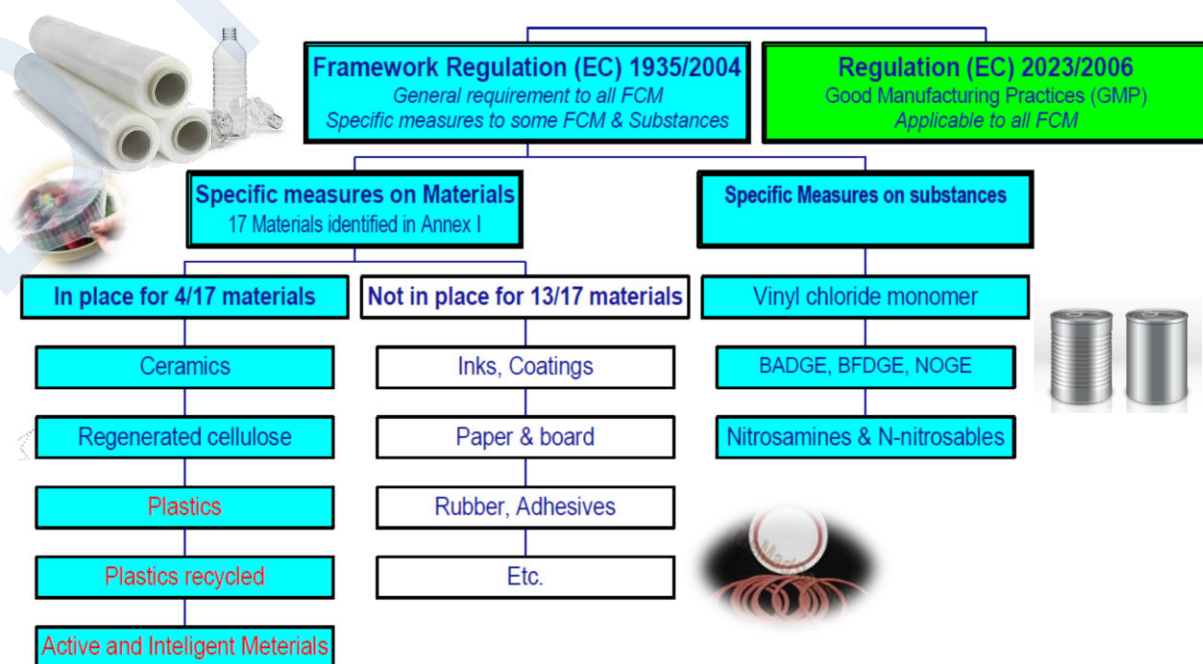
Active and Intelligent t

Recycled Plastic Materi

Ceramics

Regenerated Cellulose

EU LEGISLATION ON FCM

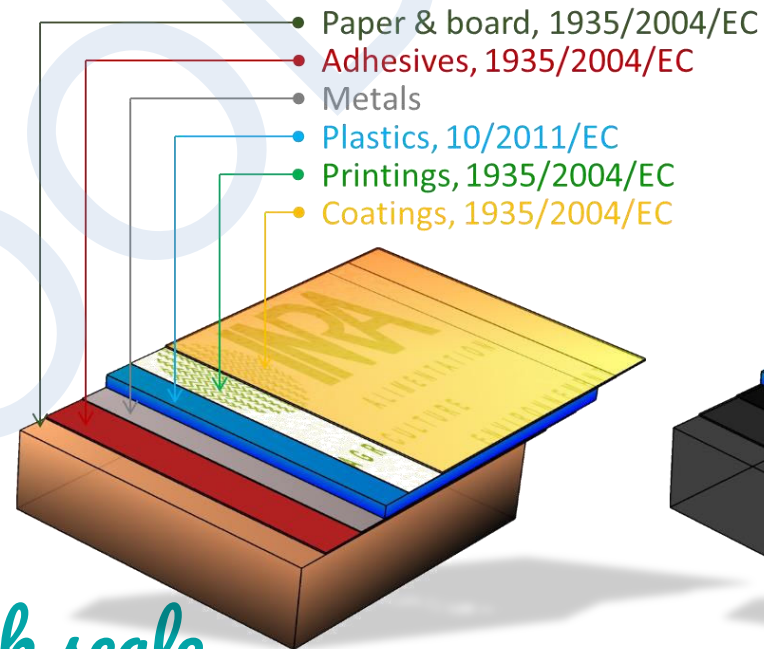
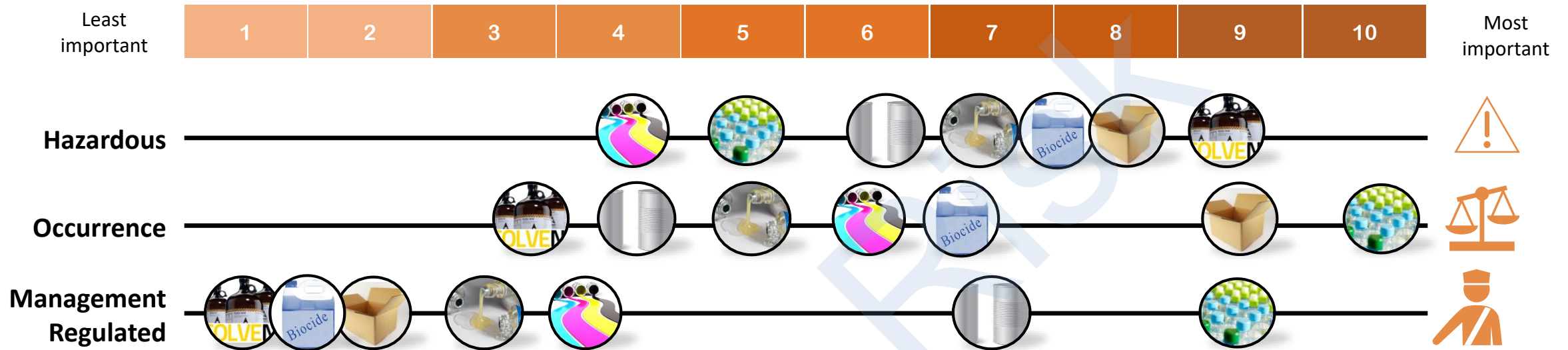


III. Other Legislation

Legislation on Specific Substances

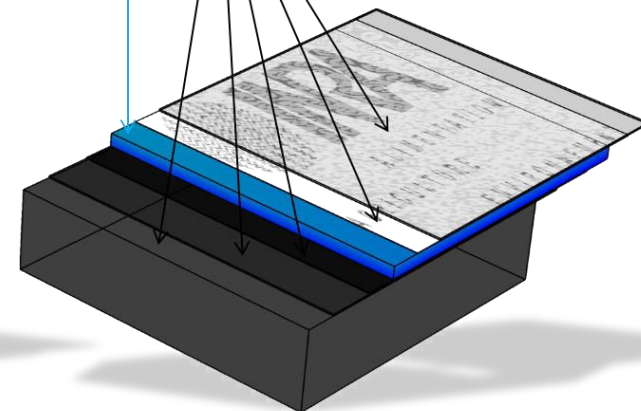
- Regulation 1895/2005/EC - restricting use of certain epoxy derivatives in materials and articles intended to come into contact with food
- Directive 93/11/EEC - release of N-nitrosamines and N-nitrosatable substances from rubber teats and soothers





**POSITIVE LIST (LOW TOXICITY:
monomers, additives)
LOW MIGRATION**

**GENERAL REQUIREMENT:
MUST NOT ENDANGER
HUMAN HEALTH**



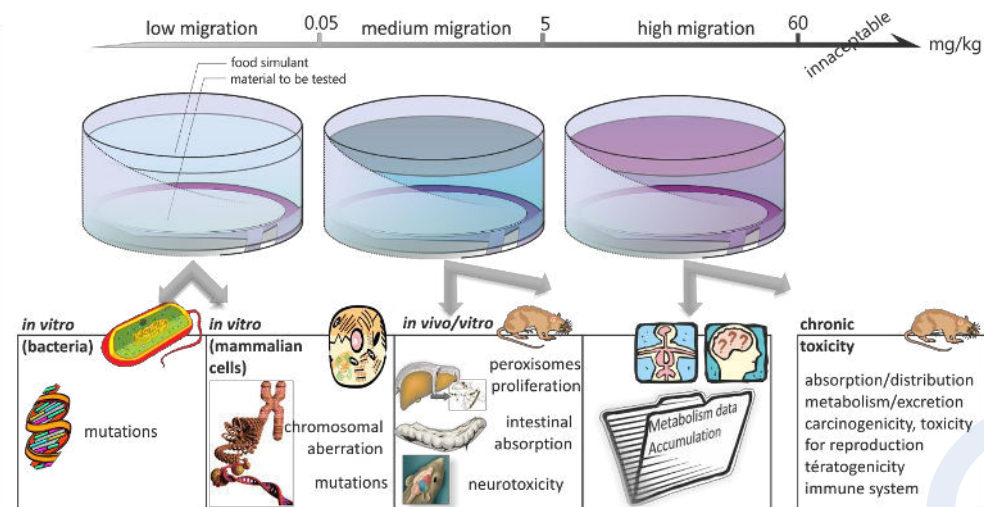
Contradictions and risk scale



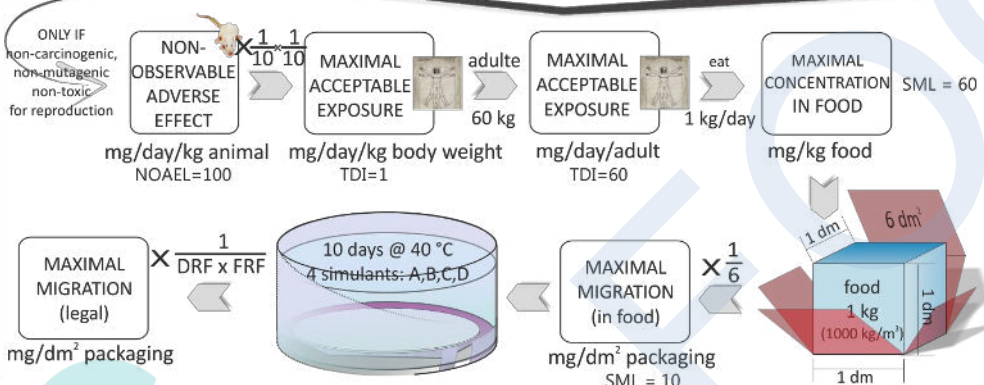
> SPECIFIC RULES FOR PLASTICS

EU regulation 10/2011/EC

SUBSTANCE AUTHORIZATION



APPLICATION AUTHORIZATION



INSIDE FOOD CONTACT MATERIALS

HOW CAN WE MAKE SURE THAT MIGRATION IS SAFE?

MIGRATION OF SUBSTANCES INTO FOOD OCCURS WITH ALL PACKAGING

Migration is a physical process and happens whenever packaging — of any type — comes into contact with food. It is natural. The key point is ensuring the level of migration remains safe.

PLASTICS ARE RIGOROUSLY TESTED TO MAKE SURE THAT MIGRATION - IF ANY - IS SAFE

Testing conditions are specified legally, and need to be used by all actors performing tests in the value chain from raw materials to packaging producers and to food packers. The tests are done at several stages in the value chain to ensure that the plastic sample is suitable in its end-use.

Variables can include:

- Temperature
- Time
- Contact surface
- Food type

Take a sample of the plastic

Test in contact with a food simulant

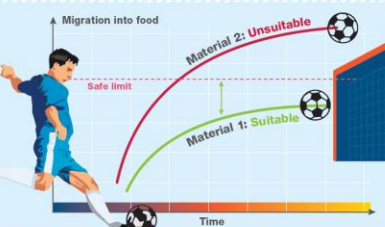
Monitor migration under standardised conditions

Analyse the results to verify that safety limits are met

WHAT DO THE TESTS SHOW?

The tests show how migration occurs in different food types under various conditions. The tests enable us to determine if a plastic packaging can be used for given food and conditions of use.

For example, it may be beneficial for long-term storage, unless they are suitable for high temperature. The tests are designed to exaggerate the real use scenario and therefore to make sure there is a safety margin, e.g. by assuming that all the food is in contact with the packaging, and by exaggerating levels of consumption. These testing conditions ensure that migration — if any — is far below the safety level.



WITH ALL THESE DATA, WE CAN ENSURE THE SAFE USE OF THE PACKAGING

INSIDE FOOD CONTACT MATERIALS

HOW CAN WE MAKE SURE THAT MIGRATION IS SAFE?

At all stages of the value chain, materials are produced in a controlled, safe and consistent way.

NINE GOLDEN RULES OF ENSURING SAFETY THROUGHOUT THE SUPPLY CHAIN:

- Assign management responsibilities for ensuring product safety, and train all operational personnel.
- Implement quality assurance systems and policies to ensure compliance with applicable regulations.
- Have procedures in place at production level to prevent contamination.
- Adhere to a stringent hygiene policy.
- Document all relevant information (e.g. product formulation, operating procedures, ensure correct labeling, and implement traceability procedures).
- Conduct internal risk assessment of the quality controls and specifications in order to ensure ongoing effective implementation.
- Have a system for complaint handling, product recall and incident management in place.
- Regularly carry out internal and supplier audits.
- Ensure that procedural changes are managed and implemented properly.

WHO ENSURES THE SAFETY OF FOOD CONTACT MATERIALS?

All of the different parties involved are required to issue a declaration of compliance that states product safety.



PROCESS FOLLOWS EFSA'S RISK ASSESSMENT PRINCIPLES



ALL THIS ENSURES SAFE FOOD CONTACT MATERIALS



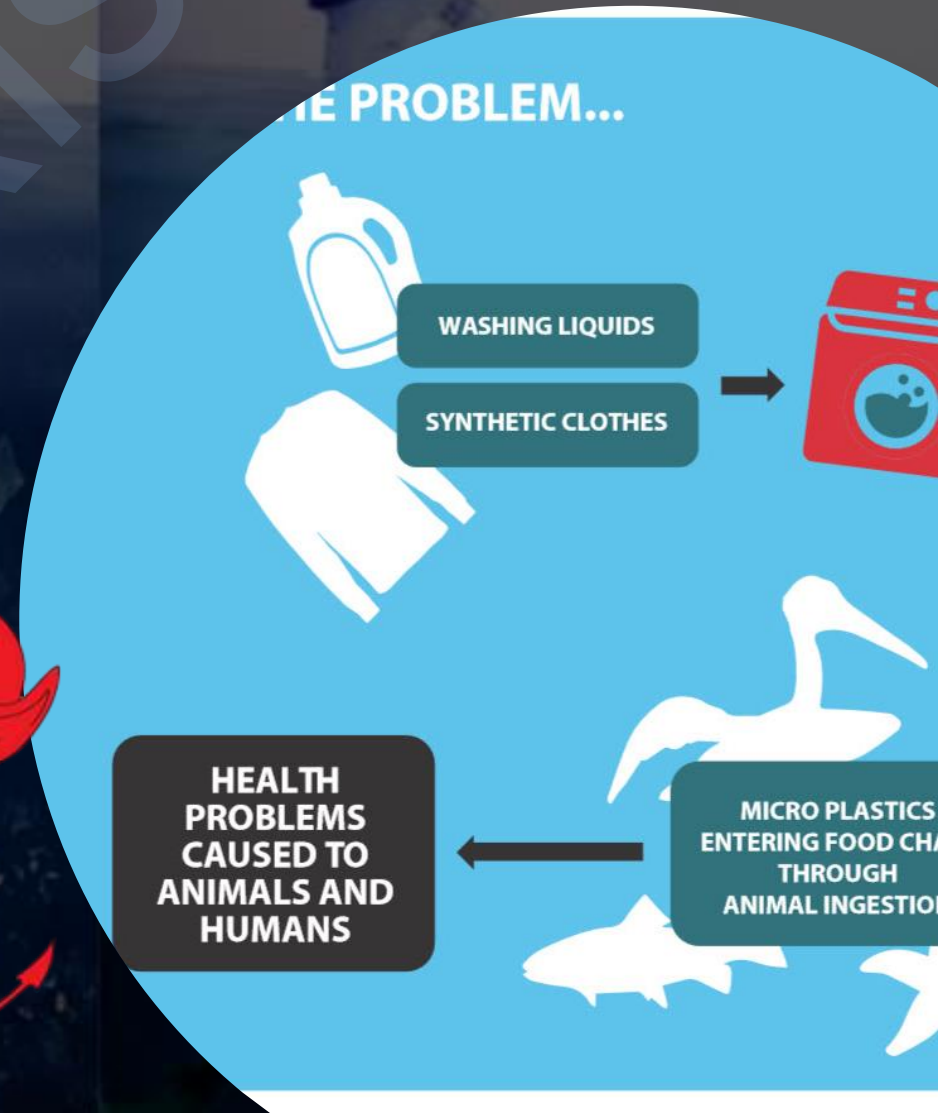
POLLUTED BY
SINGLE-USE PLASTIC

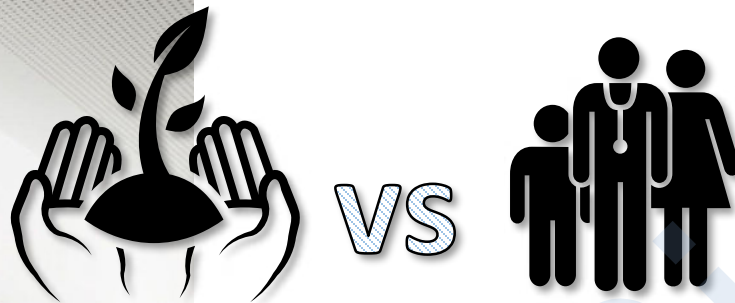
New contaminants

= Non Intentionally Added Substances

Packaging have been used for long before thinking about the consequences

*Bulky, unnecessary,
hazardous packaging*



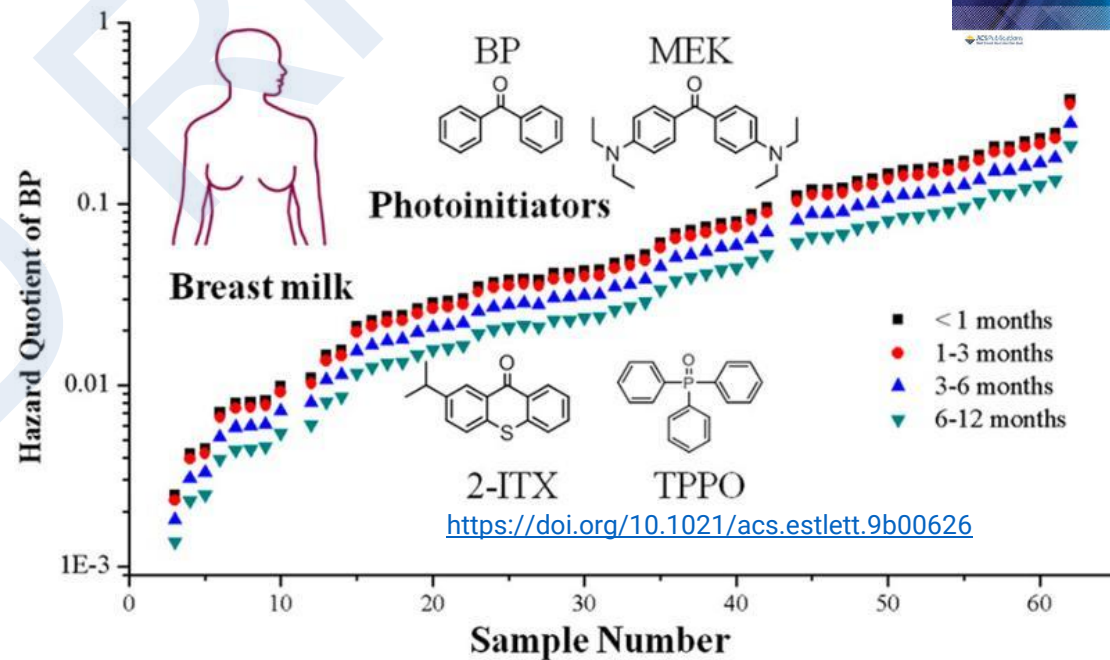


Recycling- kreislauf

Ein effektiver sowie effizienter Recyclingkreislauf basiert maßgeblich auf einer professionellen Müllsortierung. Ob Hausmüll, Gewerbe- oder Sperrmüll, Papier, Kartonage, Holz, Bauabfälle und Plastikflaschen – was für uns zählt ist höchstmögliche Sortenreinheit sowie maximaler Mengendurchsatz.

Recycling loop

Professional waste sorting is the basis for an effective and efficient recycling loop. Whether we're talking about household waste, commercial or bulk waste, paper, cartons, wood, construction waste or plastic bottles – what matters to us is the highest possible sorting accuracy and maximum throughput.



IS THE RECYCLED
MATERIAL AS SAFE
AS THE ORIGINAL
ONE ?

FILLING WITH
FOOD AGAIN

SUPER
CLEANING

FOOD GRADE

POSSIBLE
MISS-USE

GARBAGE
(POST-
CONSUMER
MATERIALS)

COLLECTION
WITH NON-
FOOD GRADE
MATERIALS

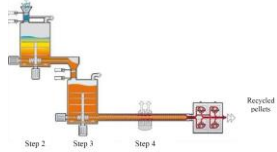
clear



EFSA has issued upward of 140 positive scientific opinions on the safety of processes to recycle plastics for use in food contact material.



ONLY recycled PET is authorized in EU.



500 M€ have been invested in plants capable of converting recycled plastic materials into materials suitable for packaging and food contact applications

In 2014, more than 50% of the recycled PET in Europe was used in food contact applications.



The lack of harmonisation amongst Member States generates legal uncertainty and unnecessary burden for the industry using recycled materials.

It also sets up obstacles for the Circular Economy

Recycling plastics for food contact

REGULATION 282/2008/EC



Polyolefins are rubber polymers which can be easily contaminated by high molecular weight contaminants after use.

Misuse issues (post-use contaminations) of Polyethylene terephthalate (**PET**) can be easily handled : glassy polymer, it is mainly contaminated by small contaminants which can be removed by a devolatilization step above T_g



1. Filling and use of HDPE milk bottles
2. Recollection
3. Sorting

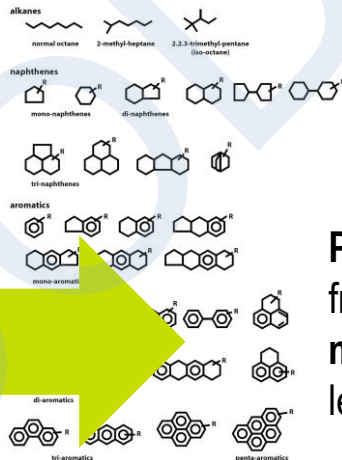


Foodgrade HDPE milk bottles



Suitable for Food Contact?

Recycling



Paper and board contains large amount of residues from printing inks: aromatic (carcinogenic) and aliphatic **mineral oils** can be transferred without contact and lead to cross-contamination between materials

J. of Chromatography A. 2013;1293:107-19.

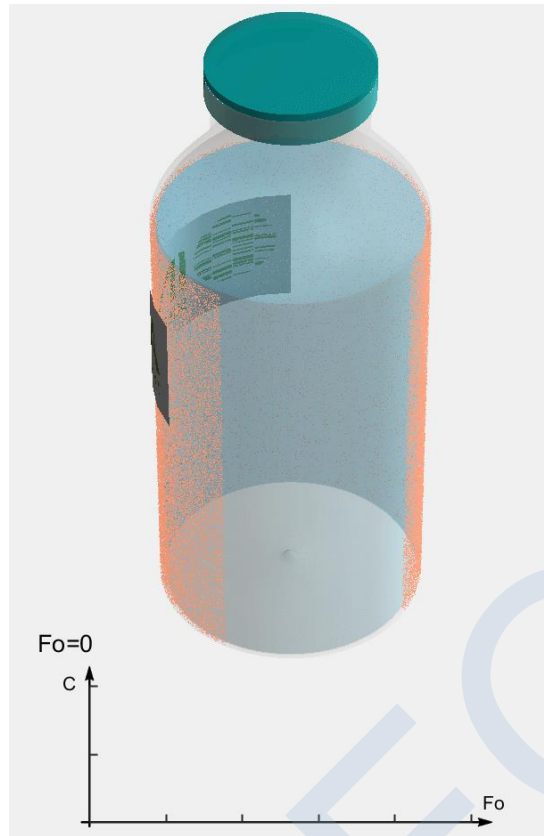
Recycled PET for food contact is authorized (282/2008/EC)
 Recycled polyolefins are authorized only in Germany
 Recycled paper and boards is source of recurring crises in EU.

Recycling of PET vs other materials

> How to use recycled materials

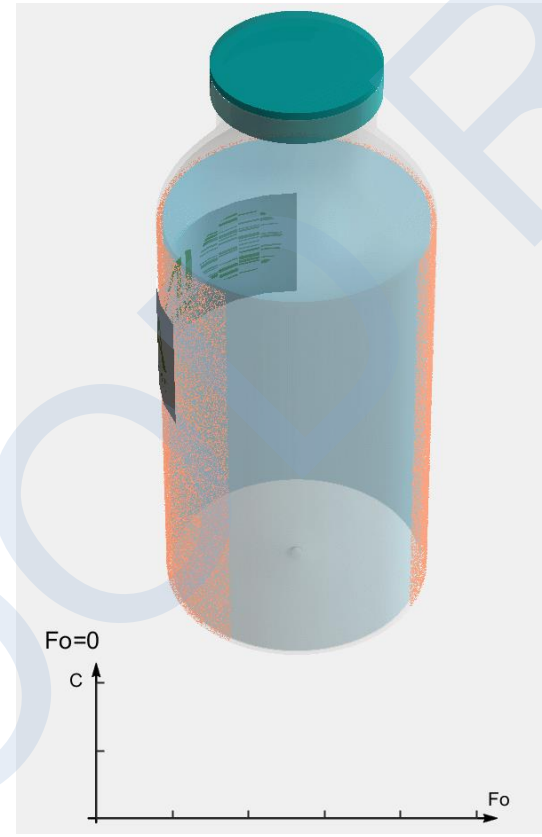
Within monolayer materials

Rule of TTC (Total Threshold of Concern)



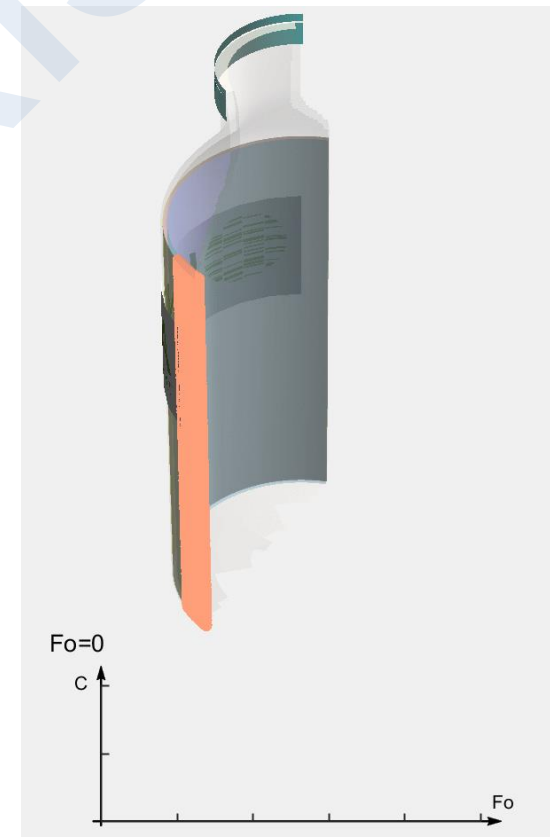
Behind a functional barrier

rule of 10 ppb for non-carcinogenic, non-mutagenic, non-reprotoxic



Within multilayer and/or multimaterial

No-clear guidance, specific rules case-by-case



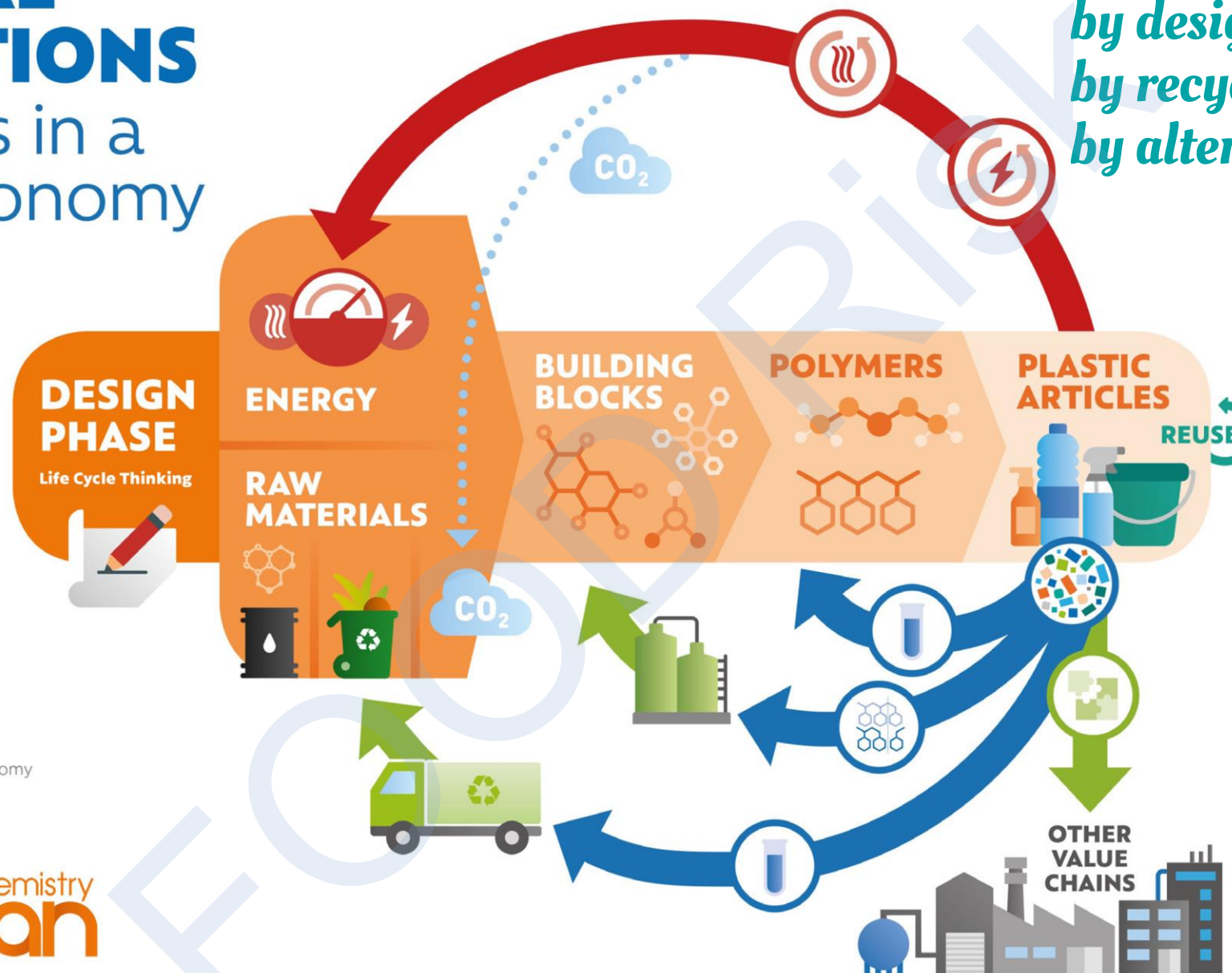
CHEMICAL INNOVATIONS

FOR Plastics in a Circular Economy

-  **Production chain**
-  **Recycling technologies**
Grinding, washing, compounding
Depolymerization, solvent extraction,
controlled bio-degradation
-  **Secondary raw materials**
-  **CO₂ utilization**
CO₂ as raw materials
-  **Energy recovery**
Heat, electricity

For more information about the Chemical industry's commitment to the circular economy please check our website www.cefic.org

Follow us on social media: @Cefic



> **Circularity**
by design
by recycling
by alternative feedstocks

> Current researches

• MATERIAL DESIGN

- Longer lifetime
- Decrease material usage
- Improve sorting, separation, recyclability
- Trigger biodegradability

• ARTICLE DESIGN

- Design for dismantling
- Decrease material usage
- Digital design for reuse
- Digital development of biobased

• RECYCLING

- Mechanical
- Chemical
- Thermal and thermomechanical
- Multimaterial, multilayer

• FEEDSTOCKS

- Plastic waste based
- Food waste based
- CO/CO₂ based

The recycling journey

How your plastic bottle is reborn

1 Collection
Your empty plastic bottle is collected and taken to a recycling facility for sorting. If you have already separated the plastic bottles from the rest of your recycling they can be sent straight to a recycling plant.

2 Separating
The recycling is hand-checked to remove any non-recyclable material. It is then loaded into a 'hammer', a large perforated spinning drum. Plastic bottles and cans are separated through the perforations, and then steel and aluminium cans are removed using magnets and electromagnetic technology.

3 Sorting
The bottles are then cleaned and sorted by type and colour using infrared beams. The infrared light is reflected off the plastics in different ways, allowing a sensor to detect which is which. Precision jets of air then separate the different types.

4 Shredding and melting
Next the bottles are shredded by a machine and the shreds washed again to remove any impurities, including remnants of paper labels or the bottle's original contents. They may also be decontaminated further using a chemical solution. The shreds of plastic are then dried and melted down.

5 Flaking
The melted plastic is reformed into flakes or pellets as it cools. These can then be melted down again and used to make new products. For example, the melted plastic can be reformed into new plastic bottles, ready to be filled with a product.

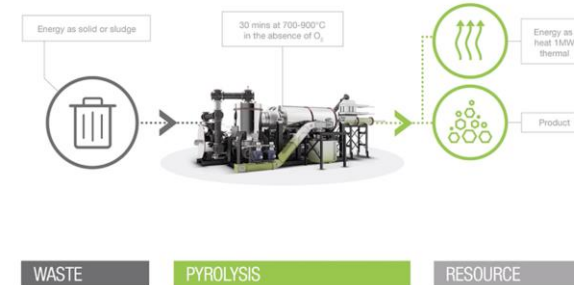
275,000 TONS
Amount of plastic used in the UK per year

500+ YEARS
How long plastic can take to decompose

40KG
How much plastic the average UK family throws out each year that could otherwise be recycled

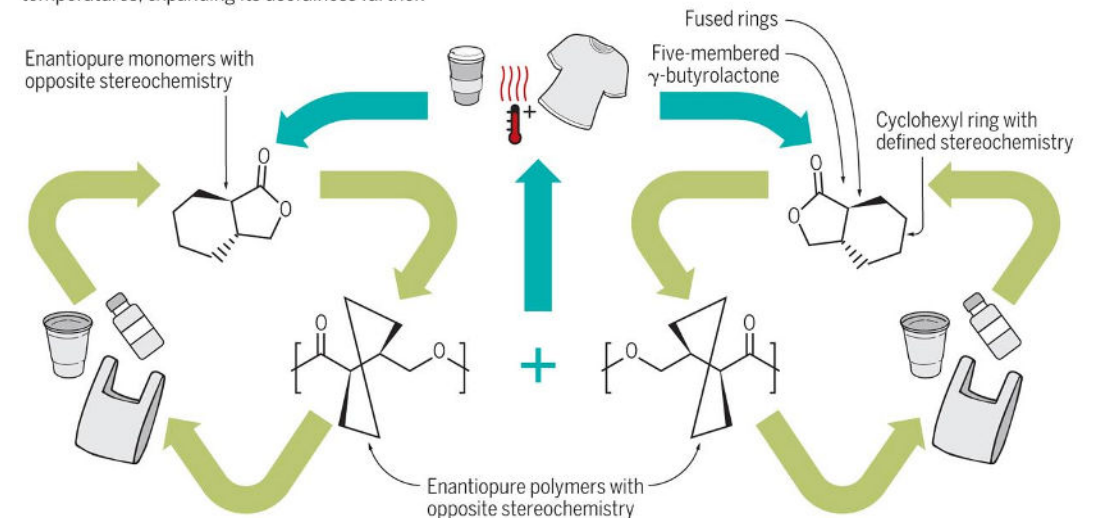
4%
The use of plastic in Western Europe grows by this much each year

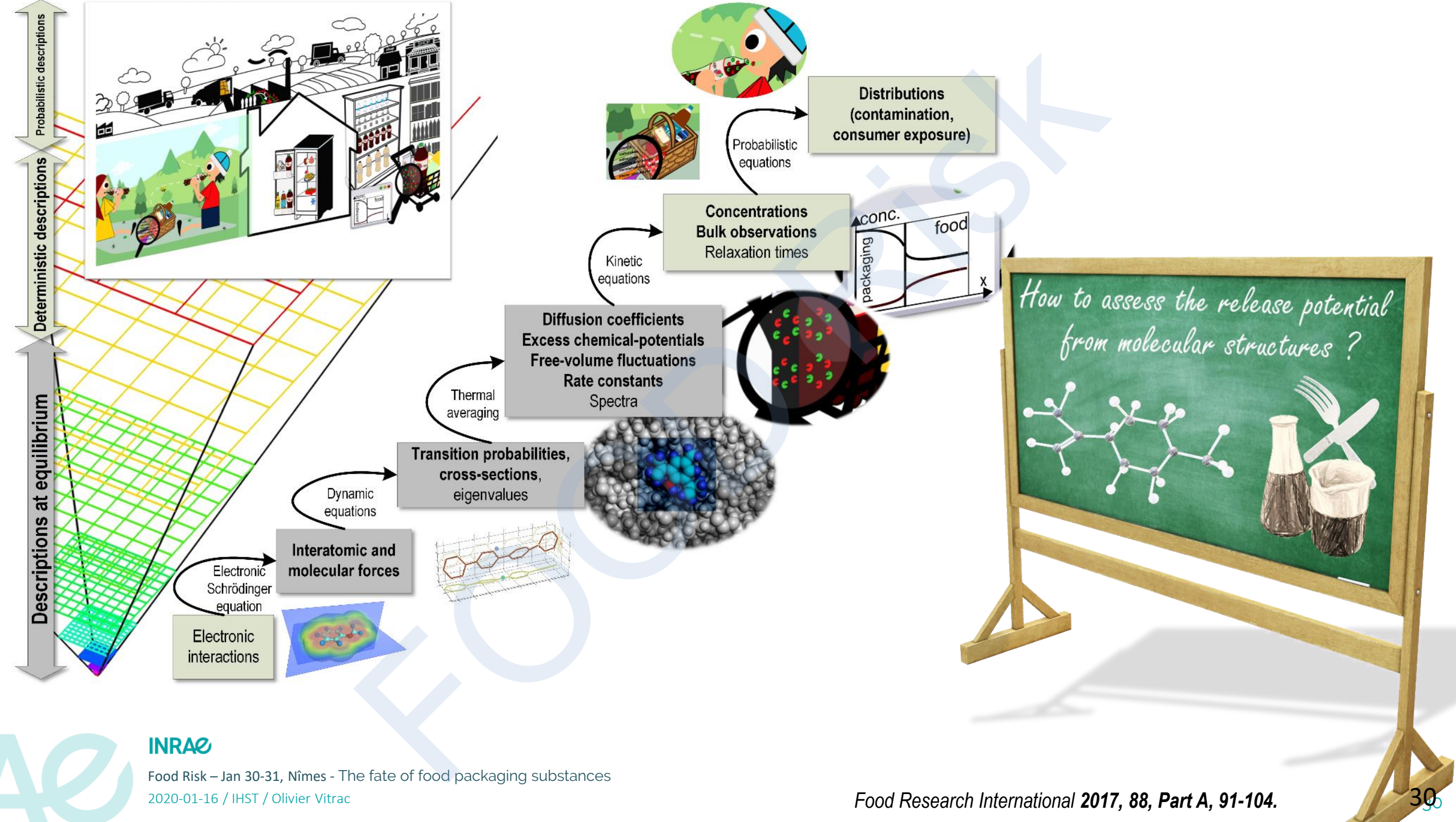
HOW IT WORKS



Repeatedly recyclable polymers

Zhu *et al.* report production of a plastic that can be recycled repeatedly through chemical methods without loss of function. Blending of the two enantiopure polymers yields a plastic that can withstand higher temperatures, expanding its usefulness further.





TRANSPORT

diffusion coefficients D
and their activation E_a

Worst-case
approaches (arbitrary)

For compliance testing
(Piringer's equation)

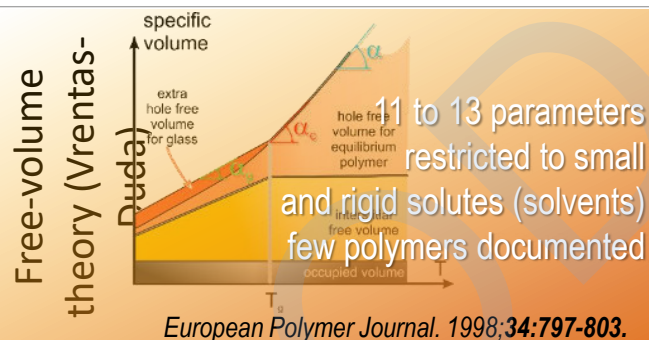
Food Additives and Contaminants. 2005;**22**:73-90.

Group contribution
methods (fitting)

Decision tree

Journal of Applied Polymer Science. 2006;**101**:2167-86.

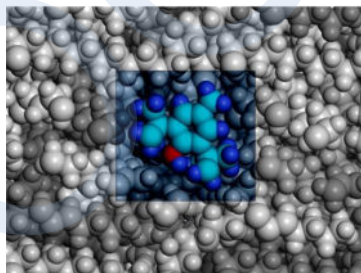
Theory from first
principles
(statistical physics)



European Polymer Journal. 1998;**34**:797-803.

Full atomistic
simulation
or coarse-grained
(no assumptions)

for $D \geq 10^{-14} \text{ m}^2 \cdot \text{s}^{-1}$



Journal of Chemical Physics. 2010;**132**:194902.

THERMODYNAMICS

chemical affinity
(Flory-type isotherms)

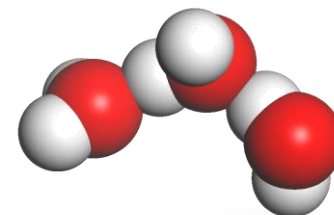
$$K_{F/P} = 1 \text{ or } 10^{-3}$$

JRC Scientific and Technical Reports EUR 27529 EN.
Ispra (Italy): European Commission; 2015.

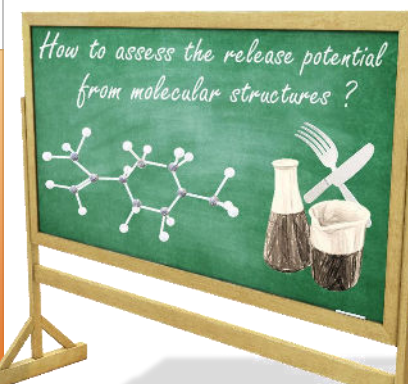
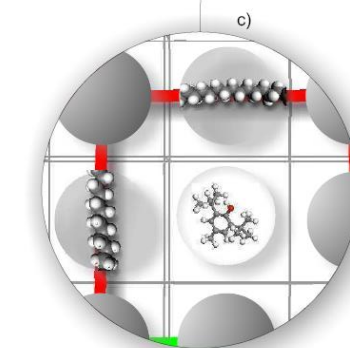
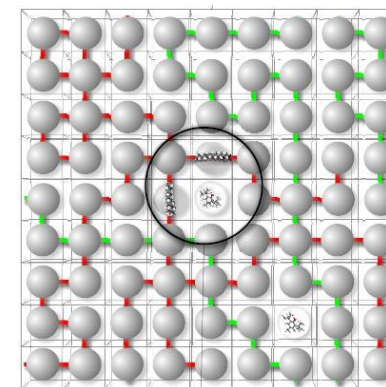
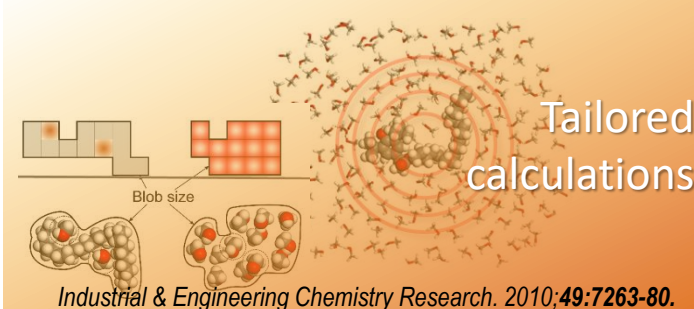
UNIQUAC, UNIFAC, Flory—Huggins

Prausnitz, Lichtenthaler & de Azevedo. *Molecular Thermodynamics of Fluid-Phase Equilibria*: Pearson Education; 1998.

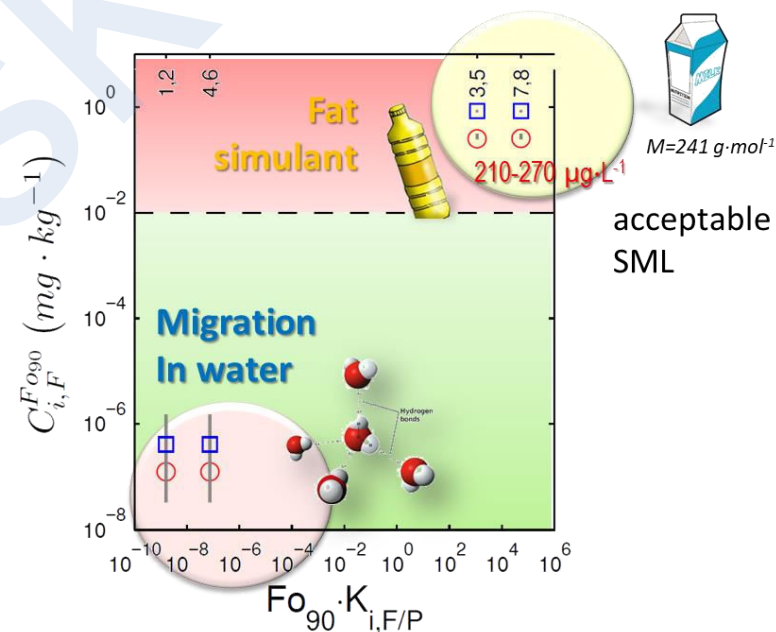
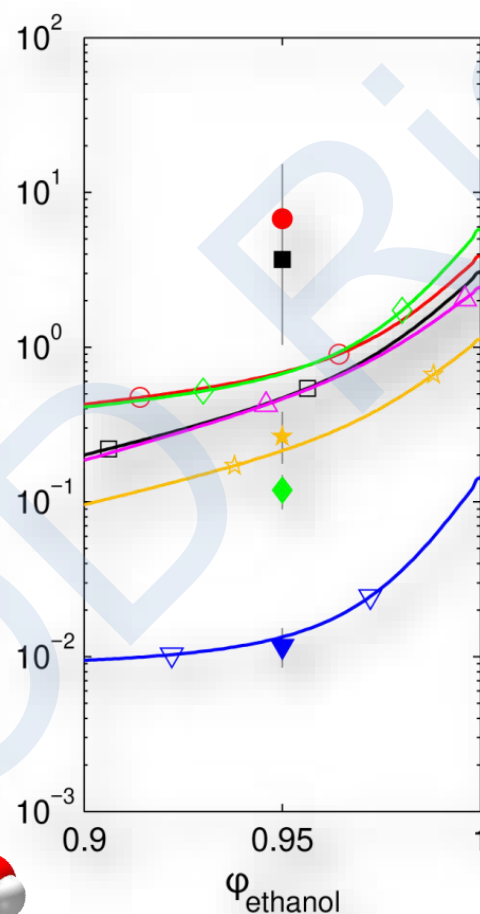
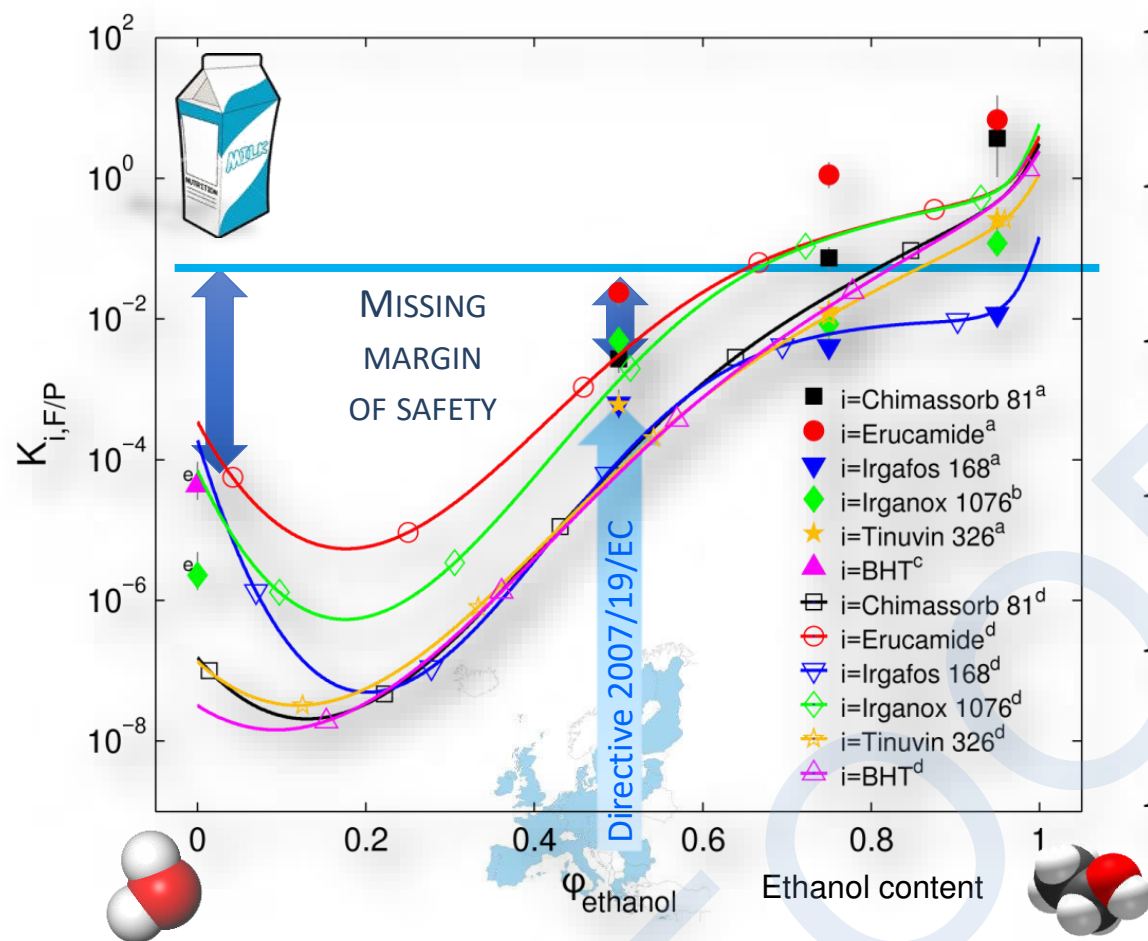
Self-association
theory



Kontogeorgis & Folas. *Thermodynamic Models for Industrial Applications: From Classical and Advanced Mixing Rules to Association Theories*: Wiley; 2009.



➤ Molecular modeling challenged the choice of food simulants



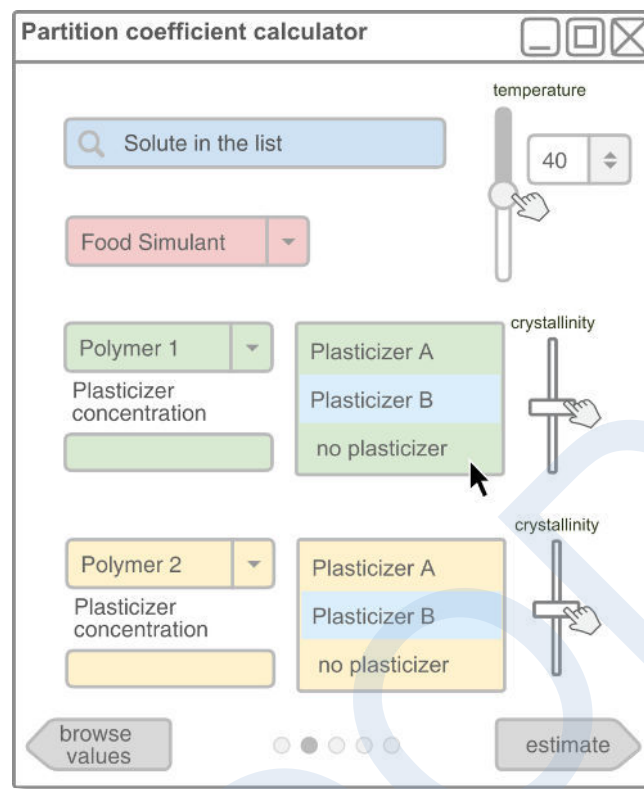
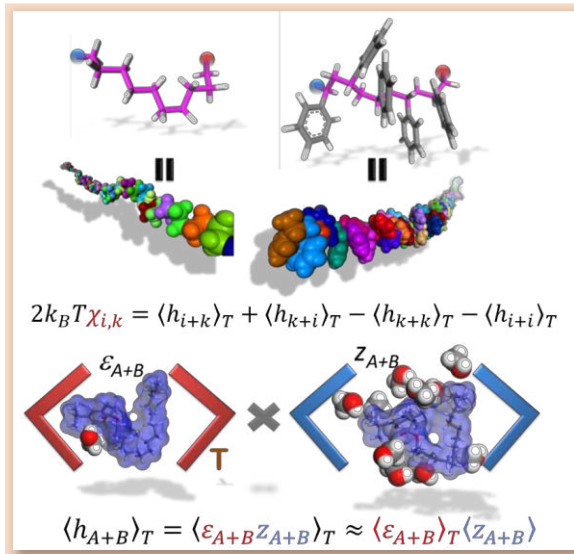
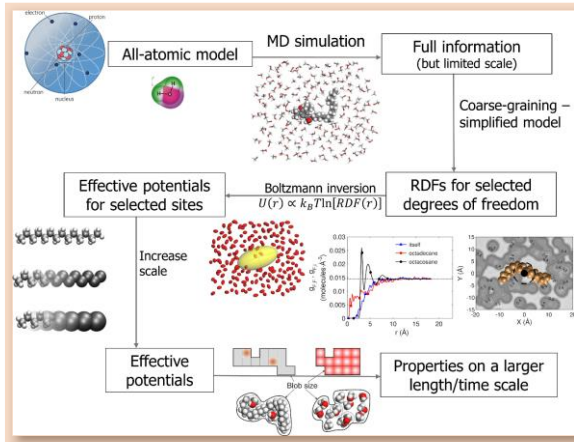
Ind. Eng. Chem. Res. 2010, 49(6), 7763-7780.
Food Additives and Contaminants, 2009, 26(2), 1556-1573.

	Date of case	Last change	Reference	Country
6.	08/09/2005		2005.631	ITALY

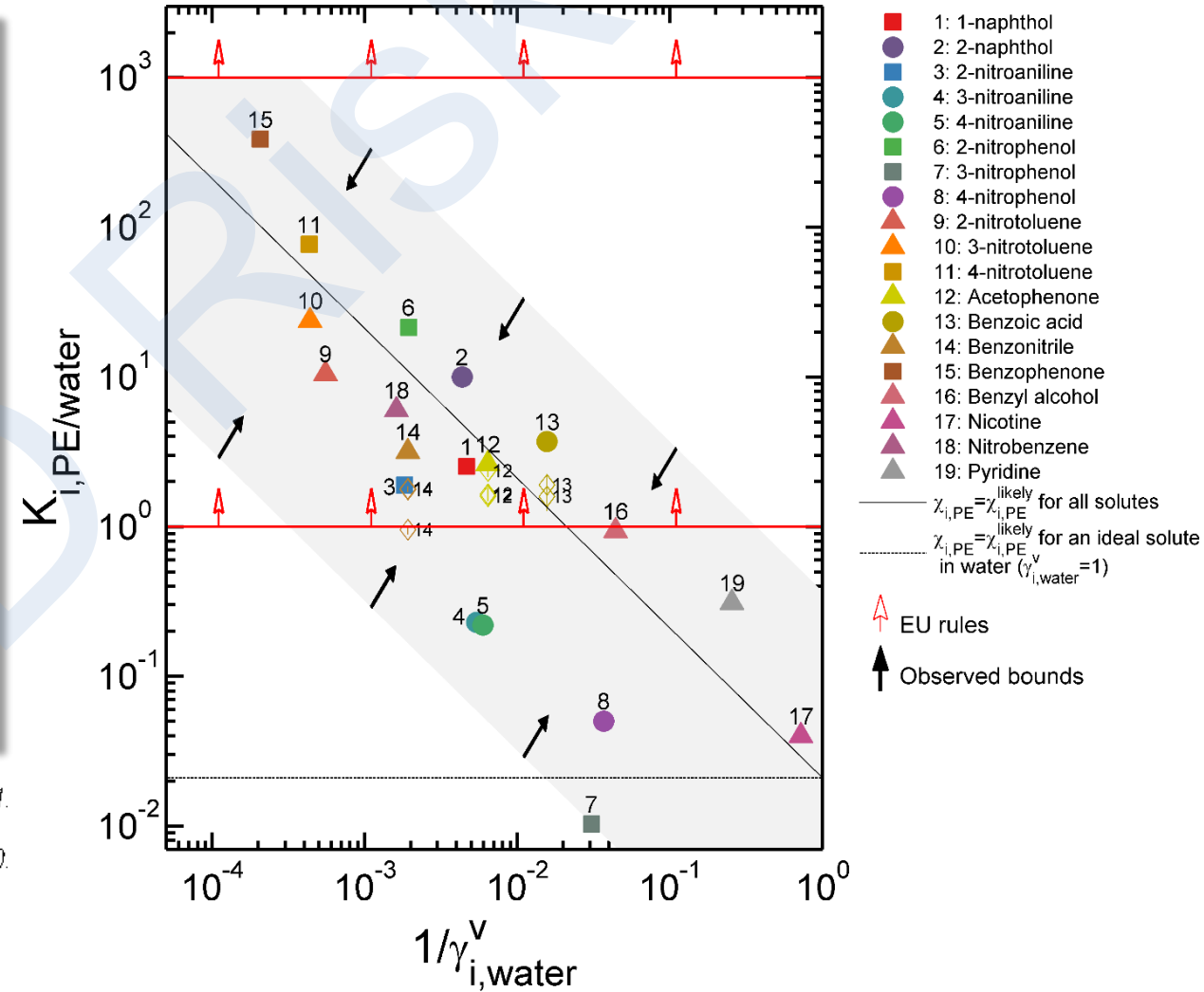
RASFF Portal

food contact materials
migration of isopropyl thioxanthone (250 $\mu\text{g/l}$) from packaging of milk for babies from Spain

➤ Prediction of partition coefficients (NIAS, water)



Industrial & Engineering Chemistry Research 2009, 48 (11), 5285-5301.
 International Journal of Chemical Reactor Engineering 2010, 8.
 Industrial & Engineering Chemistry Research 2010, 49 (16), 7263-7280.
 Industrial & Engineering Chemistry Research 2017, 56 (3), 774-787.



$$\{\mu_{i,k}^{excess}\}_{k=P,F} = \ln \gamma_{i,k}^v = \left(1 - \frac{1}{r_k}\right) \phi_k + \chi_{i,k} \phi_k^2$$

$$2k_B T \chi_{i,k} = \langle h_{i+k} \rangle_T + \langle h_{k+i} \rangle_T - \langle h_{k+k} \rangle_T - \langle h_{i+i} \rangle_T$$

$$K_{i,P/F}^{semi-crystalline} \approx \frac{1 - crystallinity}{\phi_{i,F}^{sat} \exp(1 + \chi_{i,P})}$$



Contamination without contact

*Cross-contamination = Main of NIAS and new
(old) routes of contamination*

old routes = new issues

➤ Hazard Analysis vs Risk assessment

Hazard – health

Risk – occurrence



INRAE

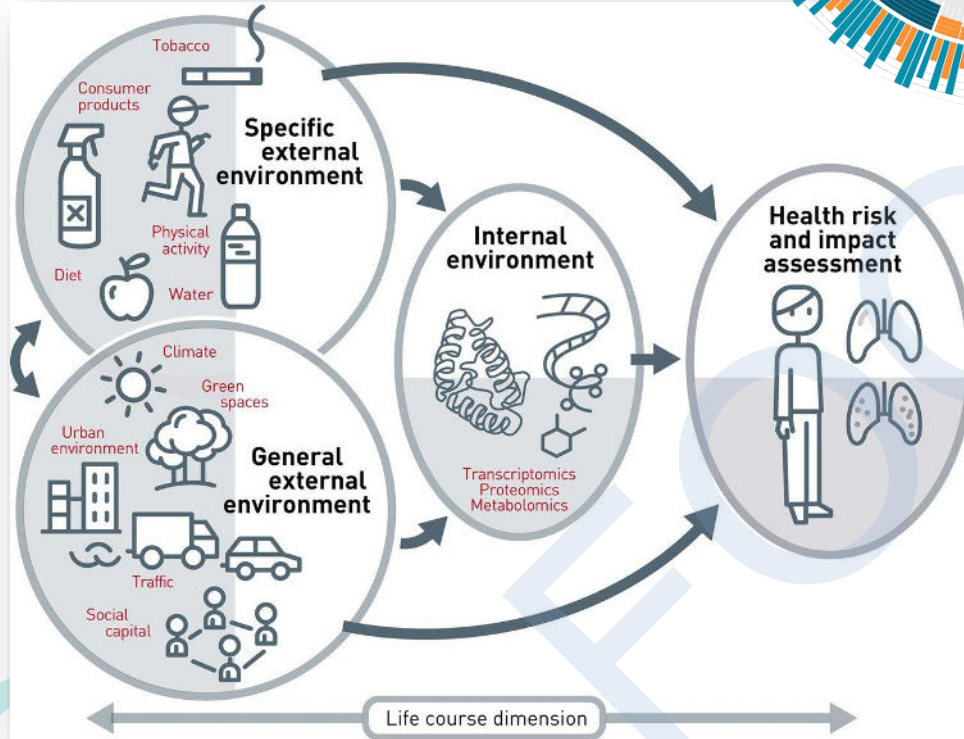
Food Risk – Jan 30-31, Nîmes - The fate of food packaging substances

2020-01-16 / IHST / Olivier Vitrac

➤ The cascade of risk assessment and management

Chronic exposure

Human exposome



			Risk Tradeoff
		Risk balancing	Conflicts
	Scientific risk assessment	Conflict: evaluative	cognitive, evaluative, normative
Routine	Conflict: cognitive	Targets:  Risiken erkennen – Gesundheit schützen  alimentation, environnement, travail  European Food Safety Authority	Targets: DG SANCO, industry stakeholders 
Target: industry	Target: professional associations		
Discourse: internal	Discourse: cognitive	Discourse: reflective	Discourse: participatory
Outcome: simple	Outcome: complex	Outcome: uncertain	Outcome: ambiguous

➤ OUTGASSING DATA

NASA and ESA maintain lists of materials with low-outgassing properties suitable for use in spacecraft, as outgass products can condense onto optical elements, thermal radiators, or solar cells and obscure them. Materials not normally considered as potent can release enough light weight molecules to interfere with industrial or scientific vacuum processes. Moisture, sealants, lubricants, and adhesives are the most common sources, but even metals and glasses can release gases from cracks or impurities.

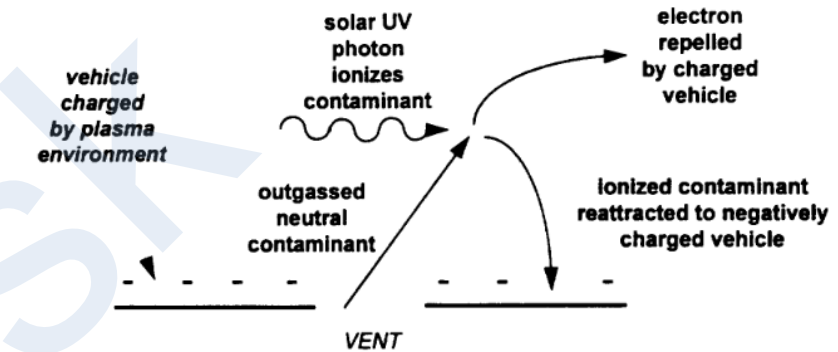


Figure 2-14. Electrostatic retraction of ionized contaminants.

<https://outgassing.nasa.gov/>

NASA NATIONAL AERONAUTICS AND SPACE ADMINISTRATION [Visit NASA.gov](#)

Outgassing Data for Selecting Spacecraft Materials Online

Data Last Updated: 04/10/2018
Searches done since 8 Jan 2008: 1052234

System Description

Categorical Listing
Alphabetical Listing
Low Outgassing
Report Documentation Page

Godard Space Flight Center
Materials Engineering Branch

Search
Advanced Search
Manufacturer
Download
Data Ref

For further information about the outgassing data, please contact Jeremy Knipple: Jeremy.T.Knipple@nasa.gov

USA.gov [Privacy Policy and Important Notices](#)

NASA Official: Charles E. Powers
Last Updated: 04/10/2018
NASA Site Admin: **Stephen Waterbury**

http://esmat.esa.int/services/outgassing_data/outgassing_data.html

ESA ESMAT European Space Agency

Home Databases Publications Specifications SME ESA Tool Materials News

This website is for information only and these pages are no longer maintained.

GENERAL REQUIREMENT FOR OUTGASSING:
The materials used for space systems shall be selected based upon low outgassing criteria. The outgassing criteria are based upon the micro-VCM test (ECSS-Q-70-02), and shall take into account the location of the outgassing source and its mass.

MORE STRINGENT REQUIREMENT FOR OUTGASSING:
The acceptance limits can be made more stringent if the materials concerned are used in critical areas. The use of materials that are deemed acceptable according to the general requirement does not ensure that the spacecraft system or component remains uncontaminated. Consequently, subsequent functional, development and qualification test shall be used where appropriate to ensure that the materials performance continues to be satisfactory.

The Table provides a recommendation for outgassing requirements based on good design practice for applications around sensitive items (e.g. optics, detectors and cryogenic equipment). For a specific application, the definition of the outgassing requirements shall take into account quantity of material concerned and specific environmental conditions (e.g. available volumes and temperatures)

ACCEPTABLE HIGH TML OUTGASSING
The water vapour release (WVR) can be calculated as follows: $WVR = TML - RML$. The TML data for water absorbing materials such as polyamides, polyimides and polyurethanes is often above 1.0%. Water absorption is in most cases reversible and can be controlled by purging of critical hardware with dry gases. Often the water absorption of materials is not harmful with respect to contamination. Materials with high TML outgassing and acceptable RML ($RML < 1.0\%$) and acceptable CVCM ($CVCM < 0.1\%$) may be accepted for the normal cases where following is applicable:
-When no equipment at temperatures below -100°C is involved;
-When the water desorption is fast (e.g. in case of polyimide films and polyurethane paints);
-When no high voltage equipment is involved;
-When dry gas purging controls the water re-absorption during ground life up to launch

MITIGATION:
Mitigation techniques, such as baking, application of protective coating or shielding, can be applied in order to protect against or remove residual contaminants, process contaminants and handling contaminants.

CONTENTS
Click on the link to bring up the search window
■ **Goto Outgassing Search**
Do a search for a material or manufacturer or product type or chemical nature. A few letters of the name are required to bring up a list of materials, manufacturers, product or chemicals. After selection of one the test results are displayed.

Mass of material concerned (grams)	CVCM (%)	RML (%)
>1000	<0.01	<1
100-1000	<0.01	<1
10-100	<0.01	<1
1-10	<0.03	<1
<1	<0.1	<1

For stringent CVCM requirement one shall consider that the CVCM detection limit for a standard micro-VCM test is around 0.02% because of both material variance and measuring errors. For cases where CVCM < 0.05% or less is required, improved sensitivity CVCM shall be implemented, such as use of quartz crystal micro-balance as a fourth collector plate or determination of mass by infrared transmission data.

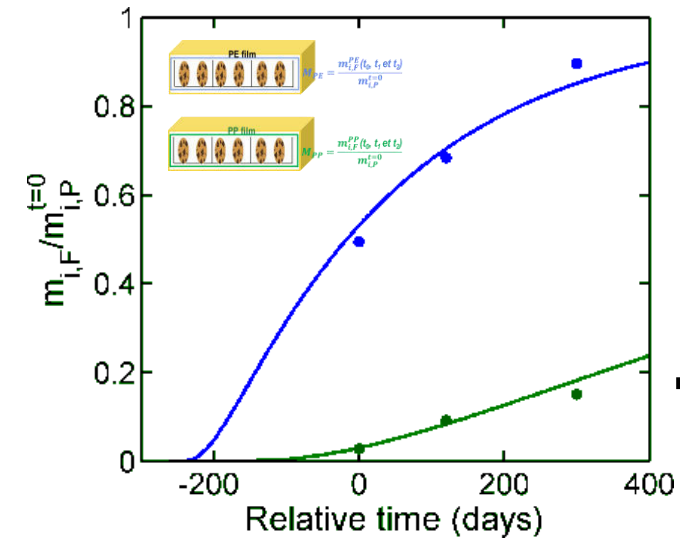
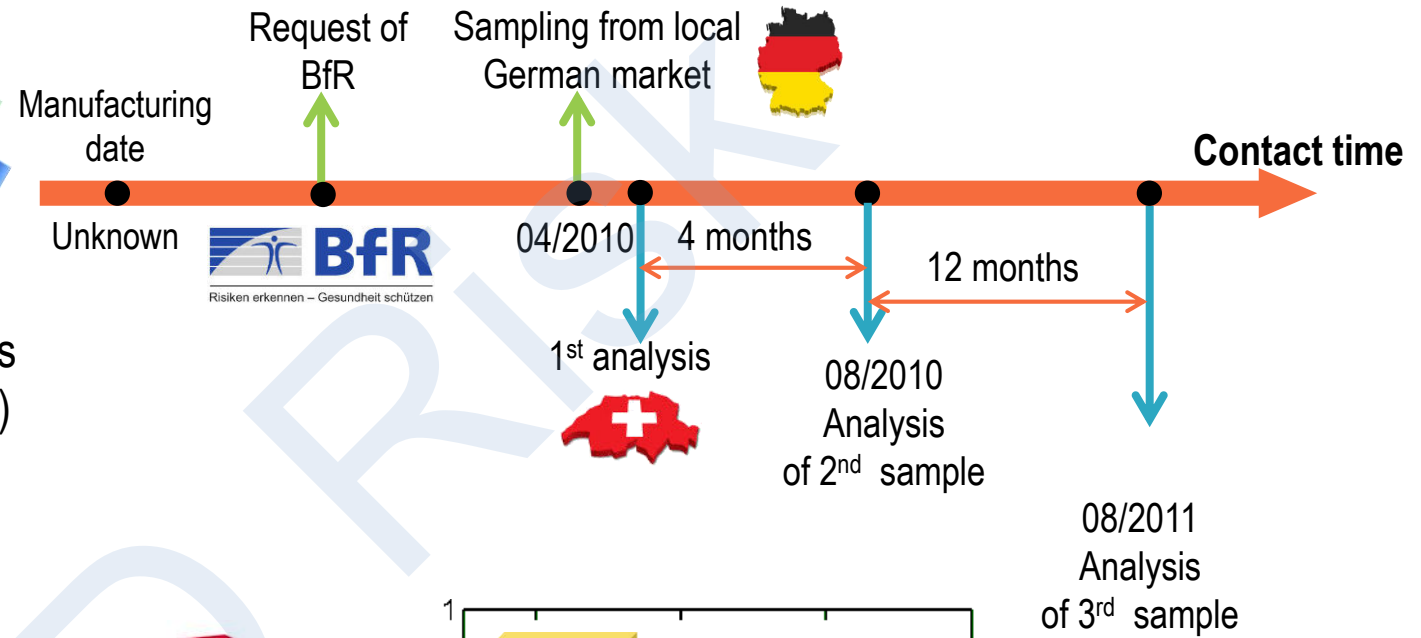
INRAE

Food Risk – Jan 30-31, Nîmes - The fate of food packaging substances

2020-01-16 / IHST / Olivier Vitrac



119 dry food products
(3 samples/category)
Biedermann et al. (2013)



$$\Rightarrow \frac{M_{PE}}{M_{PP}} \propto \frac{D_{i,PE}}{D_{i,PP}}$$

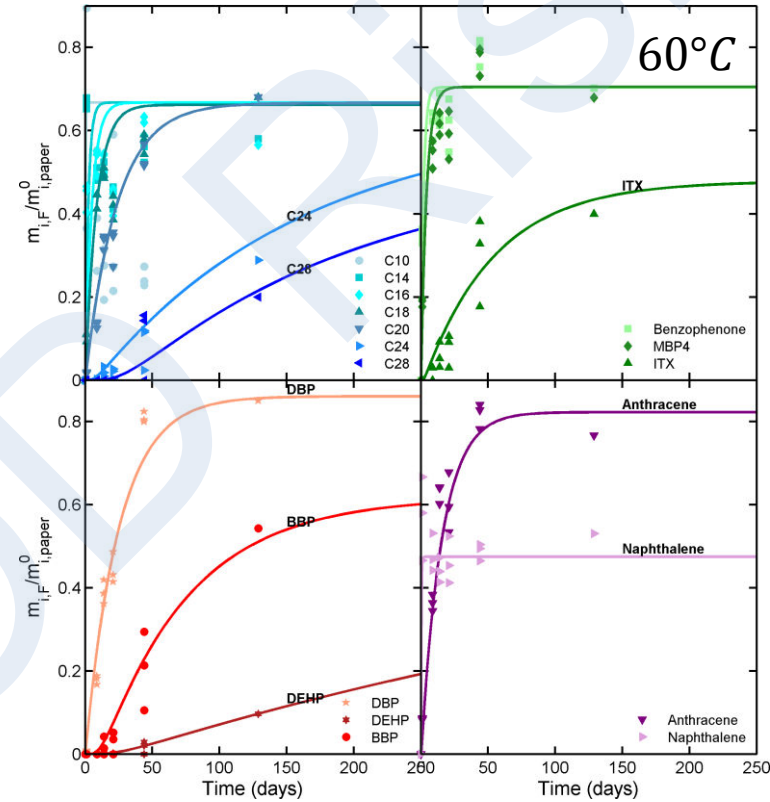
Paper and board = prevalent source of chemical contaminants in food
Mineral Oils, Printing inks, adhesives

➤ CONTAMINATION THROUGH THE GAS PHASE

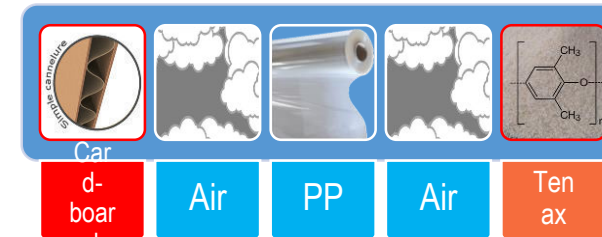
TENAX packed within a 50 µm thick BOPP bag and exposed to a cardboard material formulated with 15 surrogates



SURROGATES (i)
Decane (C10)
Tetradecane (C14)
Hexadecane (C16)
Octadecane (C18)
Eicosane (C20)
Tetracosane (C24)
Octacosane (C28)
Dibutyl phthalate (DBP)
Bis(2-ethylhexyl) phthalate (DEHP)
Benzylbutyl phthalate (BBP)
Benzophenone
4-methyl benzophenone (MBP4)
Isopropyl-9H-thioxanthen-9-one
Anthracene
Naphthalene



$$\frac{m_{i,F}^{(t)}}{m_{i,P}^0} = \frac{V_F}{m_{i,P}^0} \int_0^t C_{i,F}^{(t)} d\tau$$



Experimental results
at 60°C, i=1...15

Detailed modeling
with FMECAengine

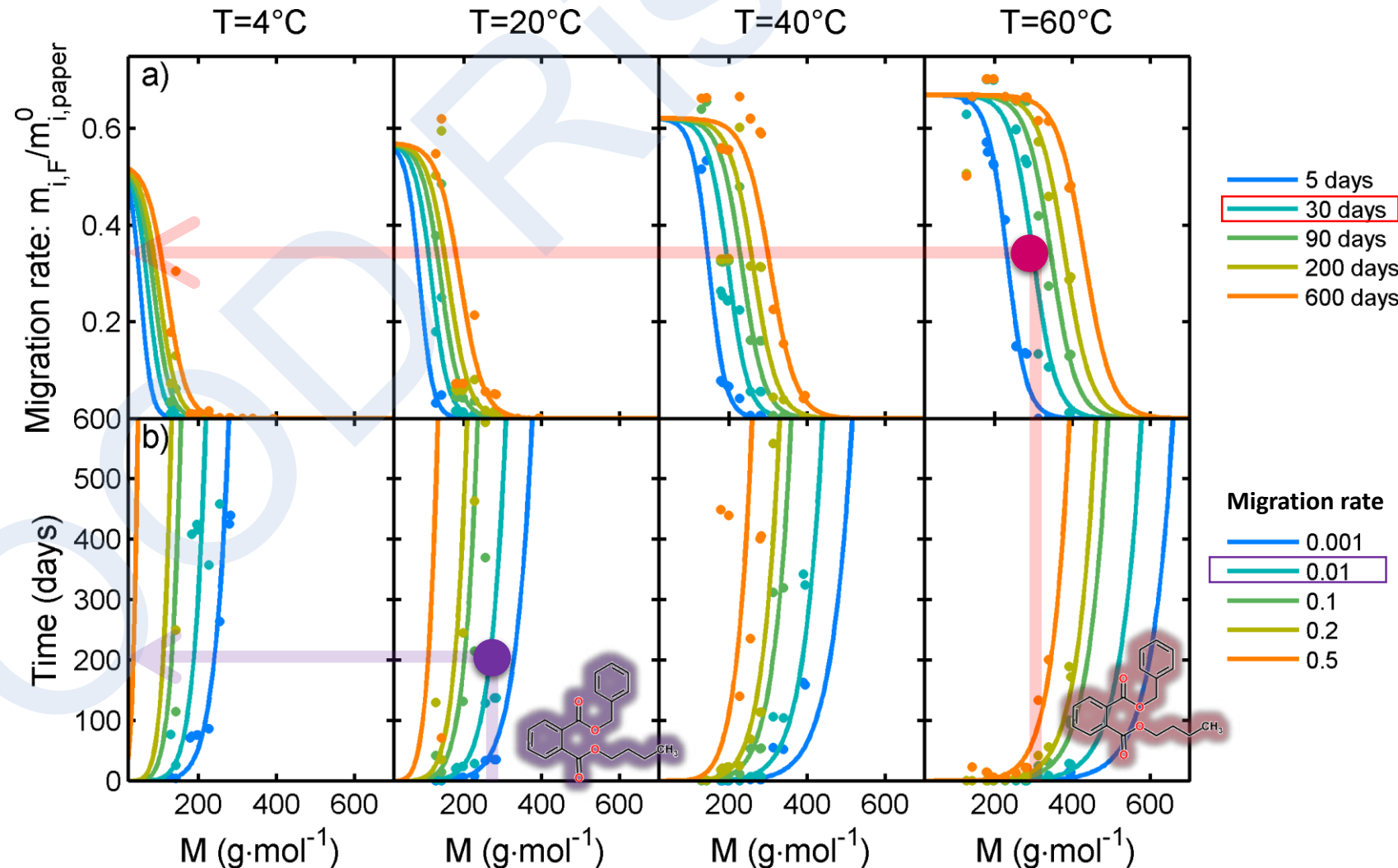
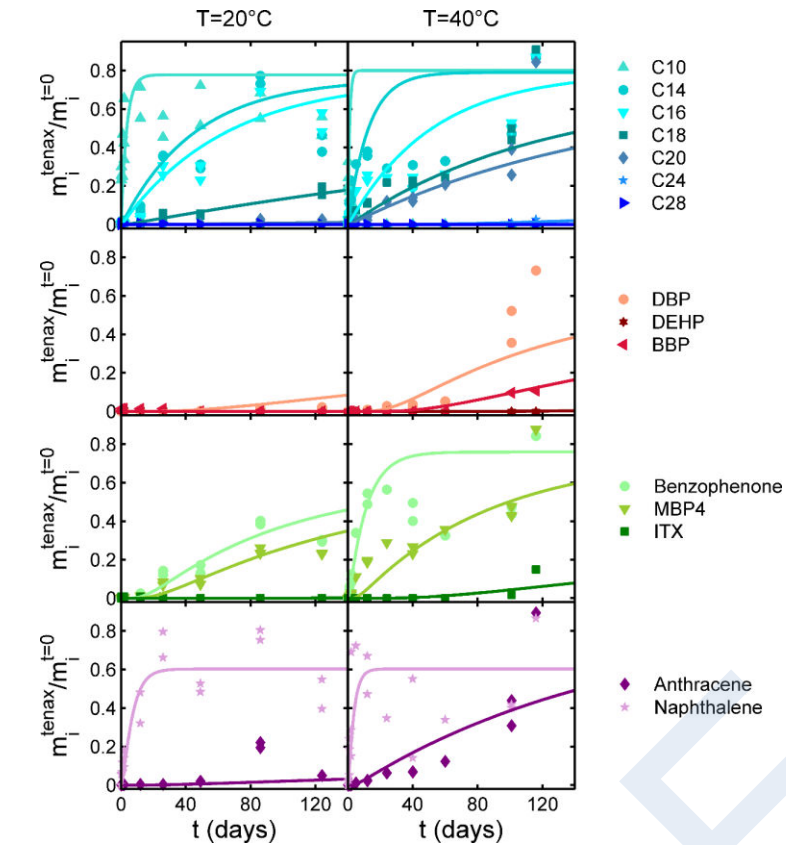
$\widehat{C}_F(T, t, i)$
i = 1..15 solutes
at any temperature

Simplified modeling
Solute independent

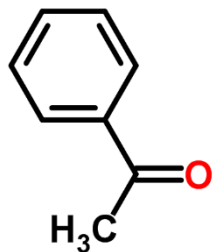
$\widetilde{C}_F(T, t, M)$
simplified
at any temperature

➤ CONTAMINATION THROUGH THE GAS PHASE

TENAX packed within a 50 µm thick BOPP bag and exposed to a cardboard material formulated with 15 surrogates

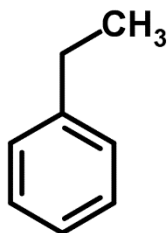


> PARTITION COEFFICIENTS WITH AIR



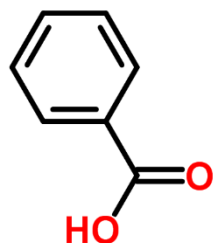
>> FMECAKairP acetophenone

```
LOAD_CHEMSPIDER    extraction of ChemSpiderID=7132 ('acetophenone') completed in 10.26 s
LOAD_CHEMSPIDER: updated cache
                    7132.mat      21-sept.-2015 21:37:19      77.6 kBytes   C:\Data\Olivier\INRA\Codes\MS\cache.ChemSpider
CHEMSPIDER reuses cached data for 'acetophenone' (date=21-sept.-2015 21:37:19)
ans =
      9.1995e-06
```



>> FMECAKairP ethylbenzene

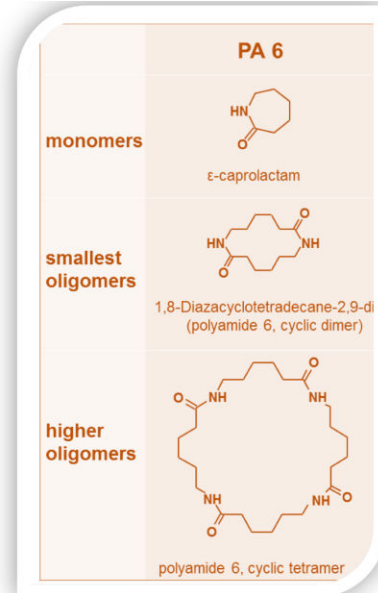
```
LOAD_CHEMSPIDER    extraction of ChemSpiderID=7219 ('ethylbenzene') completed in 11.9 s
LOAD_CHEMSPIDER: updated cache
                    7219.mat      21-sept.-2015 21:42:34     107.1 kBytes   C:\Data\Olivier\INRA\Codes\MS\cache.ChemSpider
CHEMSPIDER reuses cached data for 'ethylbenzene' (date=21-sept.-2015 21:42:34)
ans =
      2.2485e-04
```



>> FMECAKairP 'benzoic acid'

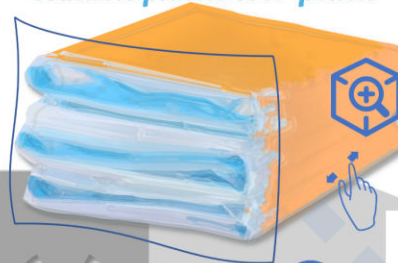
```
LOAD_CHEMSPIDER    extraction of ChemSpiderID=238 ('benzoic acid') completed in 5.746 s
LOAD_CHEMSPIDER: updated cache
                    238.mat      21-sept.-2015 21:45:01      41.2 kBytes   C:\Data\Olivier\INRA\Codes\MS\cache.ChemSpider
CHEMSPIDER reuses cached data for 'benzoic acid' (date=21-sept.-2015 21:45:01)
ans =
      1.3674e-08
```

Cross-contamination in biotechnological applications



Example of chemical
present in the over-pouch

Single-use bags folded and packed in a
sealable plastic over-pouch



Over-pouch
= tri layer material

Migration
across the
overpack

Sterilization by
gamma-irradiation of
bags and systems sealed
within an over-pouch.

Storage of
several
months +
Shipping

2

Single-use
bags and
systems

Migration to
the content of
the bag



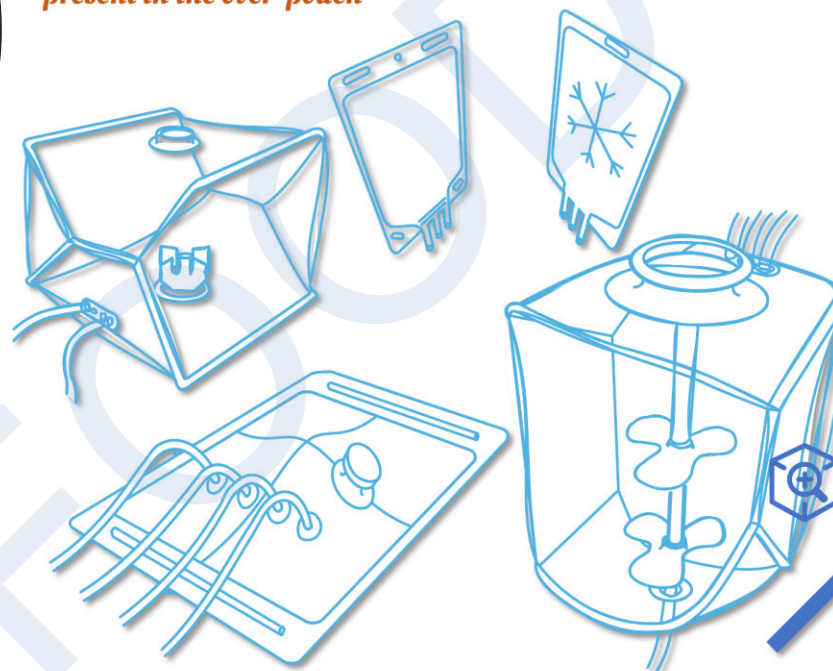
Contamination
of drugs,
vaccines etc.

Production
(from hours
to weeks)

3

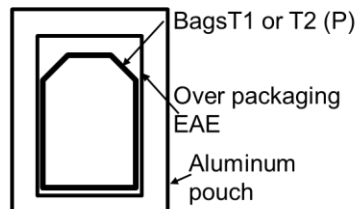
Migration
across the
bag

Over-pouch
= tri layer material



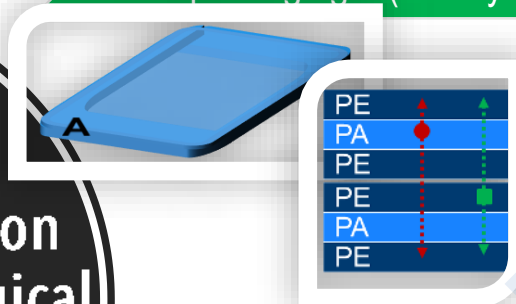
Single-use bags and systems

STEP 1
STUDY
"LOADING"



Cross-contamination in biotechnological applications

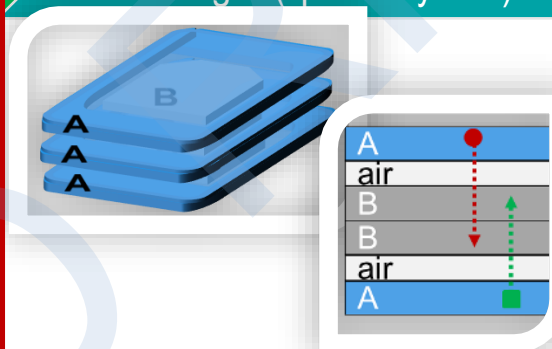
Storage before use of over-
packaging A (0 – 1 year)



Redistribution of contaminant
within the over-packaging

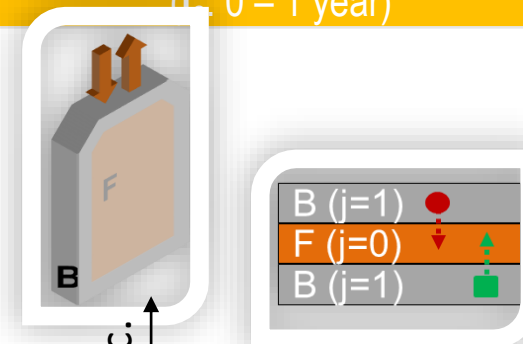
OUR SCOPE

Storage of over-packaging A and
bag B (t_1 : 0 – 3 years)

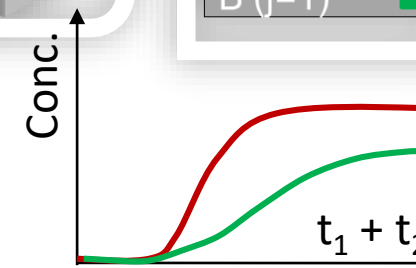


Cross-transfer between over-
packaging and bag

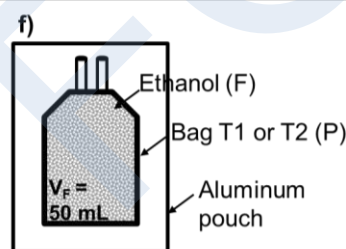
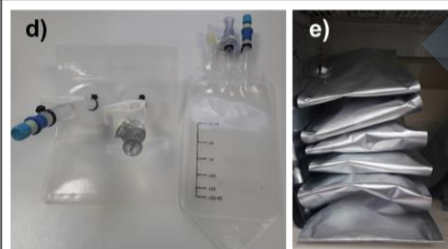
Use of bag B with a liquid F
(t_2 : 0 – 1 year)



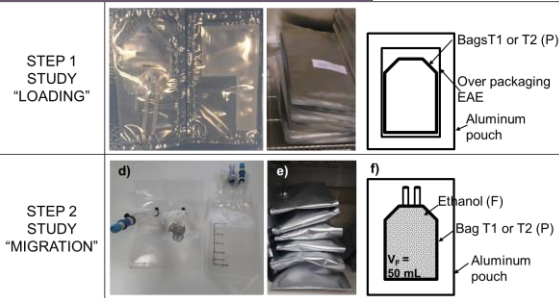
Cross-transfer between bag and
liquid in use



STEP 2
STUDY
"MIGRATION"

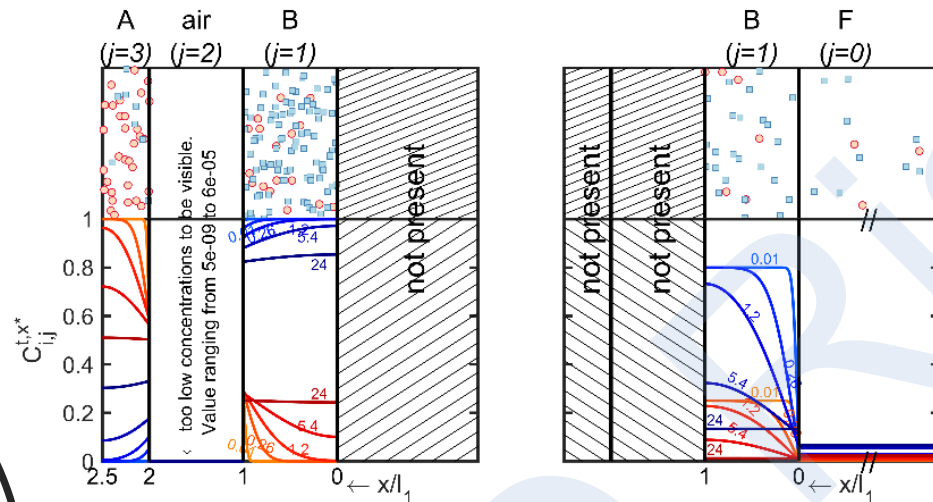


Nguyen P-M, Dorey S, Vitrac O. The Ubiquitous Issue of Cross-Mass Transfer: Applications to Single-Use Systems. *Molecules*. 2019;24:3467.

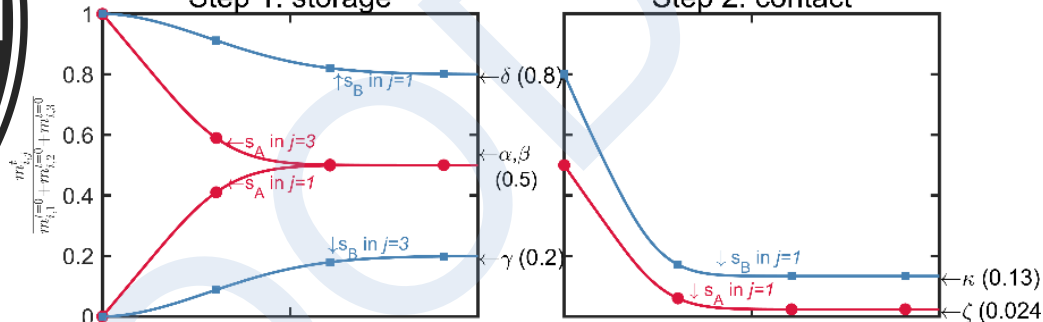


Cross-contamination in biotechnological applications

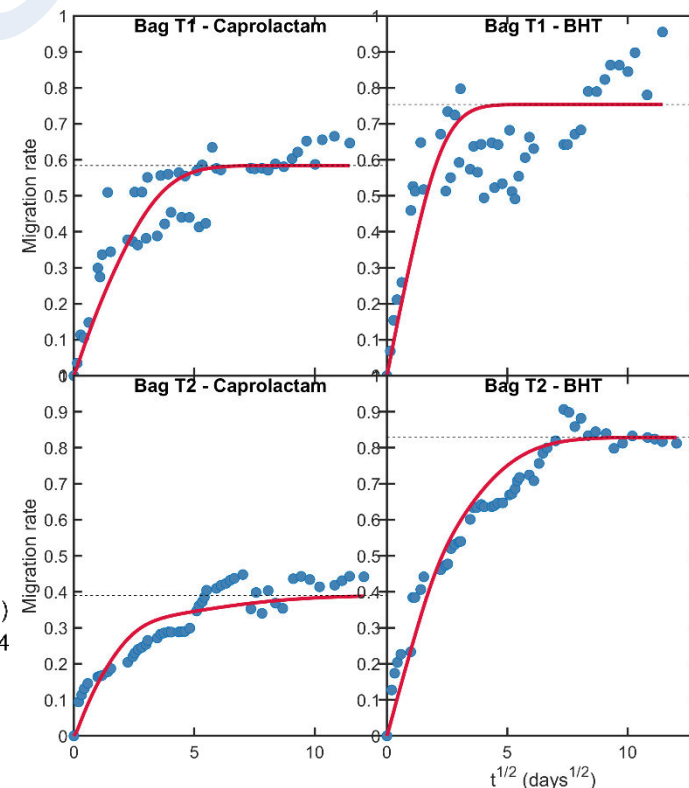
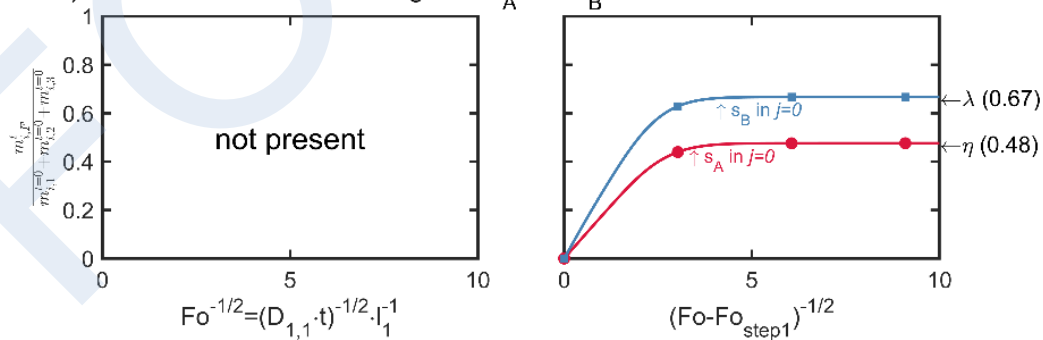
a) Migrant distributions and concentration profiles



b) Concentration kinetics of migrants s_A and s_B in A and B
Step 1: storage Step 2: contact



c) Concentration kinetics of migrants s_A and s_B in F





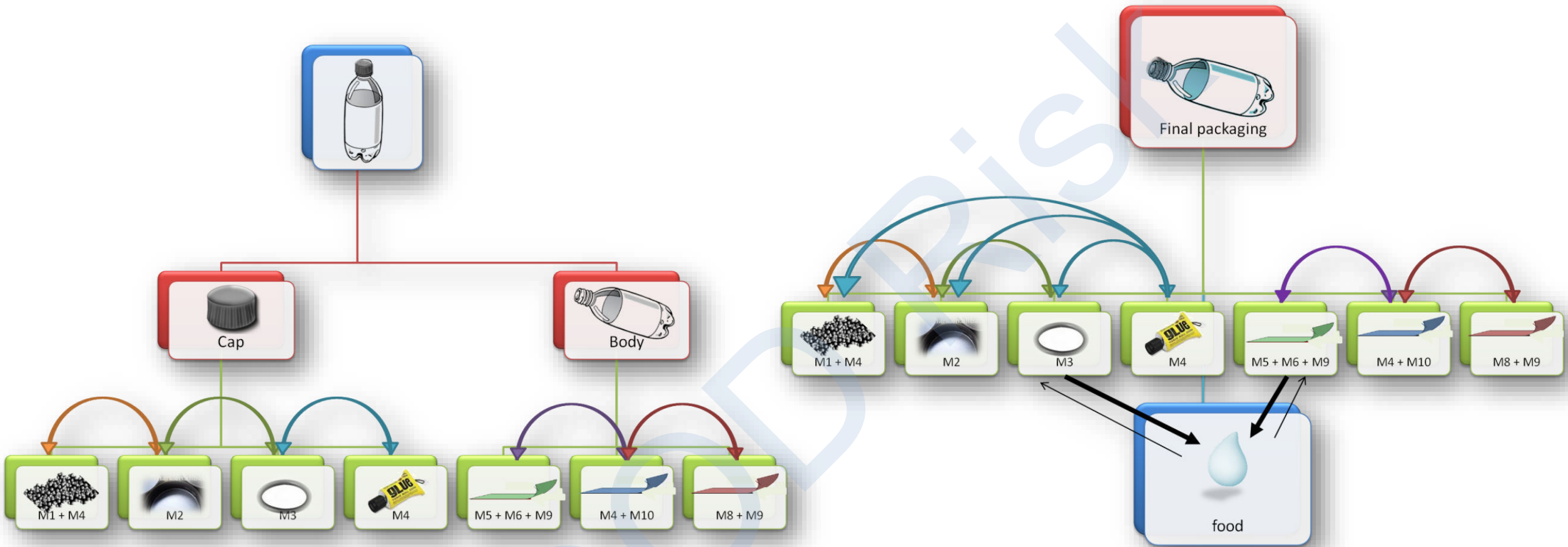
Preventive approaches

From preventive approaching to integrated engineering

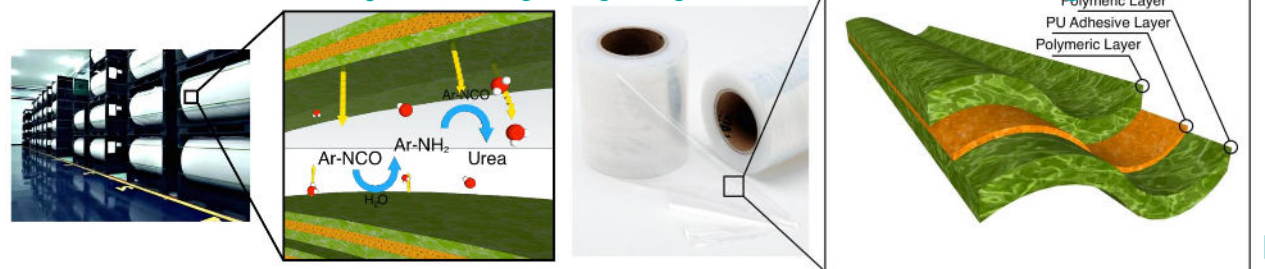


Risk management requires the full cooperation of the supply chain

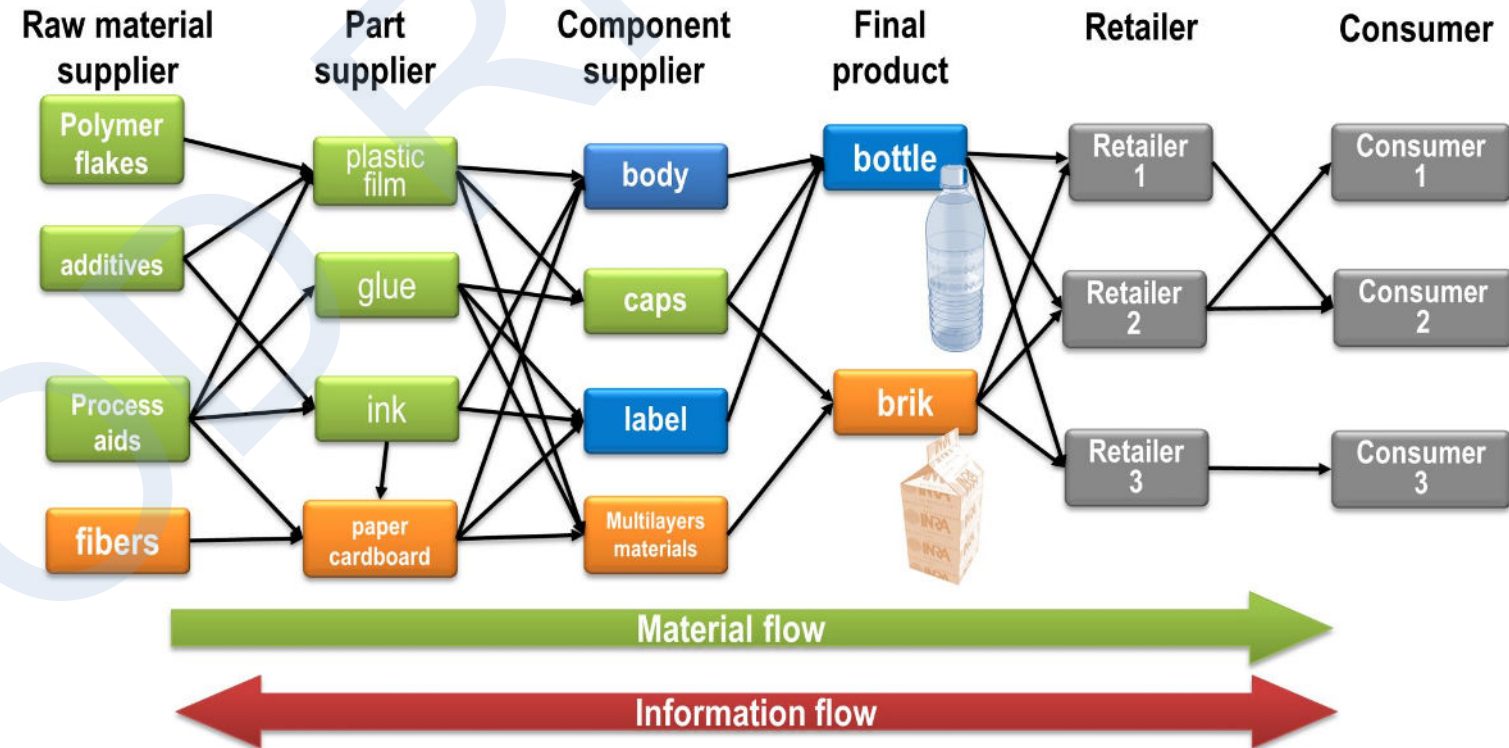
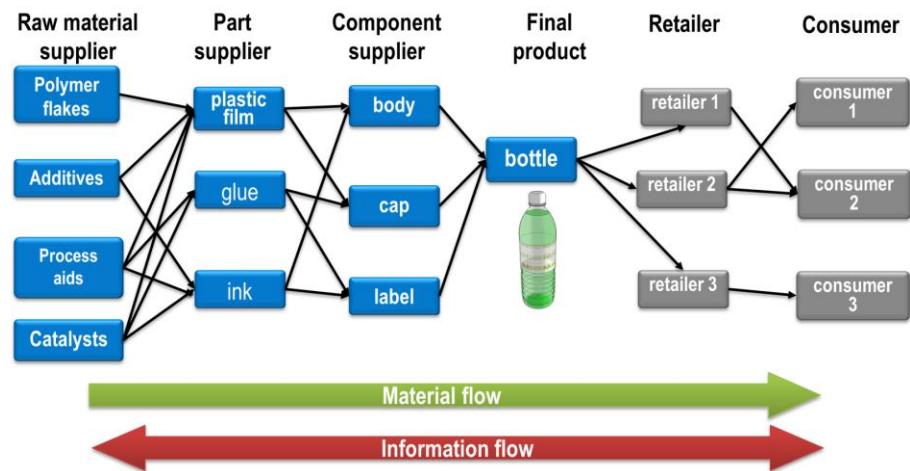
How to establish the responsibility of stakeholders?



Most of the packaging systems are composite



Developing the cooperation along the supply chain



Safety concepts



Current Approaches



Future Approaches



Low Migration



Low Toxicity



Low Consumer Exposure

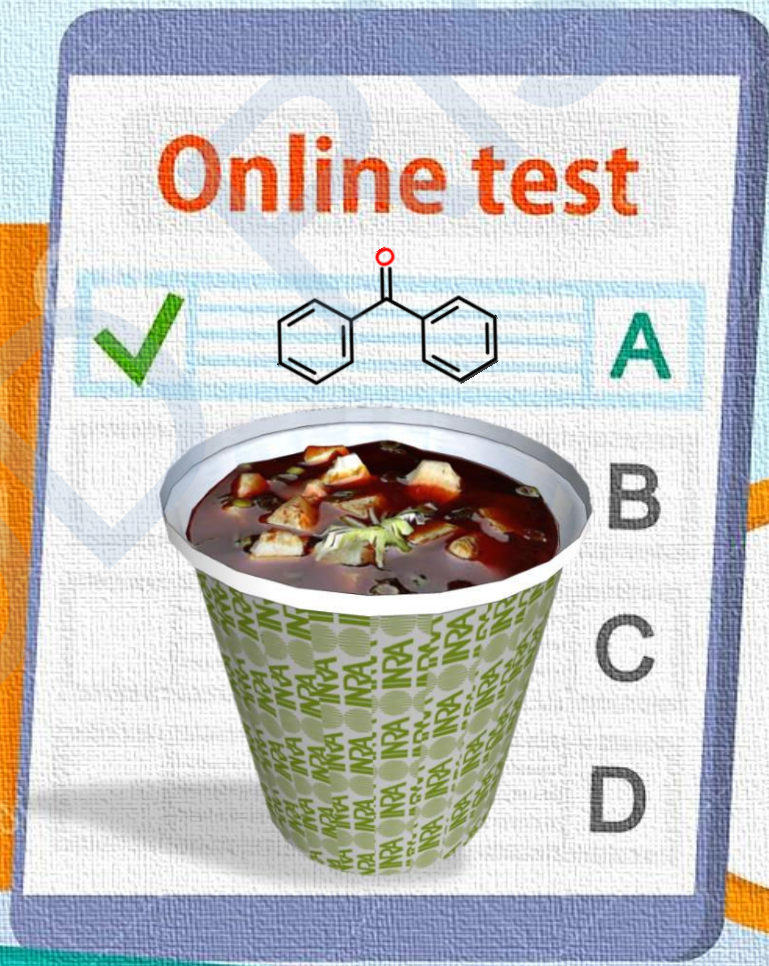


Safe-by-Design

+VOLUNTARY APPROACHES & LOCAL ORDINANCES

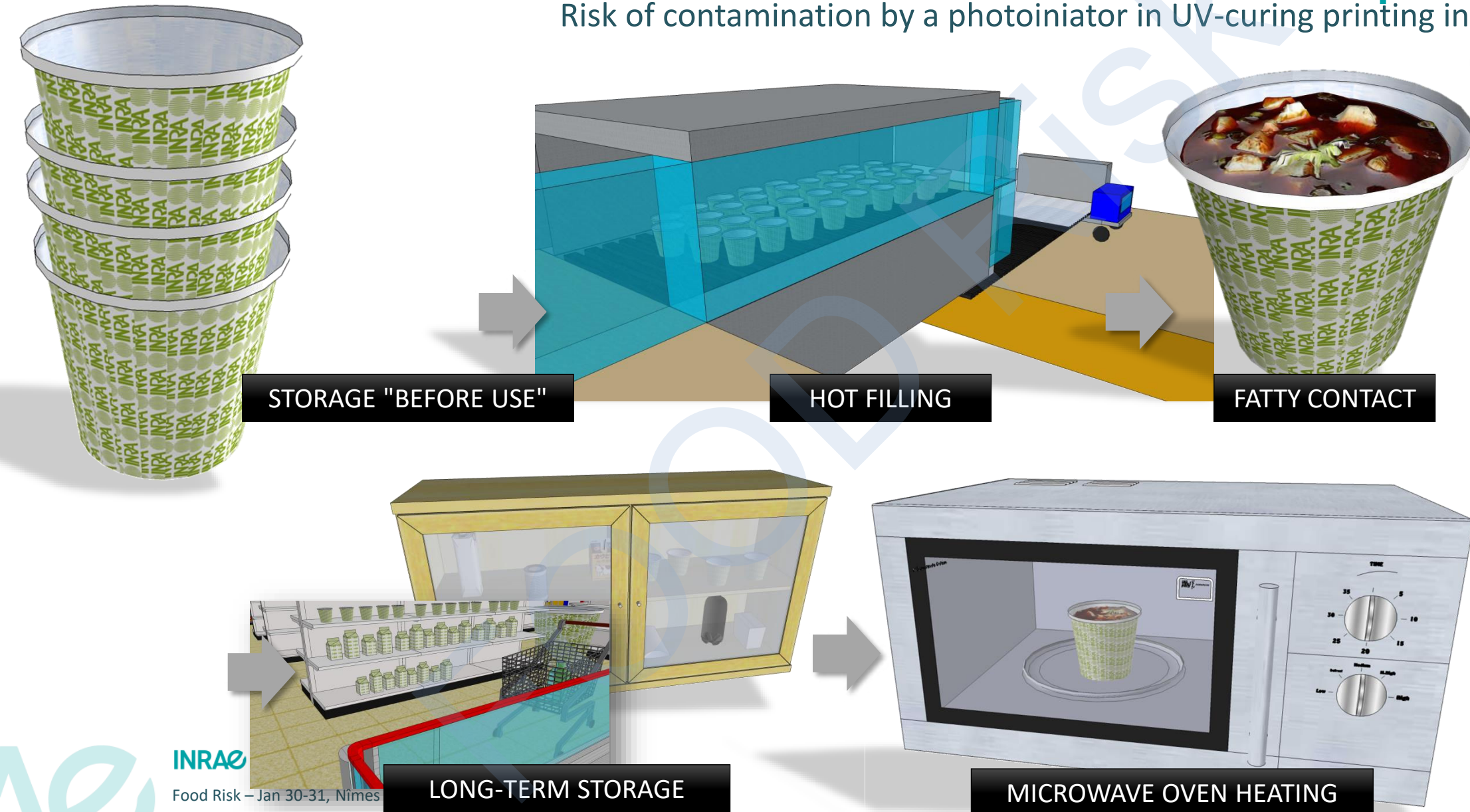
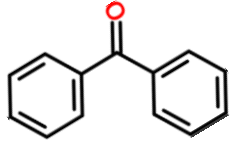
[Regulation EC 2023/2006](#) - Good Manufacturing Practice for materials and articles intended to come in contact with food





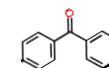
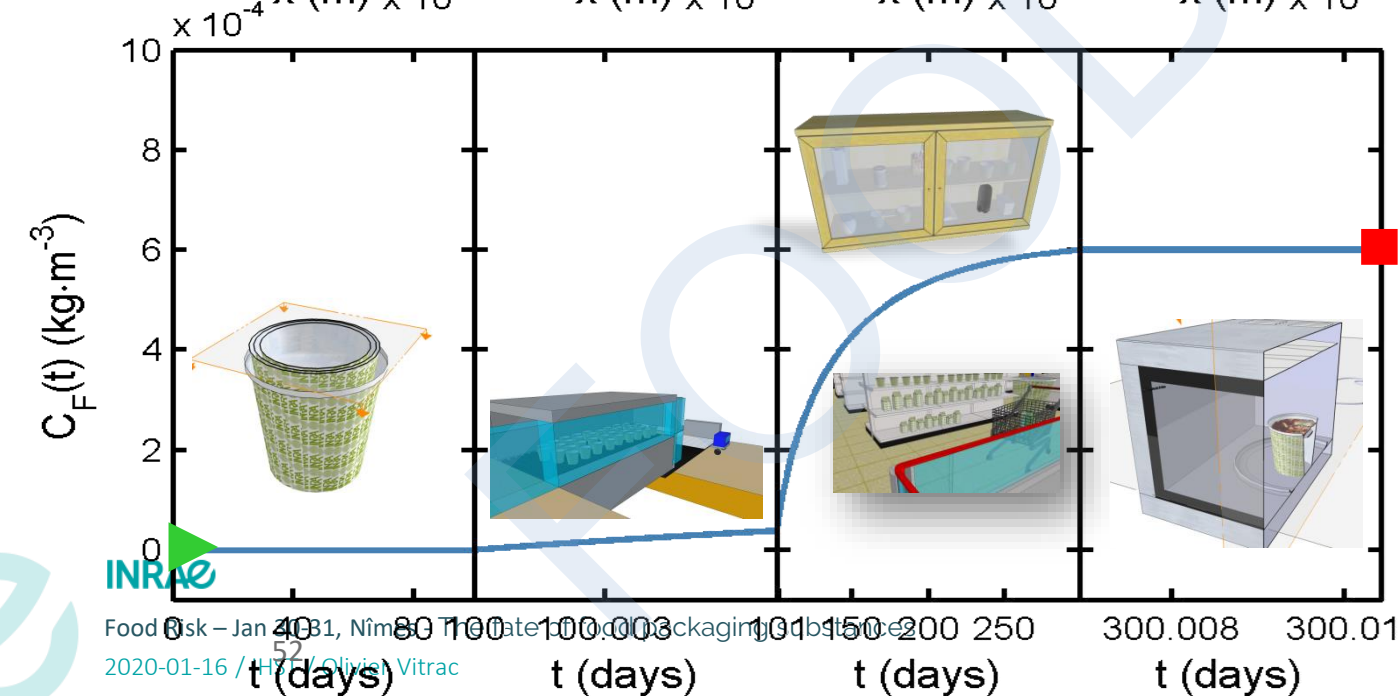
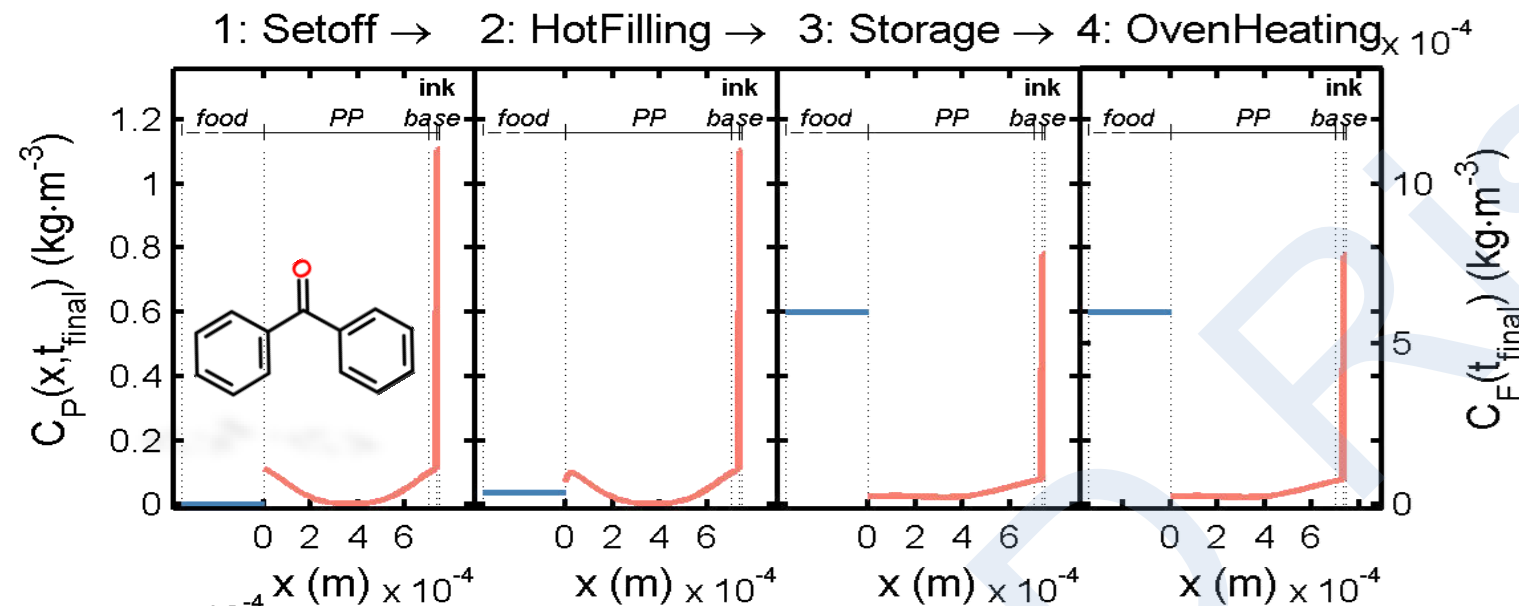
➤ CHAINED STEPS: where is the critical step?

Risk of contamination by a photoinitiator in UV-curing printing ink



CHAINED STEPS

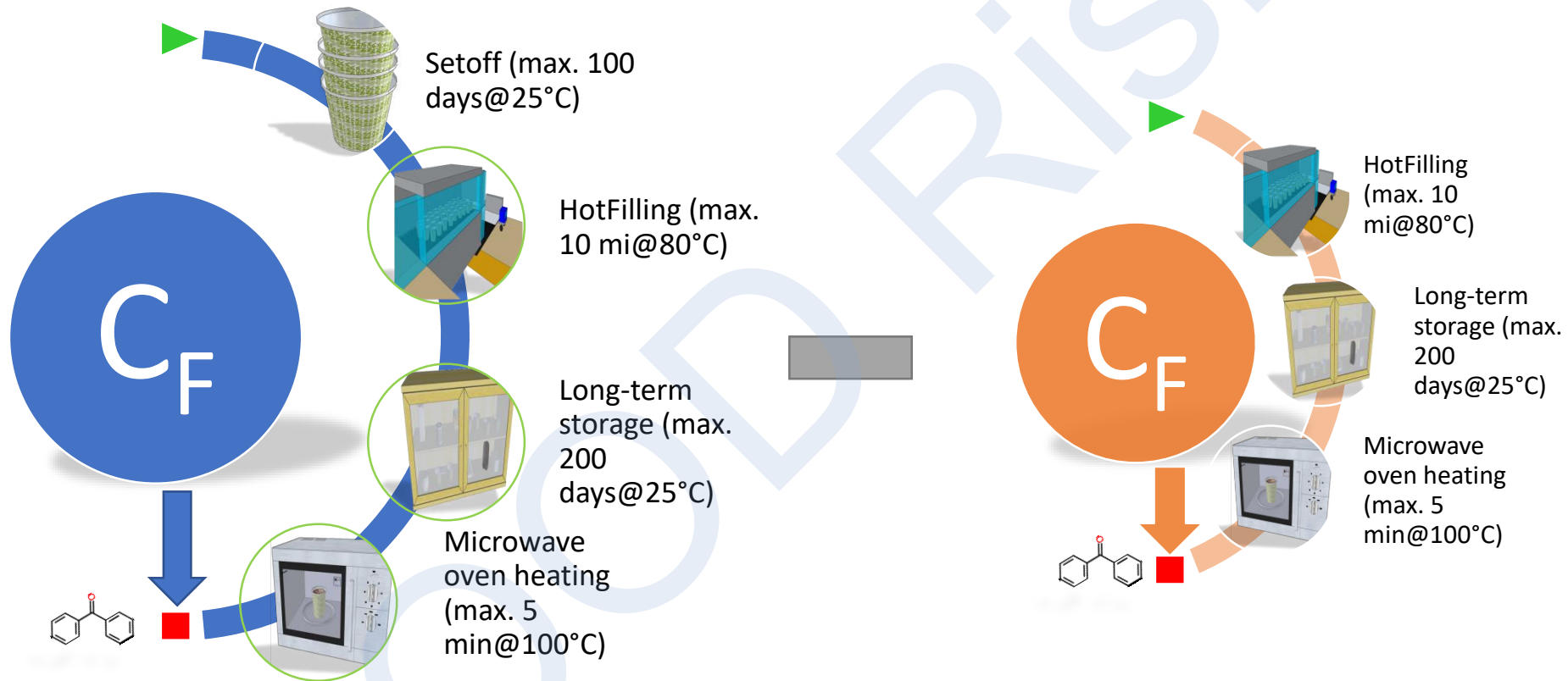
UV-curing printing ink



➤ ASSESSING THE SEVERITY OF A SINGLE STEP

CASE OF "SETOFF"

Full methodology described in *Food Chemistry* 2013, 59(4), 1031-1037



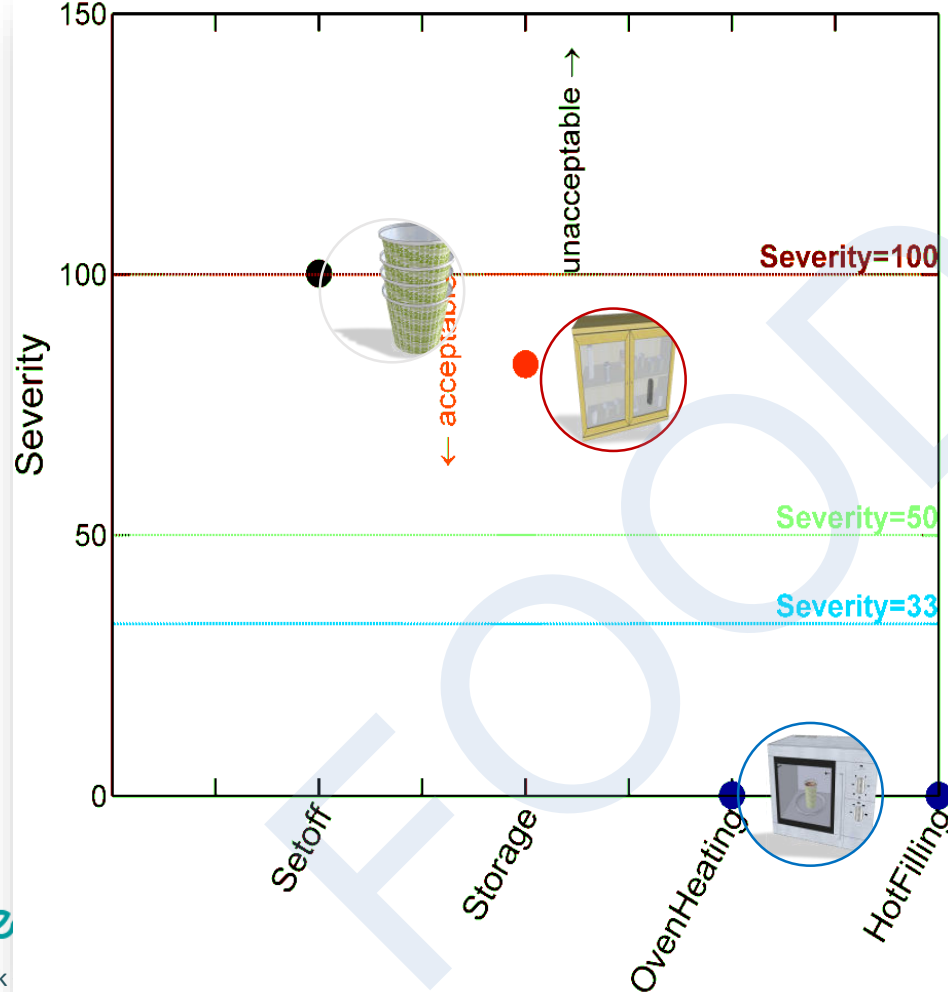
comparison with step i alone

$$\text{Severity}(\hat{C}_F(\text{step } i)) = f\left(\max(C_{F_M}|_{1 \rightarrow 2 \rightarrow \dots \rightarrow M} - C_{F_M}|_{1 \rightarrow 2 \rightarrow \dots \rightarrow M/i}, C_{F_i}|_i)\right)$$

comparison with step i removed

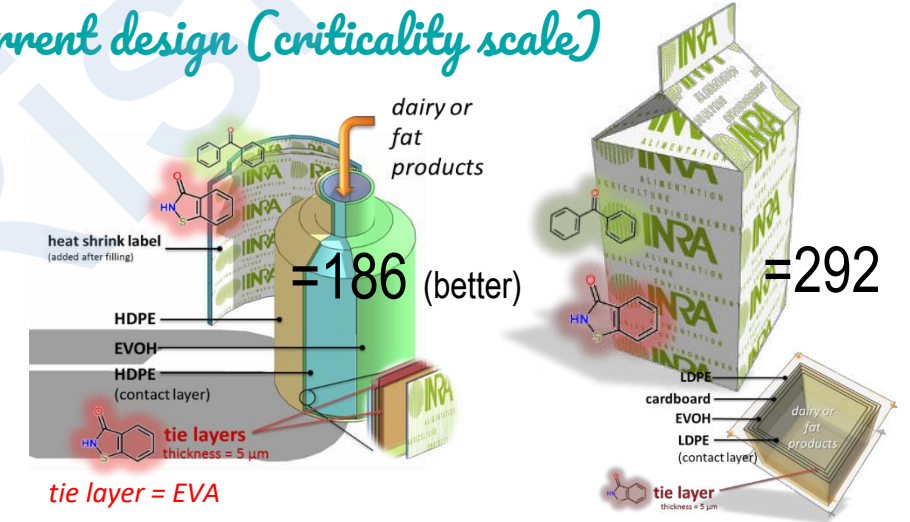
➤ COMPARING THE SEVERITY OF SEVERAL STEPS, PACKAGING DESIGNS, SUBSTANCES...

Critical step (severity scale)



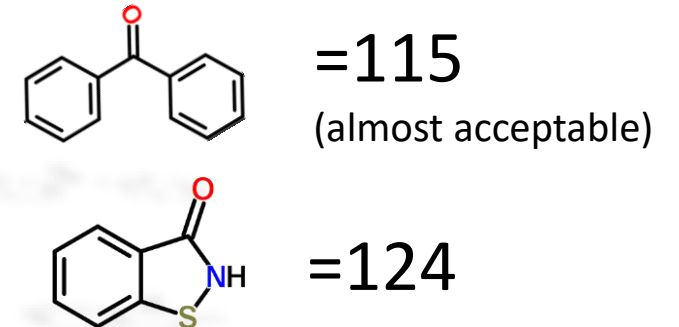
$$severity = 100 \times \frac{C_F}{SML}$$

Concurrent design (criticality scale)

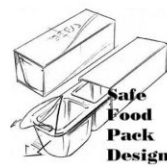


$$criticality = \sum_{all\ components} \sum_{all\ substances} \sum_{all\ modalities} pr(modality) \times severity$$

Critical substance



➤ Failure Mode Effects and Criticality Analysis



Collaborative research project SAFEFOODPACK DESIGN

FMECA « milk for infants stored in a brick »					
Phase	Formulation	Design	Process	Informations	Mechanisms
	Formulation	design	Process	Informations	Described mechanisms
Inventaire	- monomers (plastics, adhesives) - catalysts - antioxidants - lubricants - biocides (cardboard, ink) - mineral oil (cardboard) - solvents - photoinitiators - other residus (NIAS)	two components: - brick body (4 materials, 5 layers) - cap (two materials incl. the sealing system) six materials - LDPE, PP (cap) - aluminum foil - cardboard (origin) « ink » « adhesives »	- production, storage, assembly of materials - assembly and storage of components - printing (printing technology, curing/drying....) - storage of empty packaging - aseptic packaging filling (temperature, pretreatment...) - storage and retailing of the bricks filled with milk - conditions of use or storage by the consumer/end-user: chilled, ambient, oven heating? - Consumption-type (bottle feed with direct contact between the mouth and the neck...)	- identity and nature of materials in assemblies formulation of materials (substances specifically regulated or not) test conditions used to evaluate the risk of contamination conditions of preparation, packaging filling, storage, consumption of packaged food - communication of revisions and modifications in la formulation, design, process and in the final use	- diffusion across layers - set-off - cross-contamination between materials and with the storage ambience - effects of poor drying and curing on printing inks
	Highly concentrated - antioxidants, lubricants, biocides - mineral oils, photoinitiators - monomers, catalysts, solvents - other residues	Barrier material - aluminum foil Materials acting as reservoir of low molecular weight contaminants - ink - adhesive Materials acting as reservoir of high molecular weight of contaminants - PP, LDPE - paper and board	steps associated to long-time contact - storage of materials - storage of components - storage of finished products steps associated to high temperatures - aseptic filling - oven heating steps which may lead to cross-contamination - storage - printing - assembling / laminating	non-documented or missing information accessible information documented information, which follow each component and materials verifiable and auditable information frequency of update of information : regular, when a change occur, only when the design is modified,...	- mass transfer, which can be evaluated rapidly from calculations: from, trough LDPE, PP layers - mass transfer, which can be tested experimentally in a simple manner : set-off - mass transfer, which require a depth expertise: cross-contamination, aging

Hierarchisation

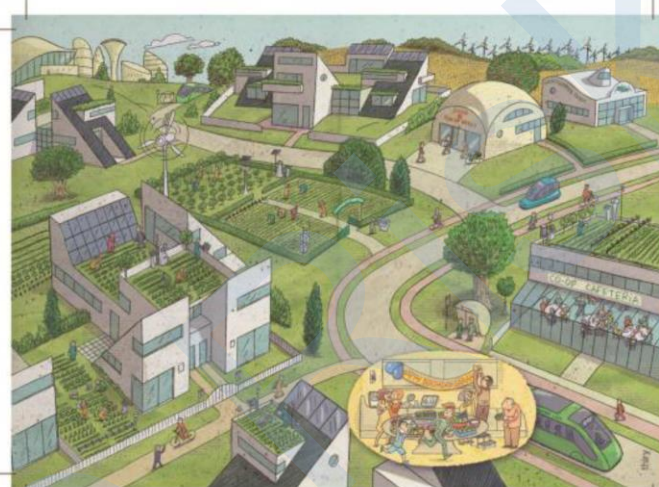
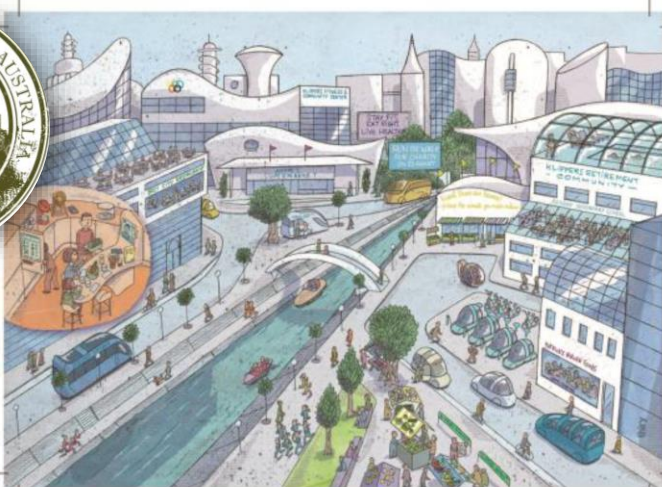
Conclusions & Perspectives



PARIS SMART CITY 2050
Vincent Callebaut Architectures, 2015



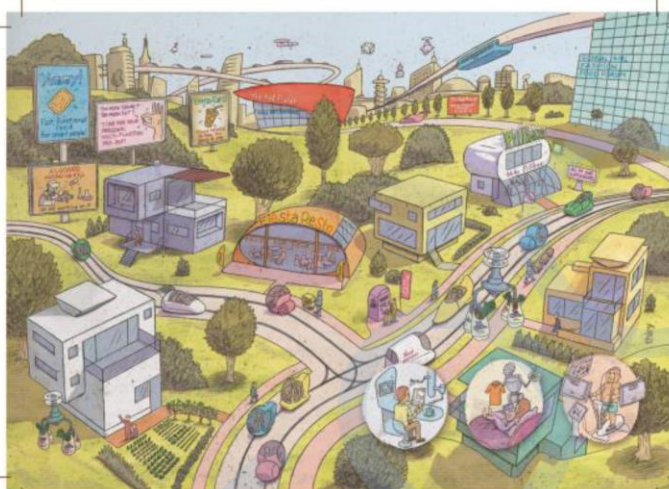
Strong community spirit (sustainable, safety and quality)



**Low agriculture
commodity
and food price**



**High agriculture
commodity and
food price**



Credits: European
Commission, JRC



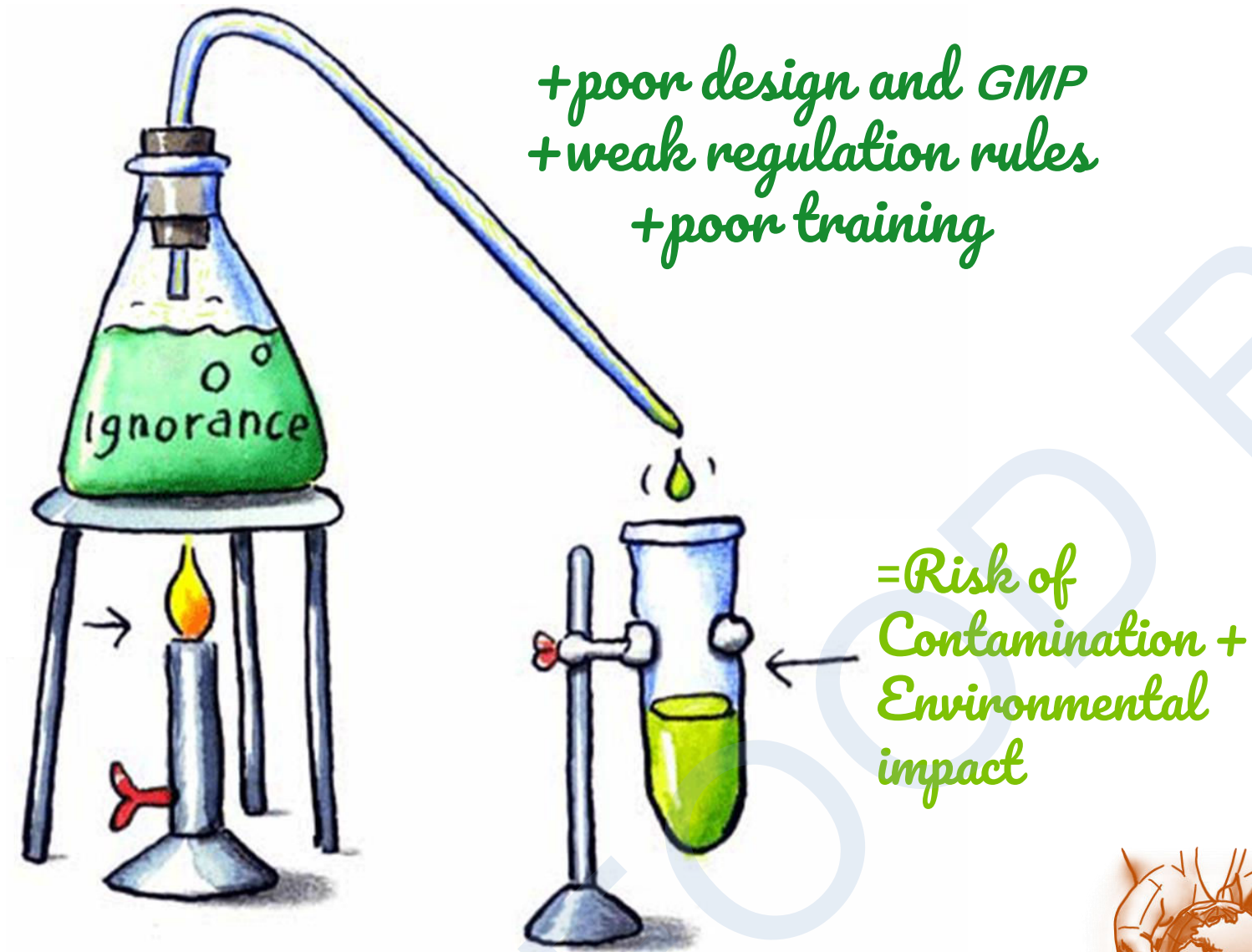
Individualistic society (individual rights and initiatives valued)

Think
BIG
with modeling

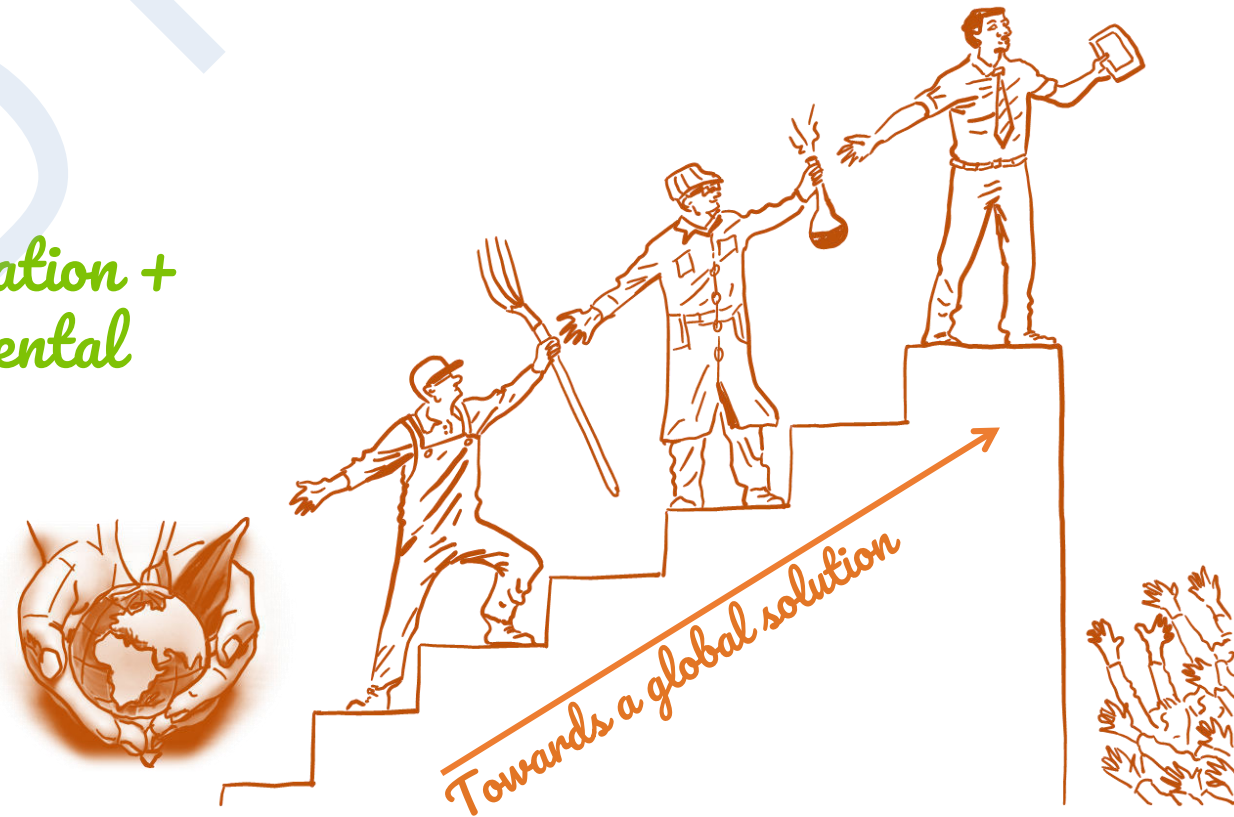


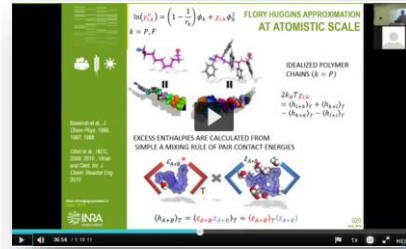
Let's the food engineer contributes to building the future.





$$\text{ignorance} = \frac{IT}{\text{WHAT ABOUT IT}}$$





- This lecture:
<http://modmol.agroparistech.fr/masterEU/>

- MY LECTURES AT MSU (MI,USA):
<http://www.fshn.msu.edu/events/event/Vitrac>
diffusion
https://mediaspace.msu.edu/media/dr.+olivier+vitrac+presentsa+diffusion+coefficients+of+organic+solutes+in+polymersa/1_zz20dgt9
PARTITIONING
https://mediaspace.msu.edu/media/Dr.+Olivier+Vitrac+presentsA+An+atomistic+Flory-Huggins+formulation+for+the+tailored+prediction+of+activity+and+partition+coefficients/1_uzi6h91k
SAFETY MANAGEMENT:
https://mediaspace.msu.edu/media/WorkshopA+Prediction+of+the+migration+onA+beyond+conventional+estimates*/1_won1m7aw

- RISK ASSESSMENT:
<https://www.youtube.com/watch?v=7LMnc4czpuY>

Welcome to FITNess

Fitness stands for **Food packaging open courseware for higher education and staff of companies**

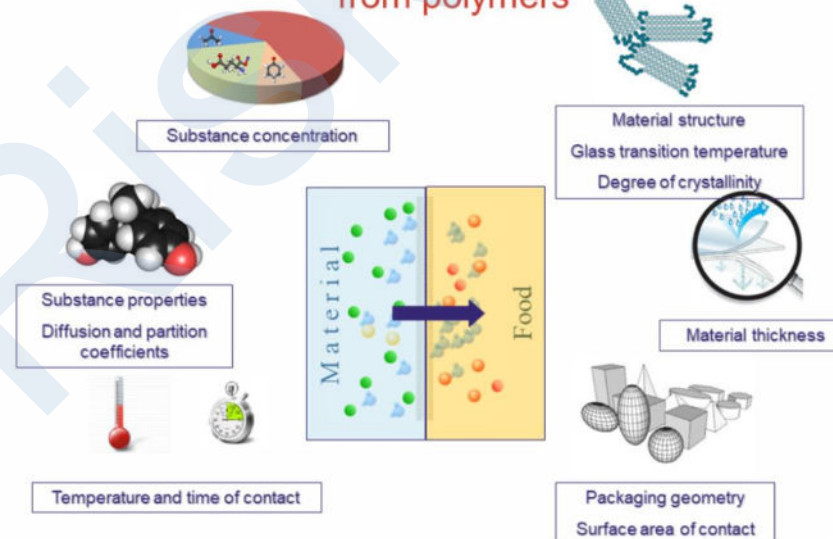
All lectures, interactive contents and Quizz are provided "AS IS" content (85 lectures from Common to Specialized Modules) is development and may contain inconsistencies and inaccura



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COORDINATOR ACTIA-LNE

Migration phenomenon of substances coming from polymers



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<http://fitness.agroparistech.fr>

author: undef

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Online lectures

Online lectures

Common modules

1. What is food packaging
 - 1.1 Panorama of food packaging
 - 1.2 Packaging materials and shaping process
 - 1.3 Basic legal framework
2. Properties of food packaging materials
 - 2.1 Thermal, mechanical and barrier properties
3. Packaging and food preservation
 - 3.1 Common physical chemical factors affecting food stability
 - 3.2 Food packaging and shelf life

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Session 4. Mass transfer in food packaging - Unit 4.2. Migration modeling in monomaterials

4.3 Modelling for multi-materials, multi-steps process

Migration modeling for multi-materials, multi-steps process, reusable materials - SPECIALIZED TRAINING MODULES

author: undef

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