# THE SAFETY OF FOOD CONTACT MATERIALS


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http://modmol.agroparistech.fr, https://fitness.agroparistech.fr

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https://fitness.agroparistech.fr/fitness/external/ESPCI/

**Permanent link**

# Beyond food packaging

- Article 17 - REGULATION (EC) No 1223/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 November 2009 on cosmetic product

*Article 17*

**Traces of prohibited substances**

The non-intended presence of a small quantity of a prohibited substance, stemming from impurities of natural or synthetic ingredients, the manufacturing process, storage, migration from packaging, which is technically unavoidable in good manufacturing practice, shall be permitted provided that such presence is in conformity with Article 3.

- 2013/674/EU: Commission Implementing Decision of 25 November 2013 on Guidelines on Annex I to Regulation (EC) No 1223/2009 of the European Parliament and of the Council on cosmetic products Text with EEA relevance

3.4.3. *The relevant characteristics of packaging material*

Packaging material means the container (or primary packaging) that is in direct contact with the formulation. The relevant characteristics of packaging materials in direct contact with the final product are important for the safety of the cosmetic product. Reference to Regulation (EC) No 1935/2004 of the European Parliament and of the Council (4) could be useful.

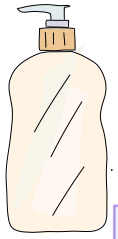
- COSMETICS EUROPE - ADVISORY DOCUMENT: Information exchange on cosmetic packaging materials along the value chain in the context of the EU cosmetics regulation EC 1223/2009

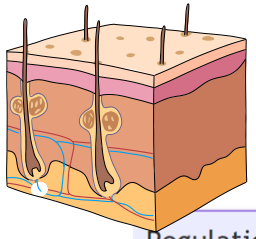
For plastic food contact materials the rules for migration testing are clearly stipulated in the Commission Regulation EU 10/2011. (e.g. the OML is set at 60mg/kg food, or 10 mg/dm$^2$ of the contact material). For many other materials like paper & board, metals, rubbers or migration of printing inks through substrates, the rules for migration testing have been established in national regulations or in industry guidelines.

Migration results to demonstrate compliance with these limits can be obtained in food itself, or in food simulants, or can originate from migration modelling or worst case assumptions (i.e. assuming that 100% of the substance would migrate into the food).

Migration can also be estimated based on worst-case assumptions or conservative modelling. More detailed assessments and/or tests are only necessary when these assumptions proof to be overly conservative. If compliance has been based on modelling or worst case calculation, there is no need to further evaluate migration through testing.

# BEYOND FOOD PACKAGING





Regulations for Cosmetics and Detergents Packaging

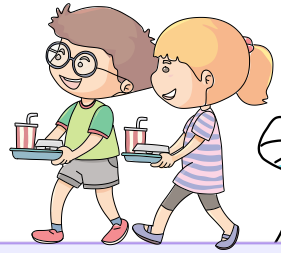
Regulation EC No 1223/2009 'Cosmetics regulation'

Food Contact Regulations

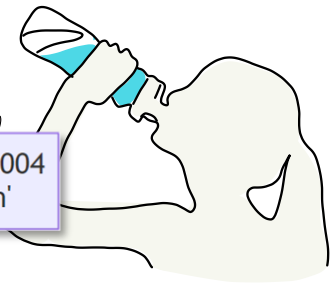
Regulation EC No 1907/2006 'REACH'

Directive 94/62/EC on packaging and packaging waste

Proposal for a regulation on packaging and packaging waste

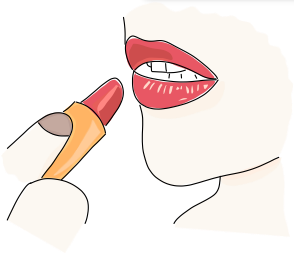


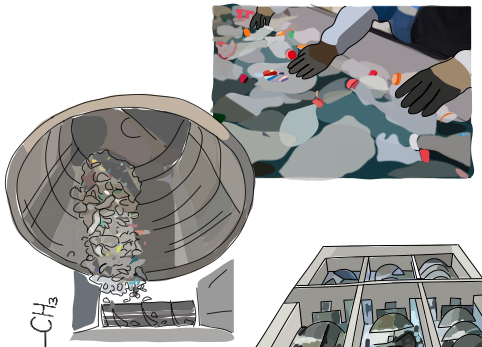
Regulation EC No 1935/2004 'Framework Regulation'



Commission Regulation EU No 10/2011 'Plastics Regulation'

Commission Regulation EU 2022/1616 'Recycled Plastics Regulation'

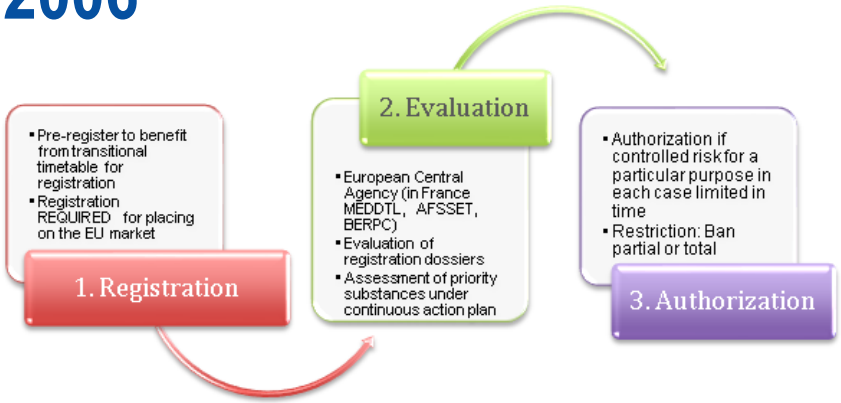



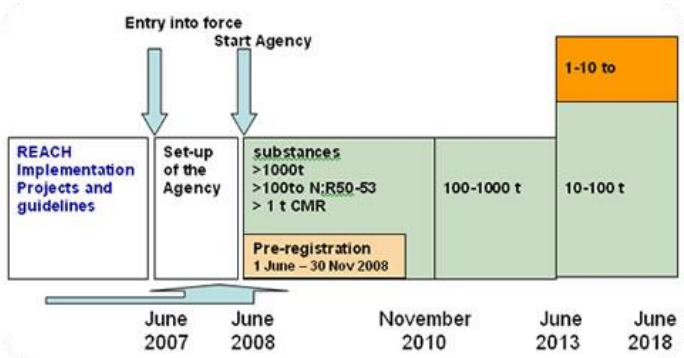


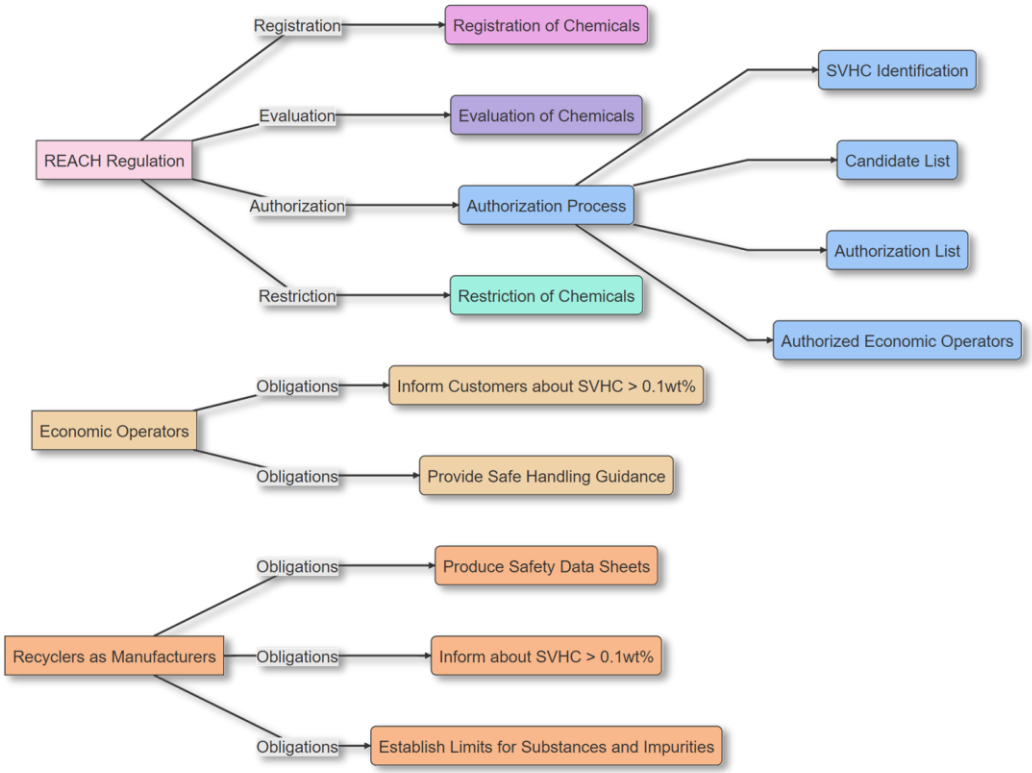
# REACH: Regulation (EC) No 1907/2006

Other inventories

TSCA – US Toxic Substances Control Act
DSL – Canadian Domestic Substances List
NDSL – Canadian Non-Domestic Substances List
ENCS (MITI) – Japanese Existing and New Chemical Substances
AICS – Australian Inventory of Chemical Substances
KECL (Korean ECL) – Korean Existing Chemicals List
ICCS – Philippine Inventory of Chemicals and Chemical Substances
Giftliste (old Swiss list of toxic substances, repealed in 2005)



# CONTENT

# _01

## Background & overview

MIGRATION ISSUES

CURRENT REGULATIONS & RECOMMENDATIONS

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Is it safe?
How to assess it?
How to grant it?
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MILK
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TUNA
INRA
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AgroParisTech
TUNA


OPEN
INRA
MILK
MILK












INRA
SCIENCE & IMP





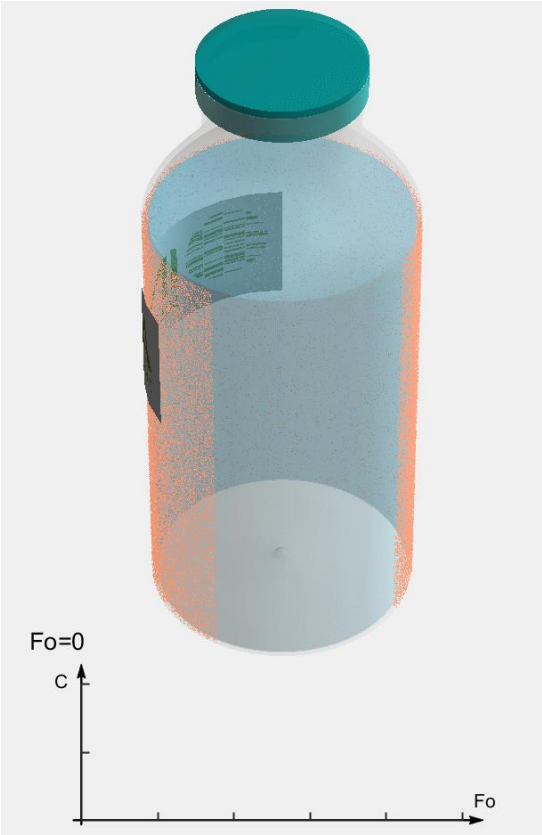

SAFEMAT


Is it safe?
How to assess it?
How to grant it?
OPEN
INRA
SCIENCE & IMPACT

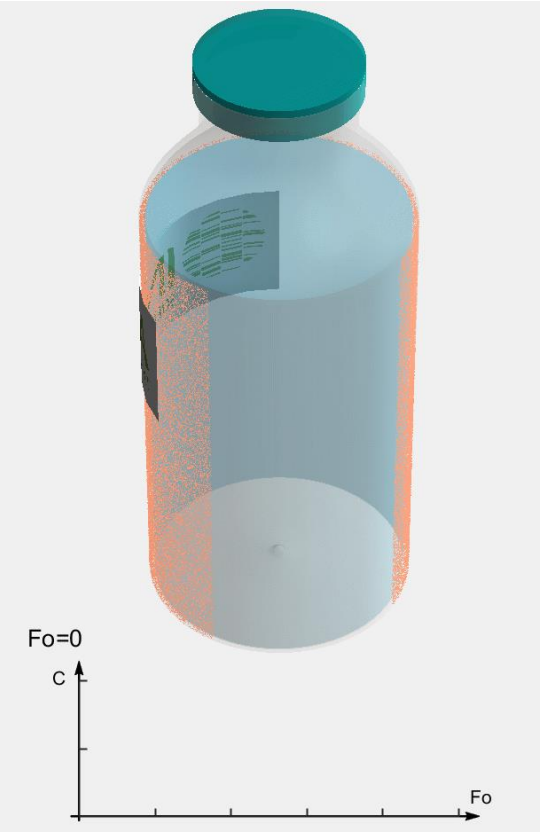
# MASS TRANSFER FROM THE PACKAGING MATERIAL (ADDITIVES, MONOMERS AND OLIGOMERS, NIAS…)

## DIRECT CONTACT

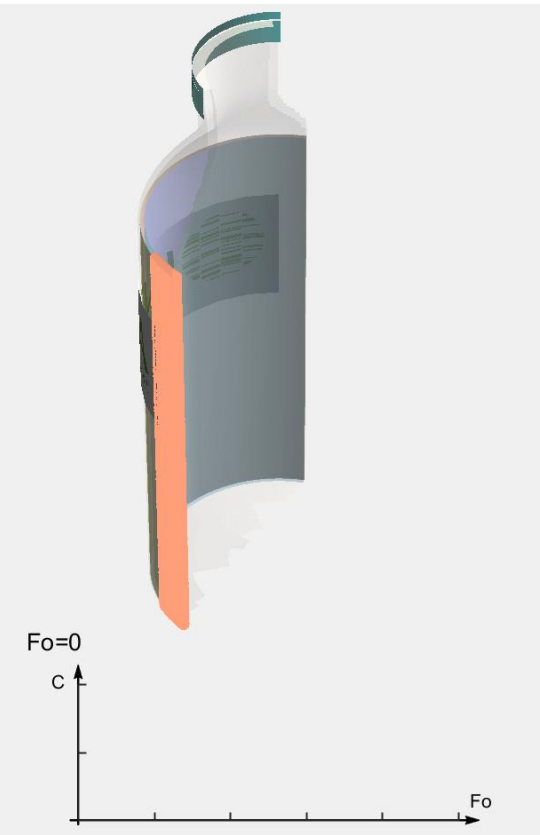
monolayer




with barrier to diffusion




multilayer



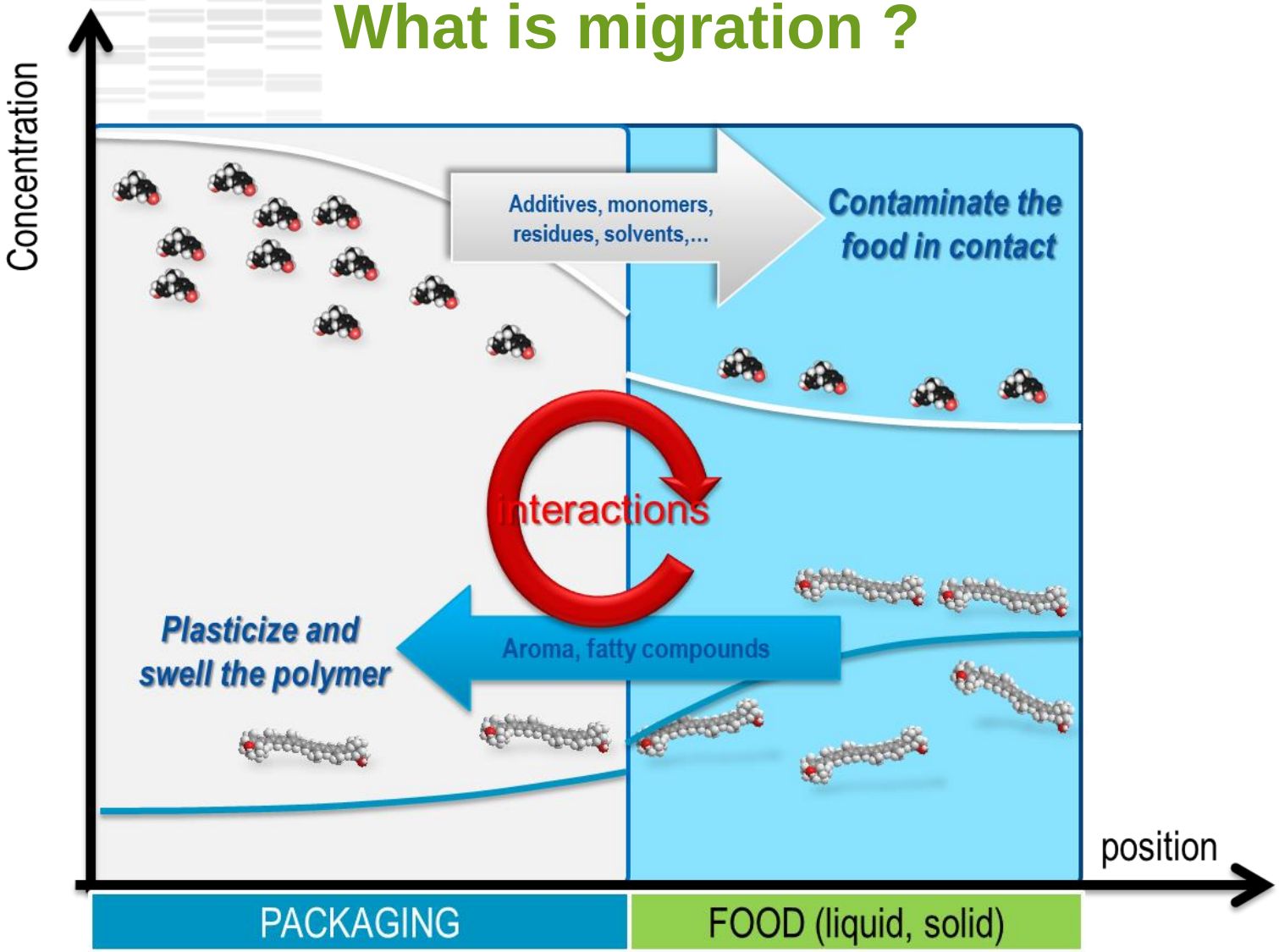

$$Fo = \frac{D_P t}{l_P^2}$$

# OTHER MASS TRANSFER

## from the food in contact


## contamination from environment

# What is migration ?



# FOOD PACKAGING INTERACTIONS

## Example of sterilized product



# PRINCIPLES OF FOOD INERTIA: A LONG HISTORY

L'ART DE CONSERVER,

PF

TOUTE

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*ancie*
*la M*

CHEZ P
NAPOL

8me ANNÉE. — N° 19 JUILLET 1910

## LA CONSERVE ALIMENTAIRE

*Bulletin mensuel de Vulgarisation Théorique et Pratique de Fabrication*

PARAISSANT LE 15 DE CHAQUE MOIS

Rédigé par un groupe de Fabricants-Industriels et de Chefs d'Emplois de cette Industrie

*Nicolas APPERT*
(1750-1841)

### 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. CROLBOIS, 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'Ecole.

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



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

*Pour le Comité de Direction :*
AUG. CORTHAY.

## Causerie Professionnelle
**par Nicolas APPERT**

### Méfions-nous des Conserves 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 Etats-Unis et en Europe, ceux du Canada sont encore à l'état embryonnaire.

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

« Je ne parle pas ici de l'inspection des viandes fraiches 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 révèlerait 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 susbstances nuisibles, aussi bien dans les conserves que dans les viandes fraiches.

« 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 rassu-

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

# REGULATION = TRANSFER OF RESPONSABILITIES

## e.g. regulation 10/2011/EC (current: 6th amendment)

https://ec.europa.eu/food/safety/chemical_safety/food_contact_materials_en



CHEMICAL SAFETY

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

ALL TOPICS

# Food Contact Materials

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
- 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.

Share

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

## 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 perform safety assessments of substances used to manufacture FCMs involving the European Food Safety Authority
- rules on labelling including an indication for use (e.g. as a coffee machine, a wine bottle, or a soup spoon) or by reproducing the appropriate symbol. For more information, please refer to the following document on Symbols for labelling food contact materials.
- for compliance documentation and traceability

**Regulation on Good Manufacturing Practices**

Regulation (EC) No 2023/2006 ensures that that the manufacturing process is well controlled so that the specifications for FCMs remain in conformity with the legislation:

- premises fit for purpose and staff awareness of critical production stages
- documented quality assurance and quality control systems maintained at the premises, and
- selection of suitable starting materials for the manufacturing process with a view to the safety and inertness of the final articles

Good manufacturing rules apply to all stages in the manufacturing chain of food contact materials, although the production of starting materials is covered by other legislation.

### II. EU legislation on specific materials

In addition to the general legislation, certain FCMs — ceramic materials, regenerated cellulose film, plastics (including recycled plastic), as well as active and intelligent materials — are covered by specific EU measures. There are also specific rules on some starting substances used to produce FCMs.

[Expand All]

- Plastic Materials
- Active and Intelligent Materials
- Recycled Plastic Materials
- Ceramics
- Regenerated Cellulose Film

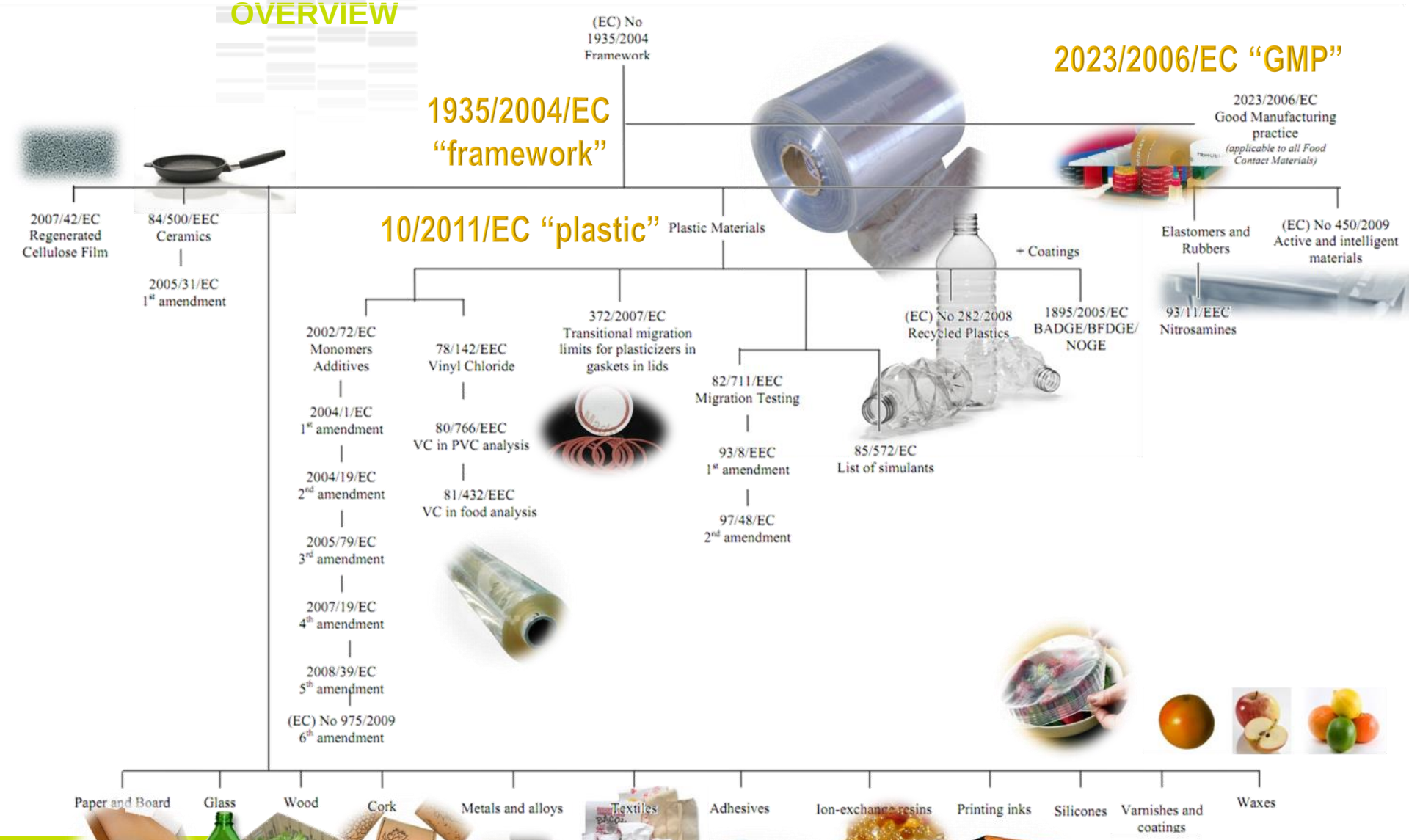
### III. Other Legislation

**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

# EU REGULATION

## OVERVIEW

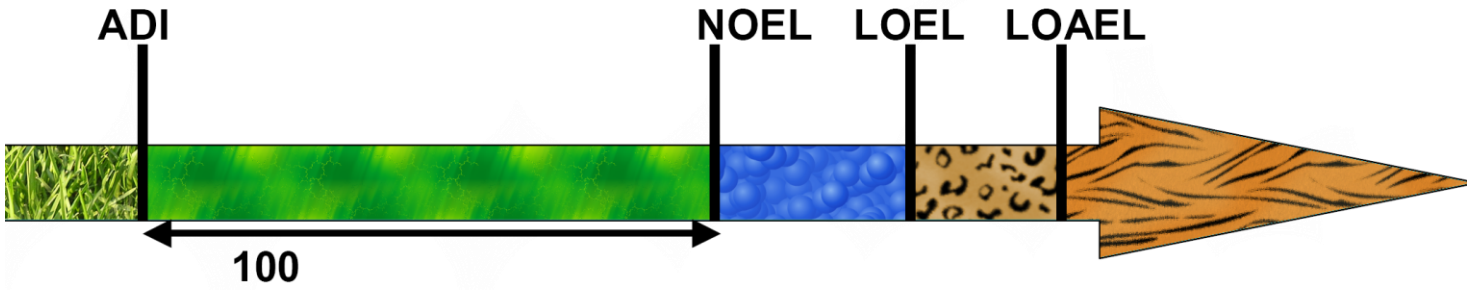


# Risk assessment vs risk management

**502 substances (including 230 monomers and 272 additives) among the 937, which are positively listed in EU directives on plastics in contact with food, are subjected to (SML)**

**EFSA:** **Risk Assessment**
ADI = NOEL/100 (per kg body weight)

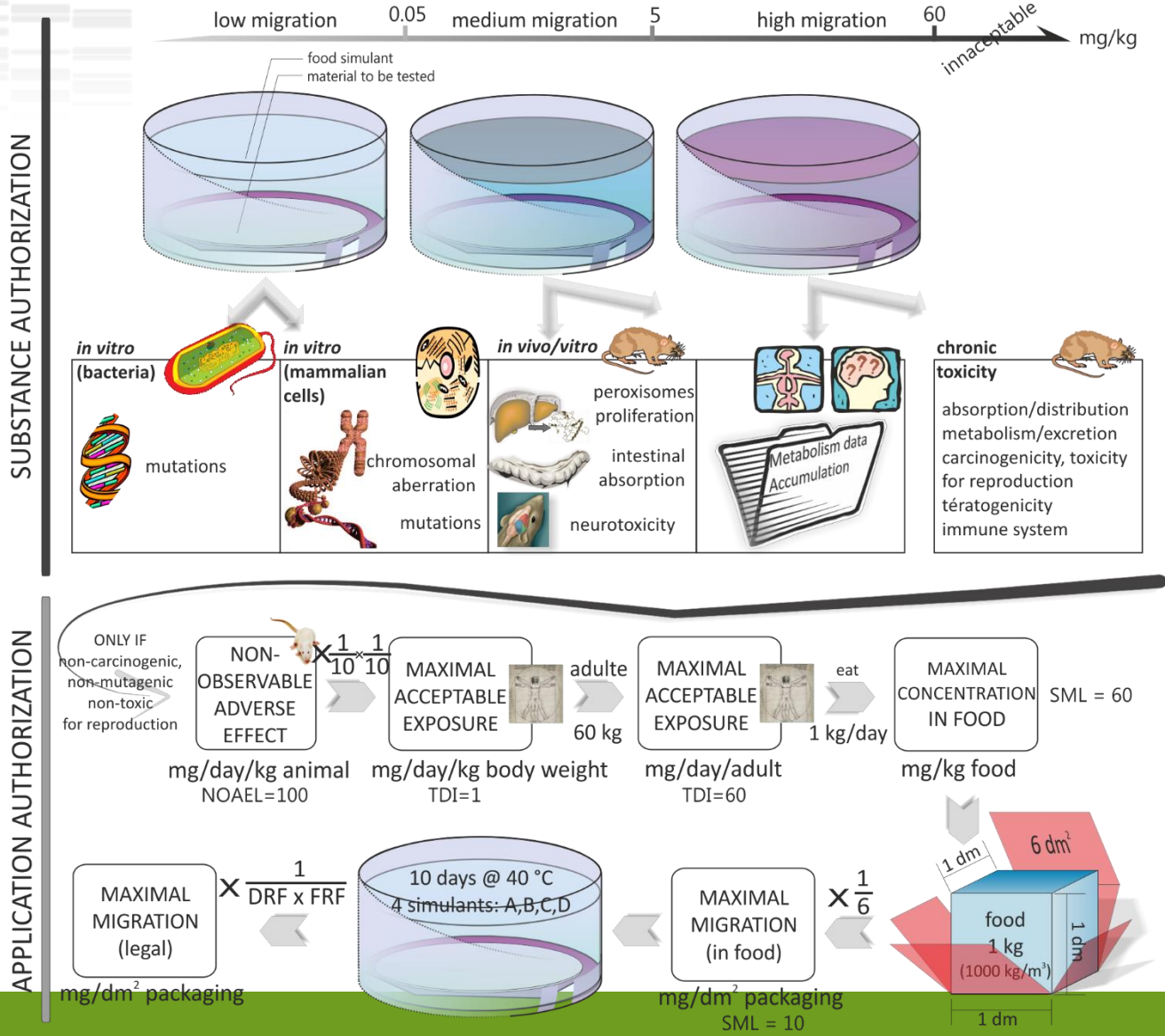
**DG SANCO:** **Risk Management**
SML= 60 * ADI (mg intake per person per day from an assumed 1 kg packaged food)




**ADI = Acceptable Daily Intake**
**SML = Specific Migration Level**
**NOEL = No Observed Effect Level**
**LOEL = Lowest Observed Effect Level**
**LOAEL = Lowest Observed Adverse Effect Level**

# SPECIFIC RULES FOR PLASTICS

## COMPLIANCE ISSUES



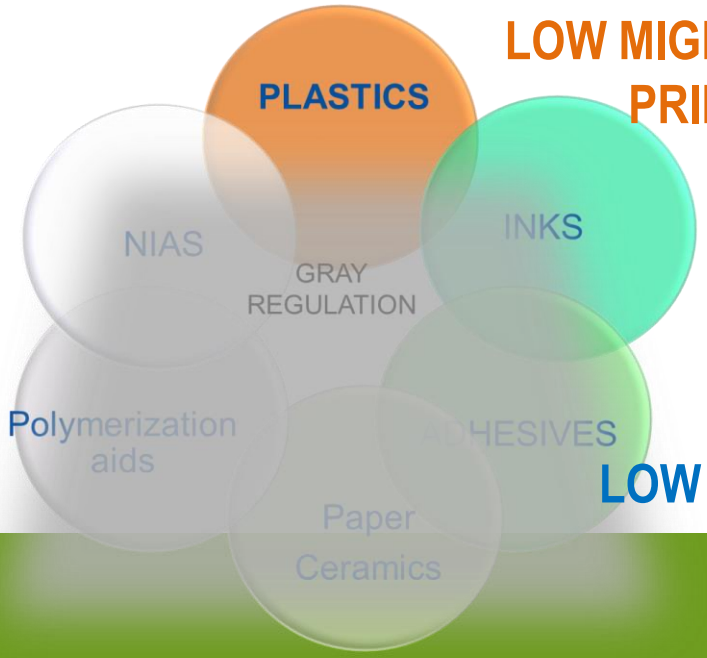
# SPECIFIC EU RULES FOR PLASTICS FOR FOOD CONTACT

## Materials can be regulated alone or in combination with other materials

- list of substances
- purity standard for substances
- **overall migration limits: OML (60 mg/kg or 10 mg/dm$^2$)**
- **specific migration limits: SML**
- other rules ensuring safety and inertness
- **compliance, sampling, analytical methods, migration modeling**
- traceability
- declaration of compliance

## Plastic materials

- exclusively plastics
- Plastic multilayers or layers tied with adhesives
- Plastic layers, coatings forming gaskets
- Plastic layers in multi-materials

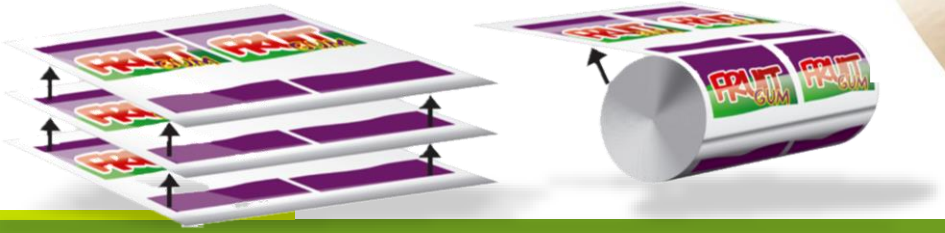


# VOLUNTARY APPROACHES & LOCAL ORDINANCES (SWISS, GERMAN)

## PRINTING INKS

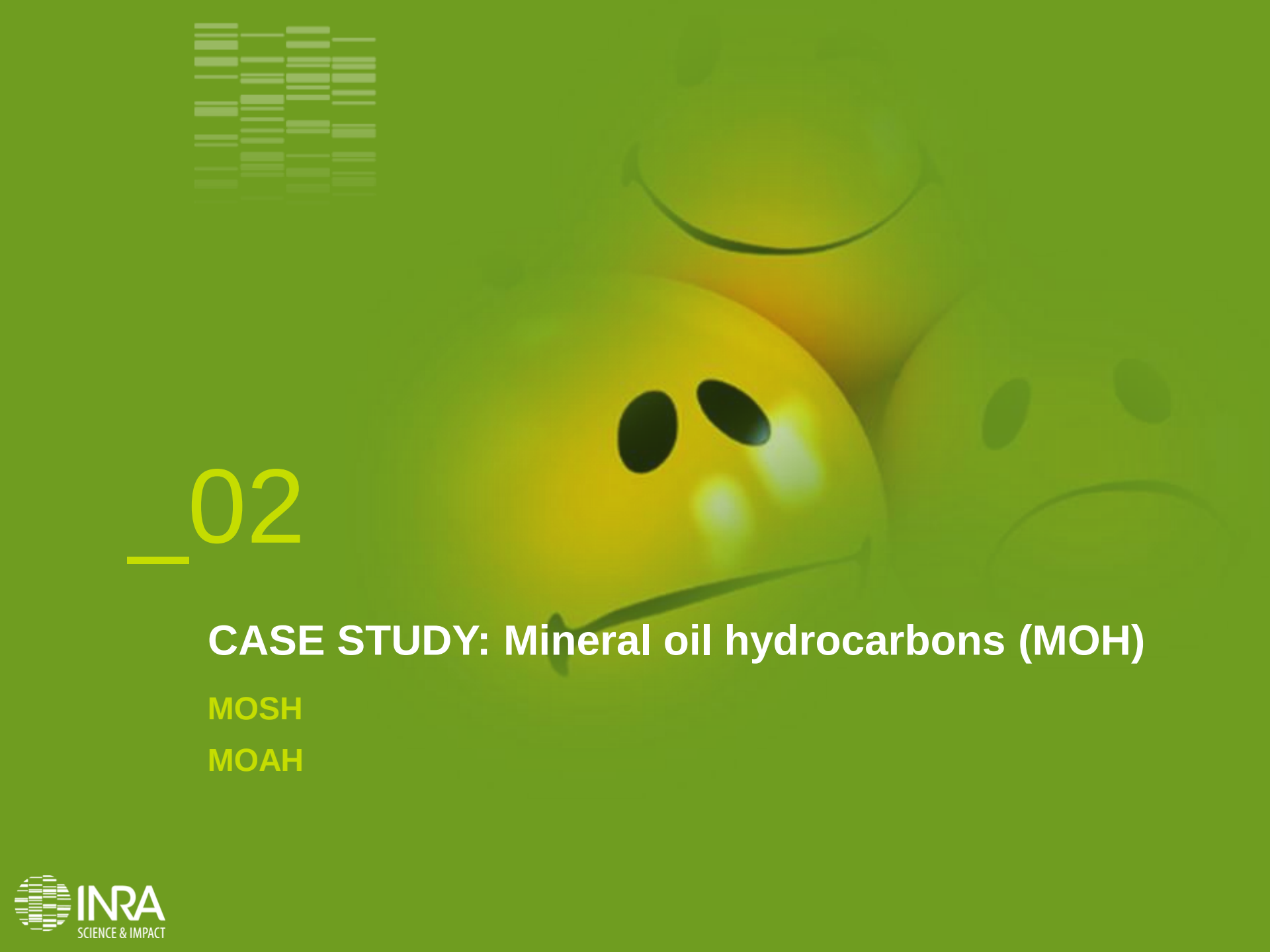
### (EUPIA guidelines to be revised)


- Exclusion/Negative lists
- Recommended substances
- Purity/traceability requirements
- Migration (less than 10 ppb for non evaluated substances) and risk assessments
- Inks prepared according to GMP
- No-direct contact with food
- No “visible’ Set-off in stacks and reels




## MINERAL OILS

- No recycled paper or paperboard
- No MOSH below C20, migration <2 ppm for C20-C35
- Migration of MOAH (C16-C35)<0.5 ppm
- List of raw materials and production aids
- No holding/reheating above 90°C
- No microwave uses
- With internal bag



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# CASE STUDY: Mineral oil hydrocarbons (MOH)

**MOSH**

**MOAH**

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# Mineral oil hydrocarbons (MOH)

## mineral oil saturated hydrocarbons (MOSH)

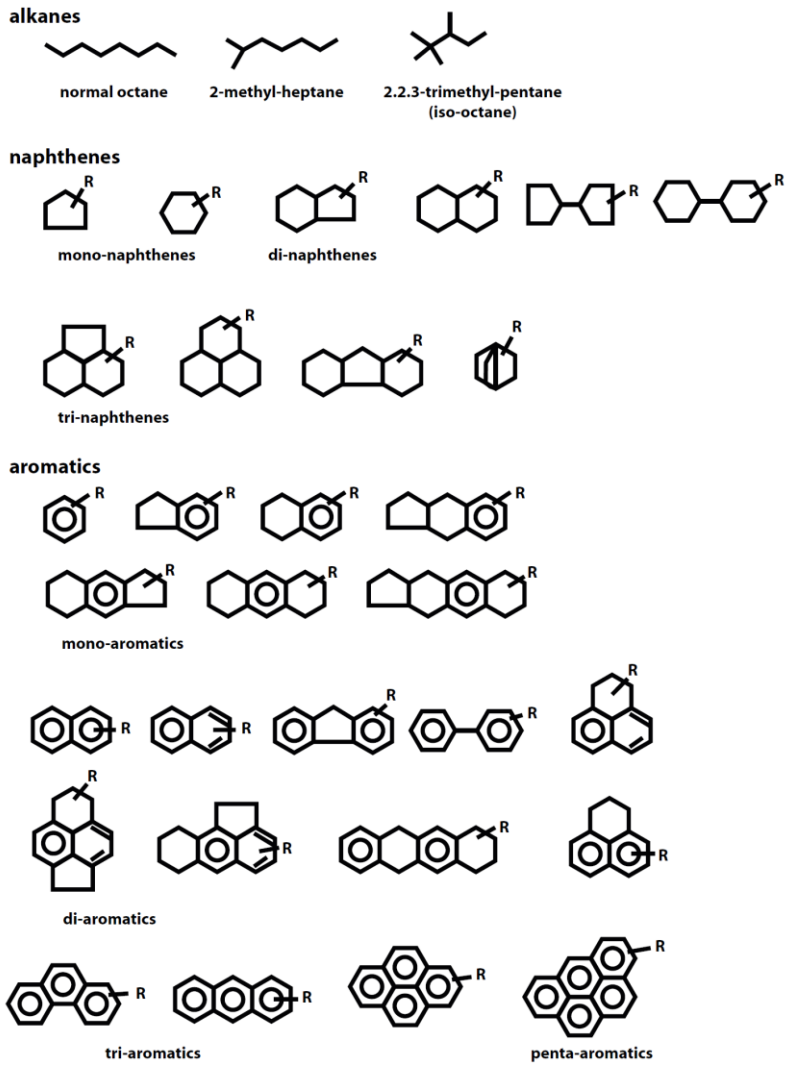
- MOH are derived by physical separation (such as distillation or extraction) and chemical conversion processes (cracking, hydrogenation, alkylation, isomerisation, etc.) from crude oils and/or synthetic products derived from liquefaction of coal, natural gas or biomass.
- Because of their complexity it is not possible to resolve MOH mixtures into individual components for quantification.
- Food grade MOH products are treated in such a way that the MOAH content is minimized. **Technical grades of MOH typically contain 15-35 % MOAH**.
- Absorption of alkanes may occur through the portal and/or the lymphatic system. For n- and cyclo-alkanes the absorption varies from 90 % for $C_{14}$-$C_{18}$ to 25 % for $C_{26}$-$C_{29}$.
- Major sources of MOH in food are food packaging and additives, processing aids, and lubricants.

## mineral oil aromatic hydrocarbons (MOAH)

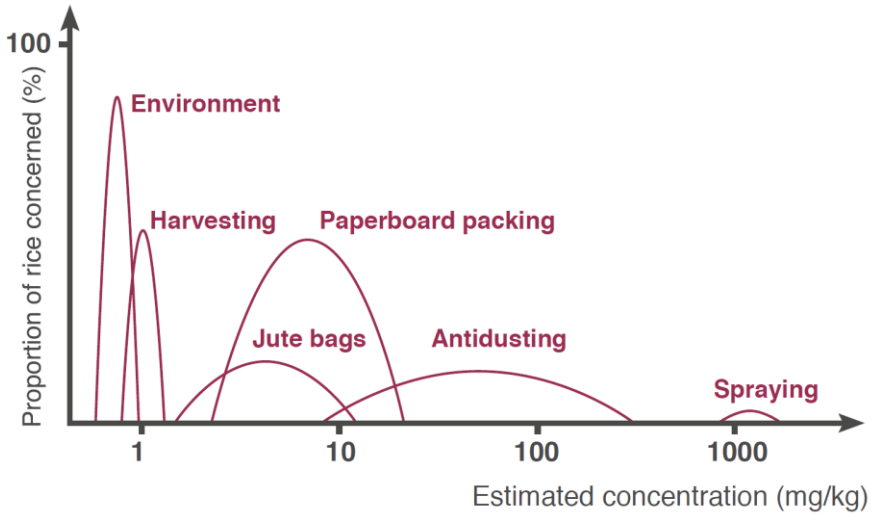
- Analytical capacity to distinguish the different MOAH subclasses in food is limited. For this purpose, GCxGC appears to be the most effective method. Due to the complexity and the variable composition of MOH mixtures, it is not possible to define certified standards of general applicability.
- Occurrence data on dry foods which could be attributed to the use of recycled paperboard packaging were available from two different surveys. Mean concentrations of MOH were up to 32 mg/kg for MOSH found in creme/pudding mix and 4.5 mg/kg MOAH found in noodles. **Maximum occurrence values were 100 mg/kg in semolina and 17 mg/kg in noodles, for MOSH and MOAH, respectively.**
- All MOH are mutagenic unless they are treated specifically to remove MOAH. The mutagenicity of MOH is caused mainly by 3-7 ring MOAH, including non-alkylated PAHs.
- A significant source of dietary exposure to MOH may be contamination of food by the use of recycled paperboard as packaging material.

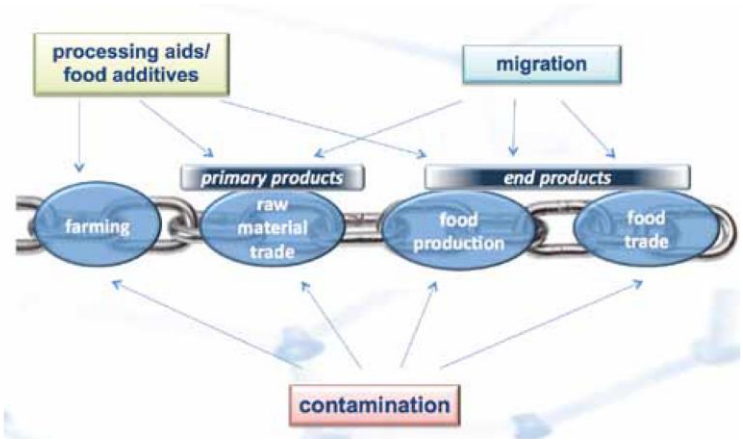
# Mineral oil hydrocarbons (MOH)

## Typical chemical structures




## Typical content



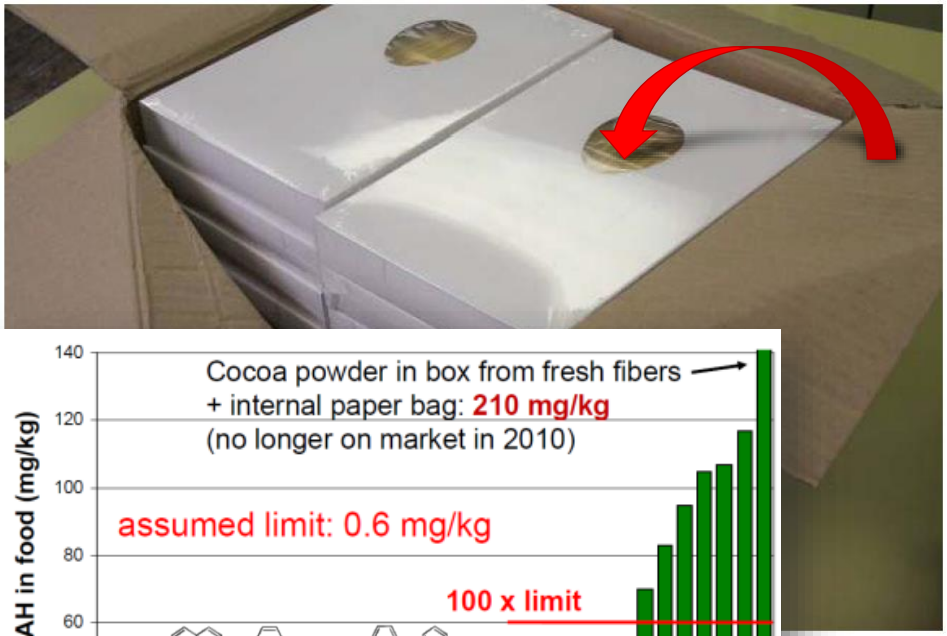

EFSA (2012): Scientific opinion on Mineral Oil Hydrocarbons in Food. EFSA Journal (10): 2704

# non-specifically regulated materials, dry and aqueous food falsely considered safe

## CONTAMINATION OF NODDLES BY RECYCLED FIBERS OF SECONDARY PACKAGING

**After 65 days of contact, 6.1 mg/kg of paraffins found in noodles stored in boxes in top and bottom positions. Estimated migration at shelf life (2 years) : 10 mg/kg**

(Biedermann *et al.*, 2011; Packaging Technol & Sci 2011, 24, 281-290)

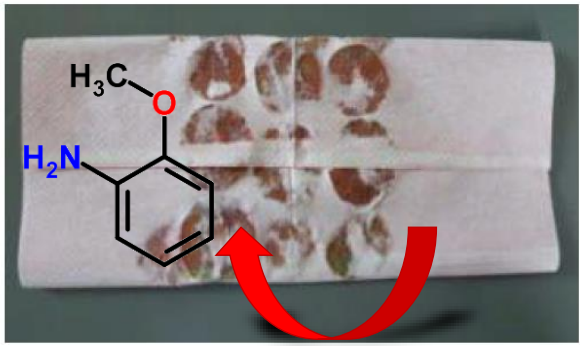





## CONTAMINATION OF FRESH FRUITS BY PRINTED TABLE NAPKIN

**Migration of o-anisidine (primary aromatic amine): printed paper 17.5 µg/l → kiwi: 5.3 µg/l (migration rate: 17 %)**

***(Helling, 2011)***



# Italian police seize contaminated Nestle baby milk

22 Nov 2005 16:45:09 GMT

Source: Reuters

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

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

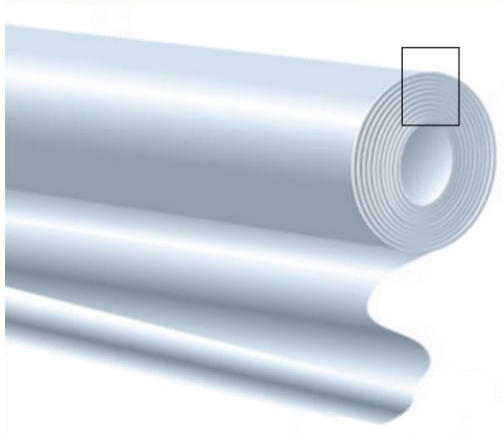
Italian officials said they had already seized about 2 million litres of Nestle baby milk earlier this month after finding traces of isopropylthioxanthone (ITX), an ink component used in the offset printing process of the Tetra Pak cartons.

They broadened their net on Tuesday, sweeping hundreds of packets of milk off supermarket shelves and out of depots around Italy. Police said they also searched lorries in their effort to root out the four Nestle products under investigation.

Nestle, the world's biggest food company, said it had decided to recall all liquid infant formula milks packed in offset printed cartons in Italy, France, Spain and Portugal.

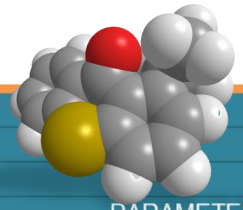


"It is incredible that such defenseless beings as babies should face such serious risks in a product as widely used as milk"

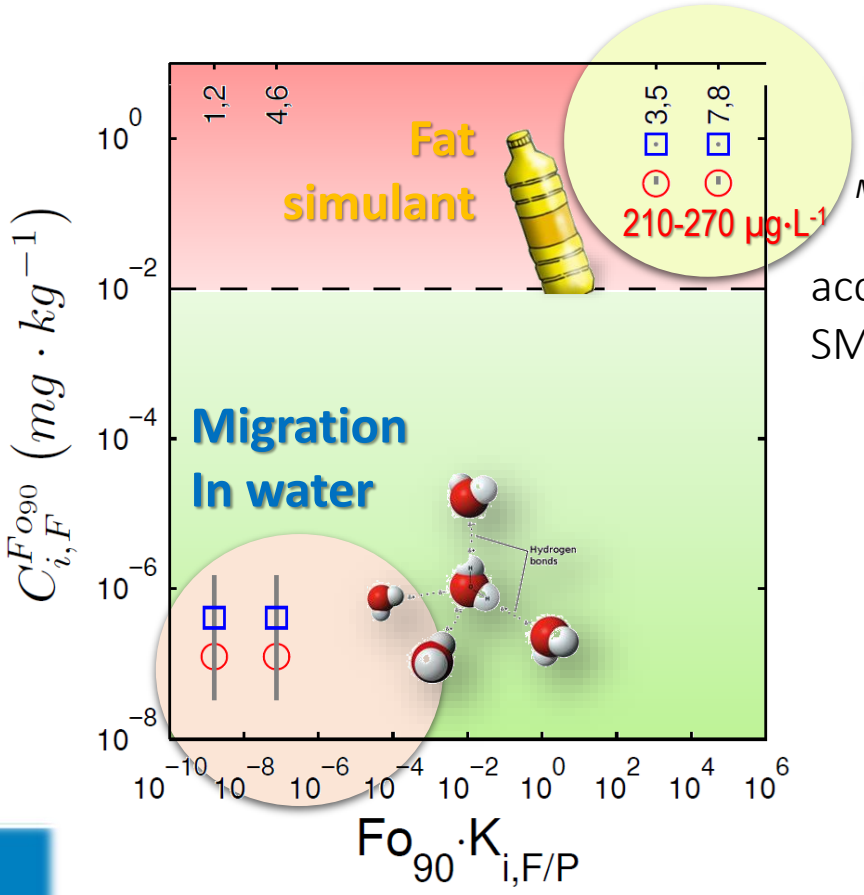



# MODELING WOULD HAVE BEEN ABLE TO PREDICT ITX VALUES IN FOOD?

## POOR RULES CREATED A CRISIS



| | Migrant | 2-ITX |
|---|---|---|
| | Homologous migrant† | not available |
| | Polymer | LDPE†† |
| PARAMETER | notation (unit) | |
| *Thickness* | $l_P$ (µm) | 50 |
| *Volume dilution ratio* | $L_{F/P}$ (-) | 360 |
| *Biot mass number* | Bi (-) | $10^3$ |
| *Contact Time* | t (days) | 90 |
| *Temperature* | (°C) | 4 |
| *Likely initial concentration*[a] | $\overline{C}^0_{i,P}$ [a] (mg·kg$^{-1}$) | 100 ± 10 |
| *Conservative initial concentration*[b] | $\left(C^0_{i,P}\right)^+$ [b] (mg·kg$^{-1}$) | 300 |
| *Likely diffusion coefficient*[c] | $\overline{D}_{i,P}$ [c] (m$^2$.s$^{-1}$) | $8.4\cdot10^{-16}$ [$7.6\cdot10^{-16}$ $9.2\cdot10^{-16}$] |
| *Conservative diffusion coefficient*[d] | $D^+_{i,P}$ [d] (m$^2$.s$^{-1}$) | $3.9\cdot10^{-14}$ |
| *Likely partition coefficient*[e] | $\overline{K}_{i,F/P}$ (-) | $1.4\cdot10^{-9}$ [$3.7\cdot10^{-10}$ $5.1\cdot10^{-9}$] |
| *Conservative partition coefficient* | $K^+_{i,F/P}$ (-) | $10^3$ |

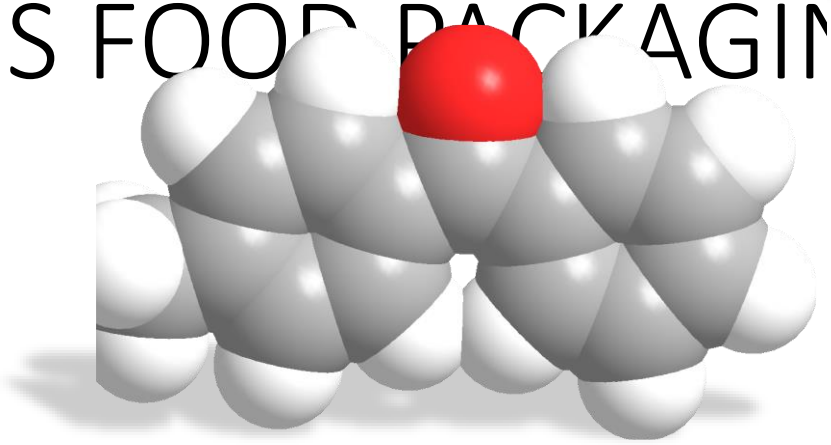


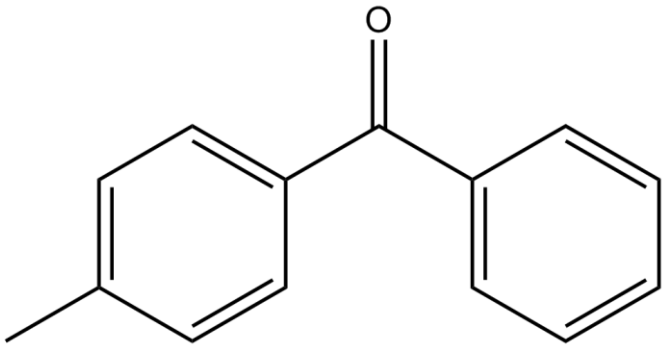

*M=241 g·mol$^{-1}$*

acceptable SML

| | Date of case | Last change | Reference | Country | |
|---|---|---|---|---|---|
| 6. | 08/09/2005 | | 2005.631 | ITALY | food contact materials |
| ***RASFF Portal*** | | | | | migration of isopropyl thioxanthone (250 µg/l) from packaging of milk for babies from Spain |

# IS FOOD PACKAGIN





4-methyl benzophenone

LE VEILLEUR@

Quelques fois on ne voit pas tout..

Contact

Accueil > Actu, France > Lidl a rappelé des milliers de boîtes de céréales en février

## Lidl a rappelé des milliers de boîtes de céréales en février

02/04/2009 Allez aux commentaires Commenter

**Des milliers de paquets de céréales pour le petit déjeuner "muësli" ont été retirés en février des rayons des 1 400 magasins Lidl de France, suite à la contamination de ces céréales par une composante toxique utilisée dans l'encre des emballages, indique, jeudi 2 avril, Lidl.**

**"Nous avons été informés le 6 février par notre maison-mère qu'il fallait retirer de la vente deux références, des muesli au chocolat et des muesli aux fruits. Les marchandises ont été retirées le 9 février", déclare Jérôme Gresland, directeur des achats de Lidl pour la France, confirmant une information du Canard enchaîné. Des sites comme 60 millions de consommateurs ou rappelsproduits.fr permettent aux consommateurs s'informer sur les produits – steaks hachés avariés, circuits hydrauliques de voiture défectueux, saucisson contenant des salmonelles – rappelés par les constructeurs et fabricants.**

**Le signalement de la maison-mère était consécutif à une alerte du système d'alerte européen pour les denrées alimentaires (RASFF), après qu'un contrôle sanitaire a mis en évidence en Allemagne la présence de 4-méthyle benzophénone (4-MBP) dans des céréales, a précisé M. Gresland. L'EFSA a fait savoir le 4 mars que "la consommation régulière de produits fortement contaminés" par la molécule incriminée pouvait présenter "dans des cas extrêmes un risque pour certains enfants". La branche française de Lidl a décidé de son propre chef de retirer les produits de ses rayons, "par précaution", a souligné M. Gresland.**

**"A aucun moment la Direction générale de la concurrence, de la consommation, et de la répression des fraudes (DGCCRF) ne nous a demandé de procéder à un rappel des produits" déjà vendus, a-t-il dit. "La DGCCRF a pris contact avec nous début mars, trois semaines après le retrait des produits de la vente", a-t-il.**

IS FOOD PACKAGING SAFE ?

# De l'encre dans le muesli

***Branle-bas de combat sanitaire à l'échelle européenne ! Des céréales contiennent de l'encre toxique provenant de leur emballage. Mais les consommateurs n'ont pas été prévenus.***

UN contrôle, un simple contrôle de routine. Le 2 février dernier, les autorités allemandes découvrent de la 4-méthylbenzophénone (4-MBP), un dérivé de la benzophénone (BP), dans des paquets de céréales muesli au chocolat. Fâcheux, quand on sait que ladite substance chimique donnée pendant des mois en pitance à des rats de laboratoire leur a flingué les reins et provoqué des tumeurs du foie et des leucémies…

Le système d'alerte européen pour les denrées alimentaires (Rasff) est aussitôt actionné. L'enquête montre que le muesli provient d'une usine belge qui appartient à l'un des plus gros fabricants européens de céréales pour le petit déjeuner. La 4-MBP est un composant de l'encre d'impression (d'origine suisse) qui a été appliquée sur les cartons dans l'usine néerlandaise d'un géant mondial de l'emballage. Elle serait tout bonnement, par accident, passée du contenant au contenu, et aurait atteint le muesli en traversant le carton et le sachet de protection.

Dans les dix-sept pays européens concernés, dont la France, on retire des rayons en urgence les produits contaminés. Mais pas question d'affoler le consommateur. Motus et bouche cousue sur les marques concernées ! Comme l'a découvert « Le Canard », les fameuses céréales à l'encre toxique ont été distribuées sous la marque Lidl dans les grandes surfaces du même nom. Questionné, le directeur des achats de Lidl pour la France reconnaît avoir été averti, le 6 février, par la maison mère en Allemagne, que des paquets de muesli au chocolat et aux fruits étaient ainsi pollués. Plus de cent tonnes ont été retirées dare-dare des 1 400 magasins en France et renvoyées au fabricant belge Mulder Natural Foods à partir du 9 février… soit une semaine après le déclenchement de l'alerte européenne, lequel fabricant affirme au « Canard » les avoir brûlés. Combien de paquets de muesli parfumés à la 4-MBP et à la BP ont atterri dans les bols des consommateurs ? A la Répression des fraudes (DGCCRF), on s'emmêle un peu les cuillères : « *Au moment de l'alerte, il n'y avait plus en vente de produits concernés depuis trois mois.* » On se demande donc bien ce que Lidl a pu retirer de ses rayons à partir du 9 février ! Cette encre a-t-elle servi en France sur les emballages d'autres produits alimentaires ? Du bout des lèvres, la Répression des fraudes reconnaît avoir bloqué cinq containers remplis d'encre. Et identifié un cartonnier français qui en faisait usage. Lequel ? « *Pour des raisons juridiques, il n'est pas possible de révéler le nom.* » Quels sont les clients dudit cartonnier ? Même réponse. A-t-on trouvé des aliments contaminés autres que les céréales ? « *Des enquêtes d'identification sont en cours.* » Circulez, y a rien à voir.

Deux mois après l'alerte, les résultats d'analyses sur les échantillons prélevés en France ne sont toujours pas disponibles. Alors qu'en Belgique, dès le 16 février, l'Agence fédérale pour la sécurité de la chaîne alimentaire révélait des teneurs effarantes trouvées dans les céréales : jusqu'à 3,7 milligrammes par kilo pour la 4-MBP et jusqu'à 4,2 mg/kilo pour la BP. Soit 6 à 7 fois ce que tolère la réglementation européenne pour les matériaux au contact d'aliments. Et cette agence de lancer l'alerte : cette contamination « *peut comporter un danger pour les enfants* ». Pis : la teneur en 4-MBP et BP « *pourrait être encore plus élevée* » : plus le paquet séjourne dans le placard, plus lesdites substances migrent dans les aliments. En France, les autorités n'ont pas cru bon de saisir l'Afssa, l'Agence française de sécurité sanitaire des aliments…

De son côté, l'Efsa, son homologue européenne, reste vague sur les risques de cette contamination : sa « *connaissance* » de la 4-MBP étant « *limitée* », « *d'autres données et analyses sont nécessaires* ». Certes la 4-MBP est « *susceptible d'être cancérogène, mais ne devrait pas soulever de préoccupations en matière de génotoxicité* ». Ouf, nous voilà rassurés.

Perplexe, la Commission européenne lui a donc demandé de lui rendre, d'ici à fin mai, un avis scientifique plus costaud. En attendant, elle enjoint les industriels de ne plus utiliser l'encre coupable sur les emballages alimentaires à moins de les protéger par un sac en plastique ou en aluminium. Ça urge : le 24 mars dernier, la Grèce a prévenu le réseau d'alerte européen qu'elle venait de trouver des tacos industriels plombés à la 4-MBP. Tacos vendus aussi à Chypre et aux Pays-Bas…

De son côté, l'Association européenne des producteurs d'encre vient de pondre une note à ses clients pour leur conseiller d'employer une encre alimentaire « *à faible migration et faible odeur* ». Oui, il existe des encres dites « *alimentaires* » qui, comme l'explique une directive européenne, ne sont pas censées refiler à l'aliment emballé « *des constituants en quantité susceptible de présenter un danger pour la santé humaine* ». Bref, des encres qui ont le droit de « migrer » en paix.

Depuis quand l'encre amie du muesli est-elle utilisée et à quelle échelle ? Pourquoi toutes les encres ne sont-elles pas « *alimentaires* » ? Parmi toutes les encres non alimentaires utilisées pour décorer barres chocolatées, paquets de riz ou de biscuits, combien et lesquelles contiennent des substances toxiques qui peuvent atterrir dans notre assiette ? En attendant les réponses, on évitera de se faire un sang d'encre…

**Professeur Canardeau**

**Le Canard enchaîné**

Journal satirique paraissant le mercredi

1 avril 2009, page 5

# IS FOOD PACKAGING SAFE ?

Sunday 17 April 2011

The Telegraph

HOME NEWS SPORT FINANCE COMMENT BLOGS CULTURE TRAVEL LIFESTYLE FASH

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Health News

## Cereal box health warning after recycled cardboard study

Breakfast cereal manufacturers are to stop using recycled cardboard in packaging after a study indicated that current boxes could pose a cancer risk.


Link to this video

8:25AM GMT 08 Mar 2011

Jordans - whose brands include Country Crisp and Crunchy Oats - has already stopped using recycled cardboard, while Kellogg's and Weetabix say they are taking steps to reduce the risk to human health.

The alert was sparked when researchers in Switzerland found that mineral oils in printing ink from recycled newspapers used in cardboard can get into foods - even passing through protective inner plastic bags.

Brands of pasta and rice which are packaged in recycled cardboard could also pose a risk.

Dr Koni Grob, of the Food Safety Laboratory in Zurich, said toxicologists had linked the oils to inflammation of internal organs and even cancer, though he stressed that individual meals would contain only a tiny dose of the chemicals.

The BBC reported that cereal firm Jordans has stopped using recycled cardboard while other manufacturers are reducing levels of mineral oils

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IN HEALTH

Pollen grains up close

Wolf child

From Drugs to Mugs

The end of BSE


# MOH SURVEY

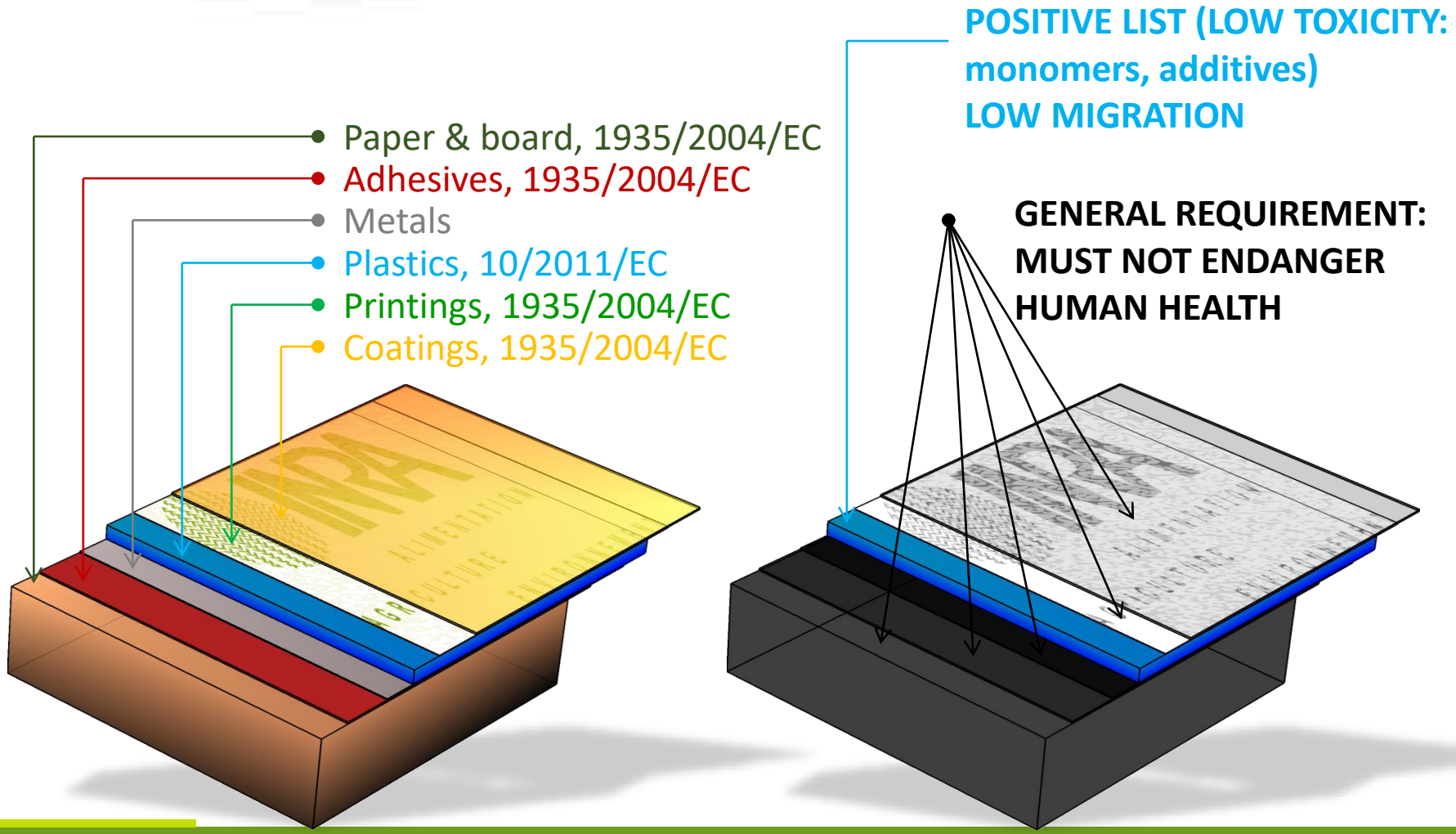
## FOOD WATCH – October 2015



http://www.foodwatch.org/fr/presse/communiques-de-presse/page-detail-communiques-de-presse/des-hydrocarbures-dans-nos-assiettes-foodwatch-tire-le-signal-dalarme/

# HETEROGENEOUS EU REGULATIONS

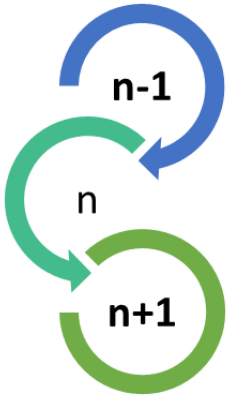
## Variable concepts




**17 groups of materials** listed in Annex 1 of regulation 1935/2004/EC are still not covered by specific measures.
They must be produced according to **Good Manufacturing Practices** (Regulation 2023/2006/EC)
incl. 3 pillars: quality assurance system, quality control system, documentation.

# Chain of responsability along the supply chain

## Material vs Information flux (1935/2004/EC)




traceability

Upstream

e.g. Adhesive industry

Retailer

Converters

Quality Control

Packaging filler

Quality Control

Consumer

Information on composition

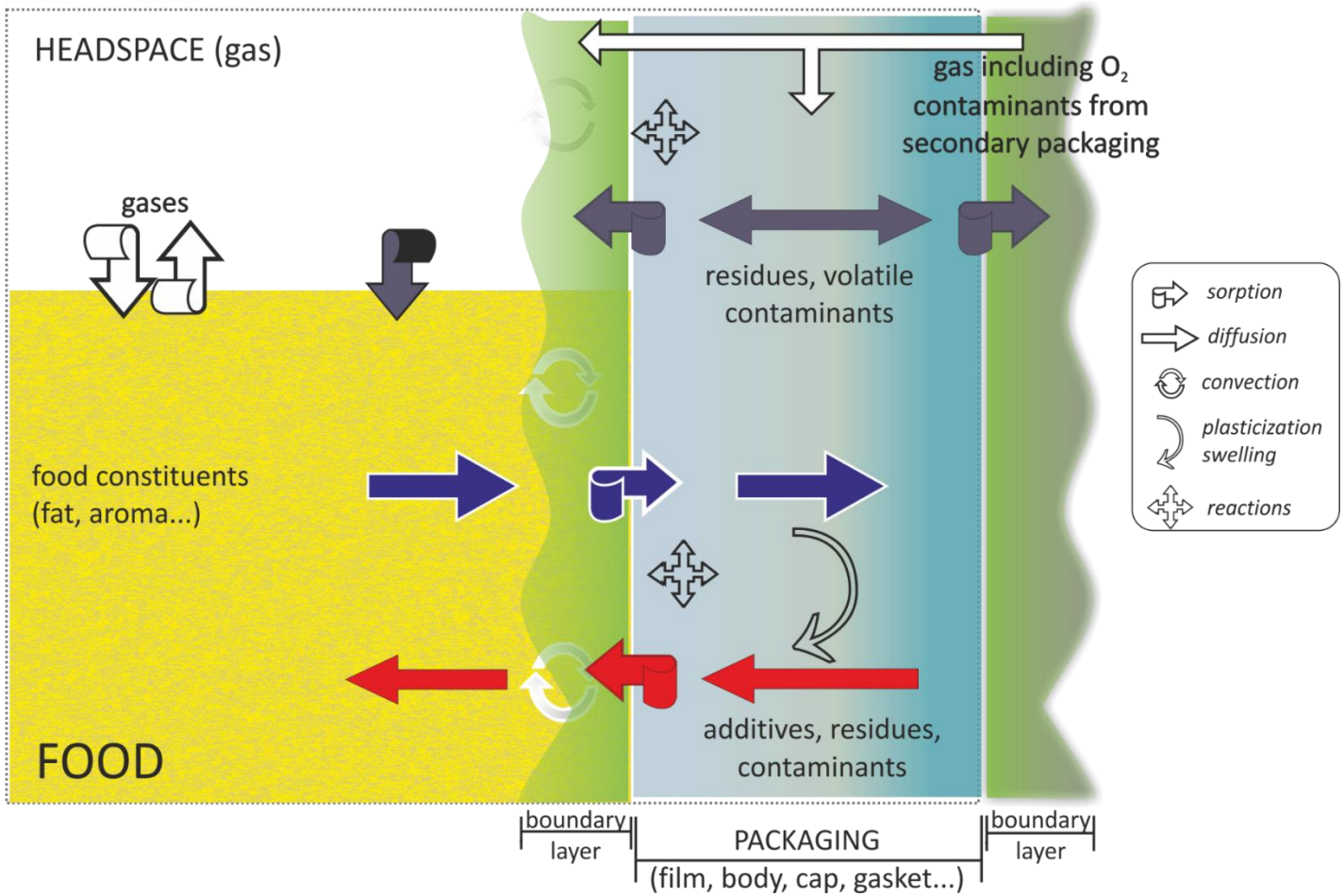
*Trigger initiation/update*

*Trigger initiation/update*

Information on final use

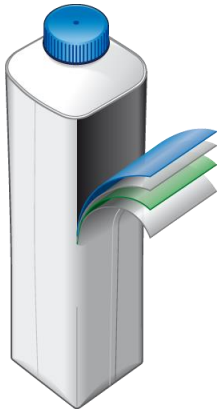
# Coupled mass transfer

## between the food product and the packaging material

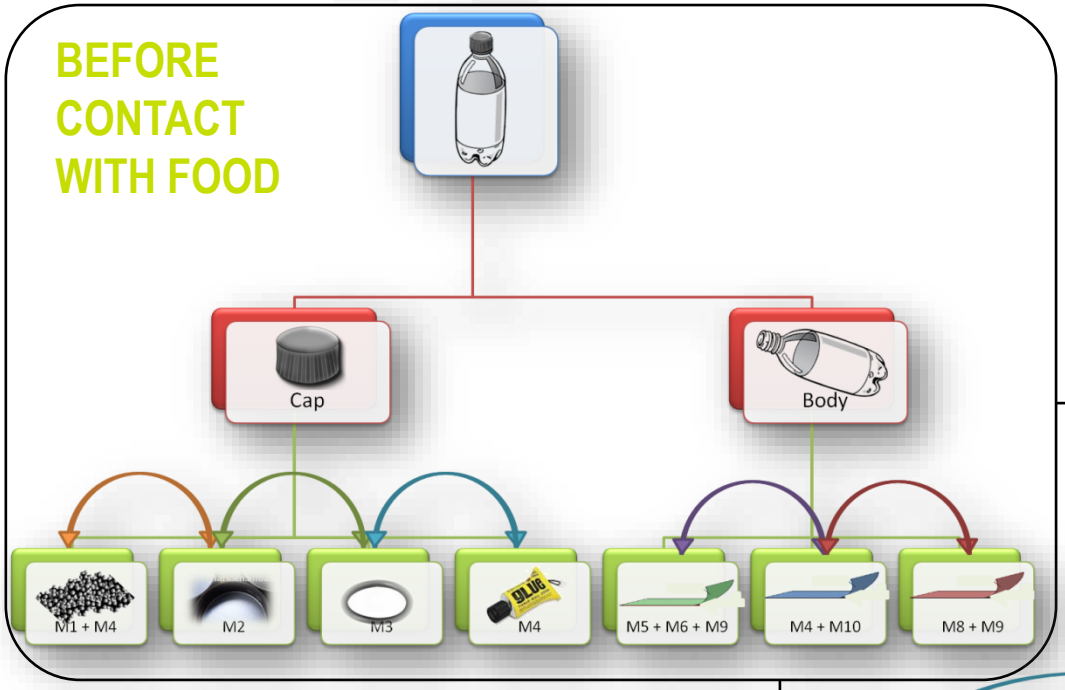



plastic
celluloses
adhesives
metals and alloys
varnishes and coatin

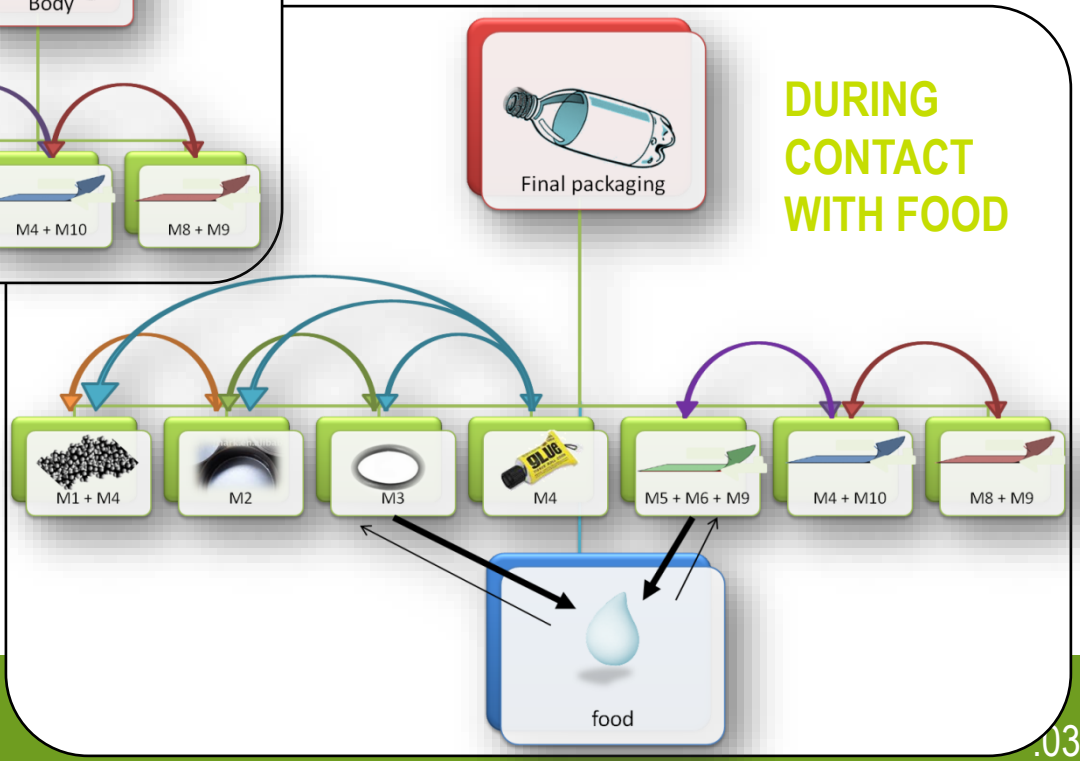
# CROSSED-MASS TRANSFER BETWEEN MATERIALS



## BEFORE CONTACT WITH FOOD

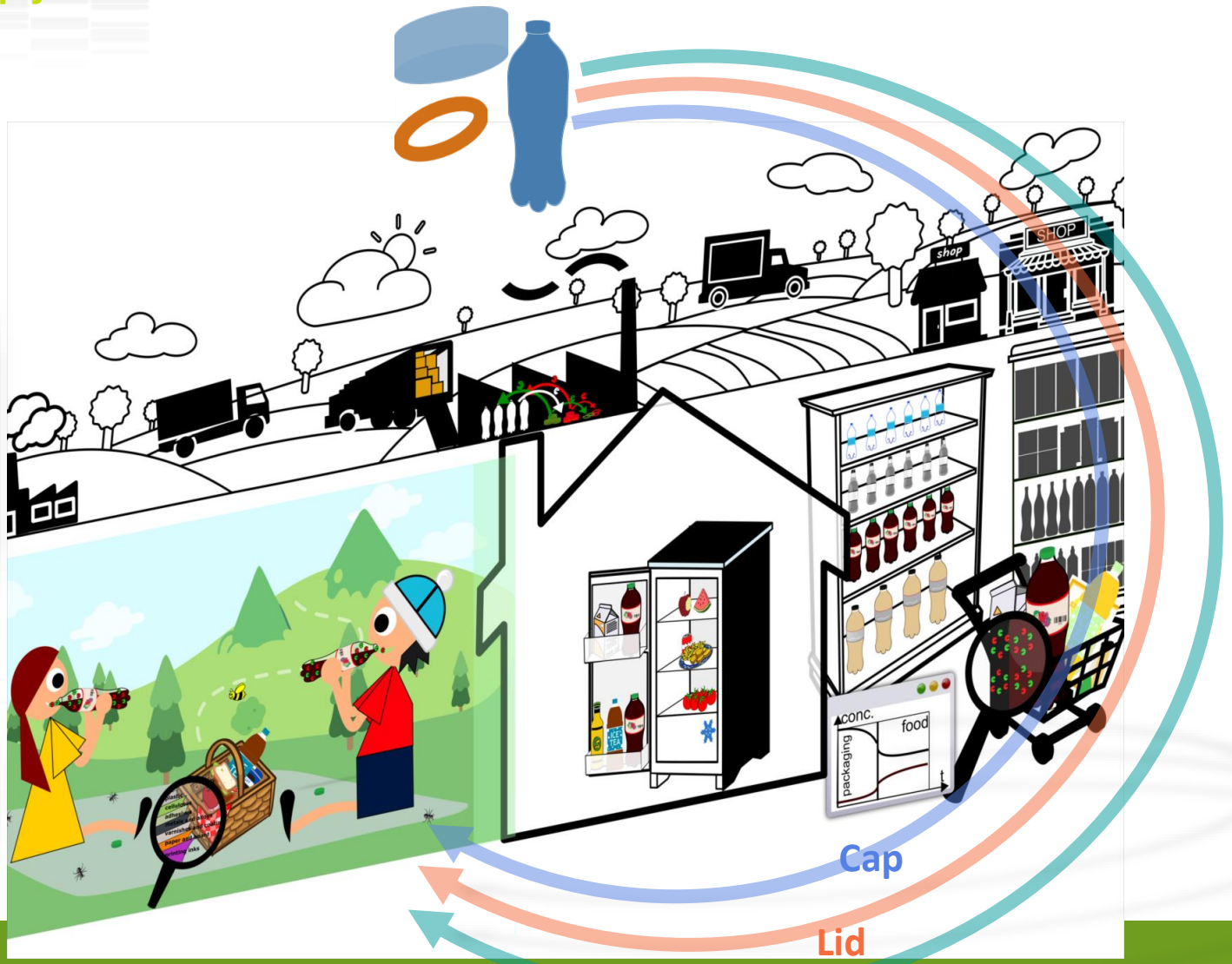



## DURING CONTACT WITH FOOD

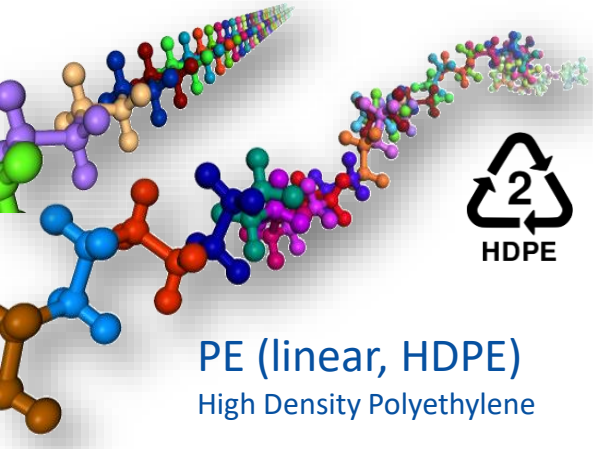


# CHAINED STEPS, COMBINED MATERIALS

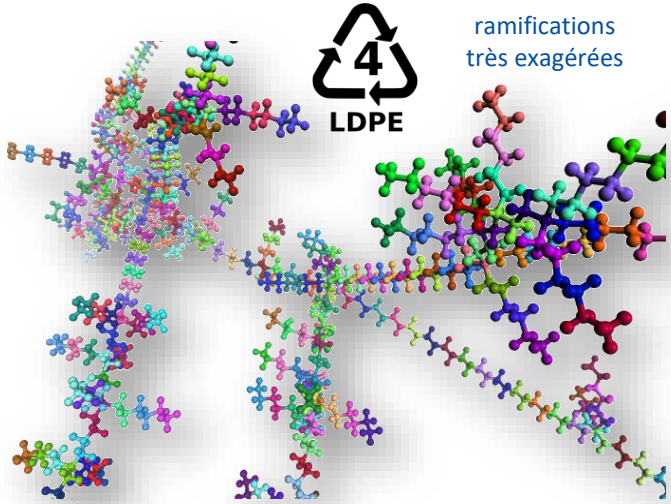
## Supply chain



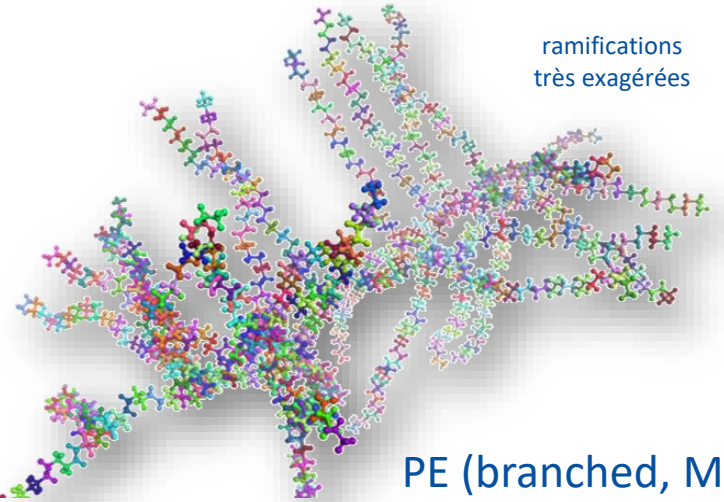
# Polyolefins : PE – PP



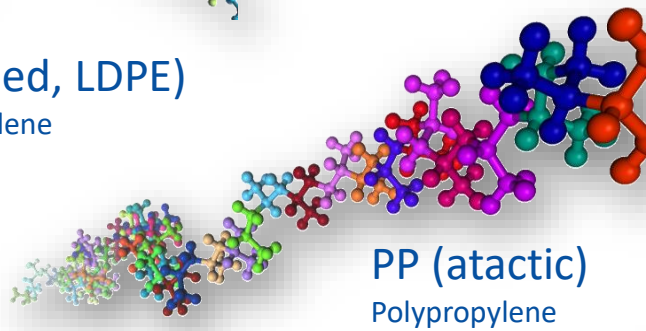

PE (linear, HDPE)
High Density Polyethylene



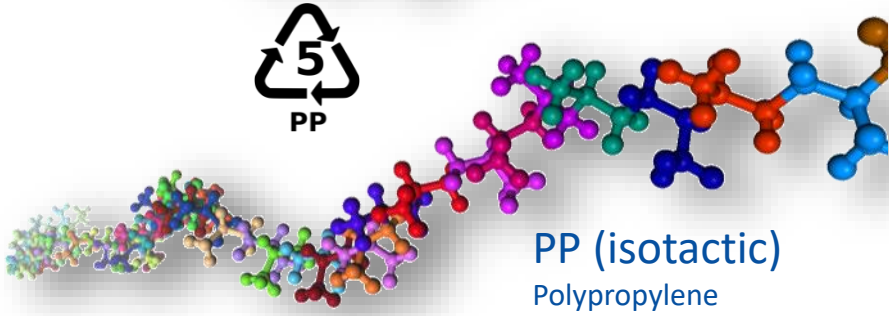

PE (very ramified, LDPE)
Low Density Polyethylene




PE (branched, MDPE)
Medium Density Polyethylene



PP (atactic)
Polypropylene




PP (isotactic)
Polypropylene

POLYÉTHYLÈNE

# POLYOLEFINS

**LDPE**
(Low density polyethylene)

- Vapour barrier
- Flexibility for seals
- Mouldability • Tearability
- Flexibility • Excellent stretchability • Sterilisation
- Chemical inertness
- Transparency • Tactile effect

- Trays • Boxing
- Screw or clip tops • Nozzles
- Stretchable and retractable films for bundling (multiple-unit packs) and palletting • Bottles
- Stopper seals • Carrier bags
- Small bags • Tubes

**HDPE**
(High Density Polyethylene)

- Vapour barrier
- Mouldability • Rigidity (for mechanical testing) • Impact resistance • Chemical inertness
- Resistance to stress-cracking
- Sterilisation • Suitable for freezing (-40°C) • Opaqueness

- Large drums
- Screw or clip tops
- Bottles
- Crates and cases • Covers
- Films for postal dispatch
- Flasks • Drums and reusable containers • Pots • Tubes

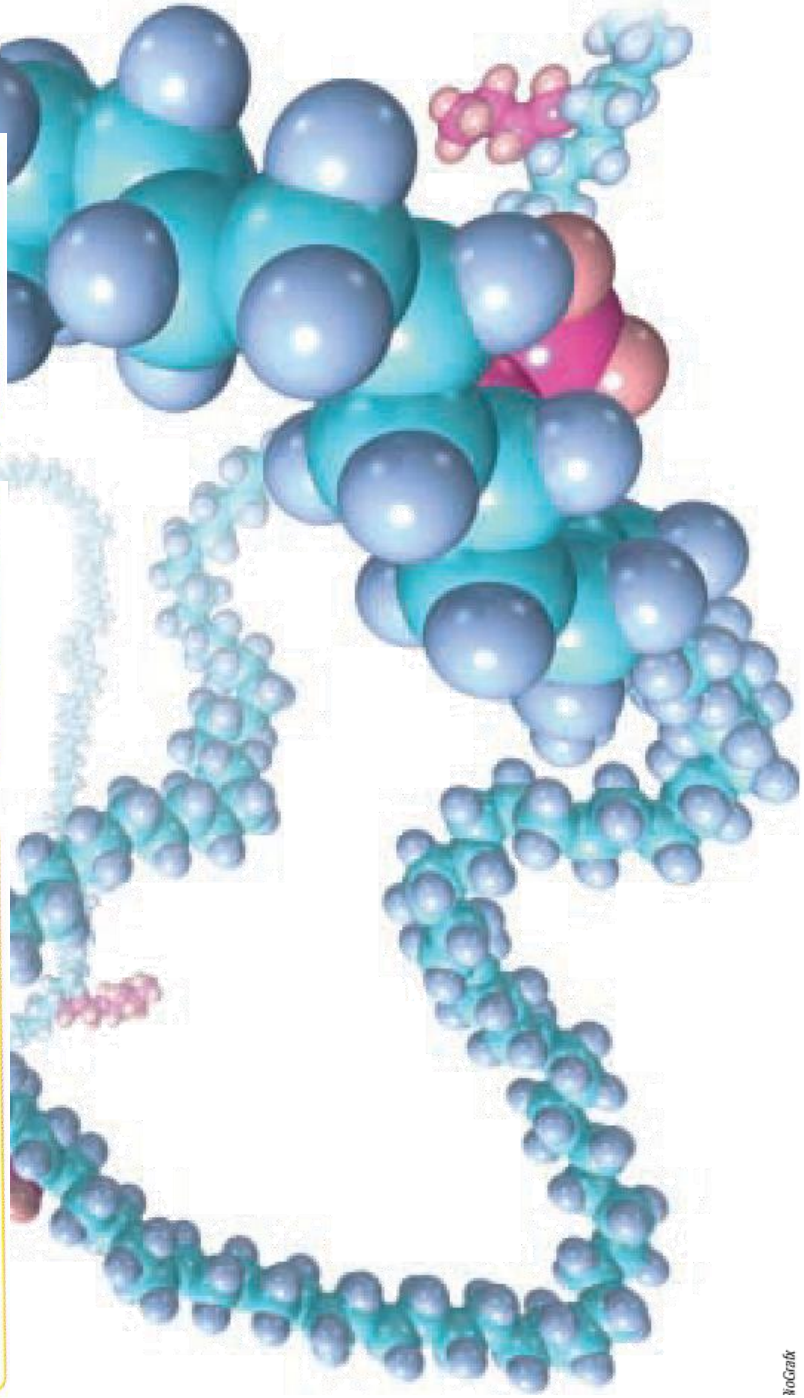
**PP**
(Polypropylene)

- Rigidity (Resistance to sterilisation)
- Resistance to cold • Vapour barrier
- Chemical inertness
- Suitable for freezing (-40°C)
- Suitable for micro-waves (+120°C)
- Low density
- Resistant to stress-cracking
- Resistant to folding • Thermal packing • Contact transparency

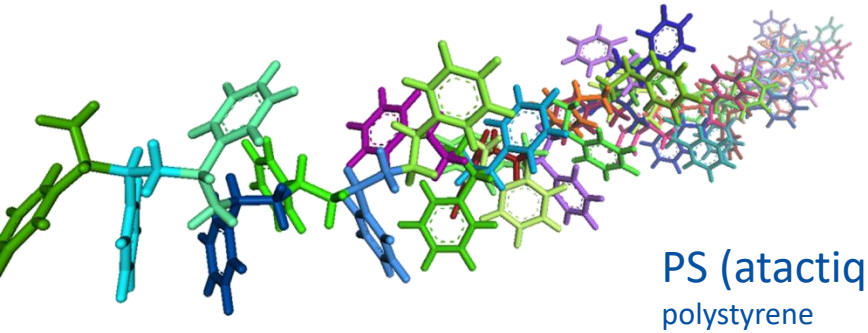
- Alveolate material • Tray containers
- Screw and clip tops
- Reusable crates and cases • Covers
- Thermoforming sheets
- Transparent films and bags
- Bottles
- Reheatable plates • Pots
- Tubs • Tubes

- Clarified PP
- OPP (oriented PP)
- EPP (expanded polypropylene: resistance to repeated impact)

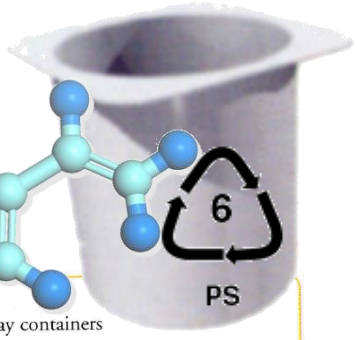
- Flasks
- Films
- Reusable wrapping



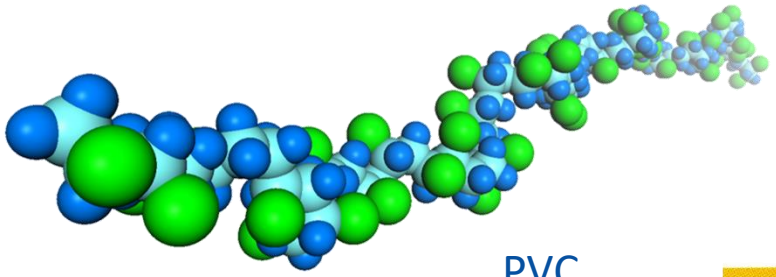
# POLYVINYLS



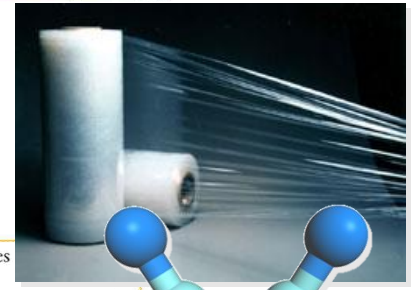
## PS (atactique)
polystyrene



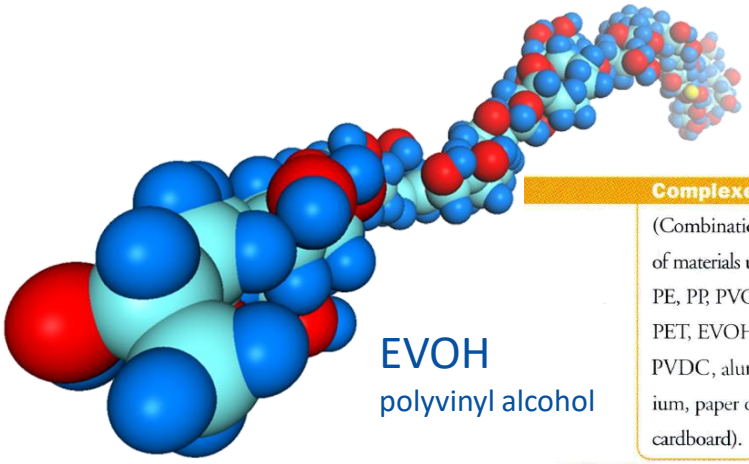

| PS (Polystyrene) | | |
|---|---|---|
| | **Compact:** ■ Crystal PS: Transparency • Brilliance • Rigidity | • Tray containers (with stretch film) |
| | ■ PS impact: opaque • impact-resistance • Brilliance • Cleavability | • Egg containers • Stoppers • Covers • Thermoforming sheets, pots for dairy products, cups for automatic drink machines |
| | **Direct gassing:** • Light • Heat sealable • Warm touch | • Plates/trays |



## PVC
polyvinyl chloride

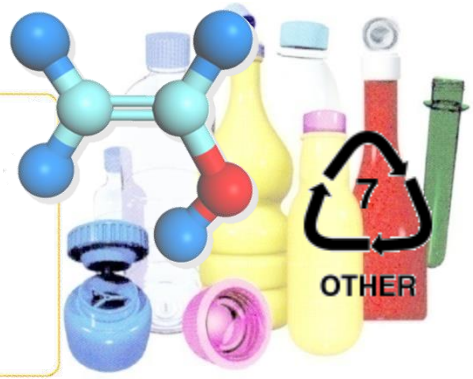



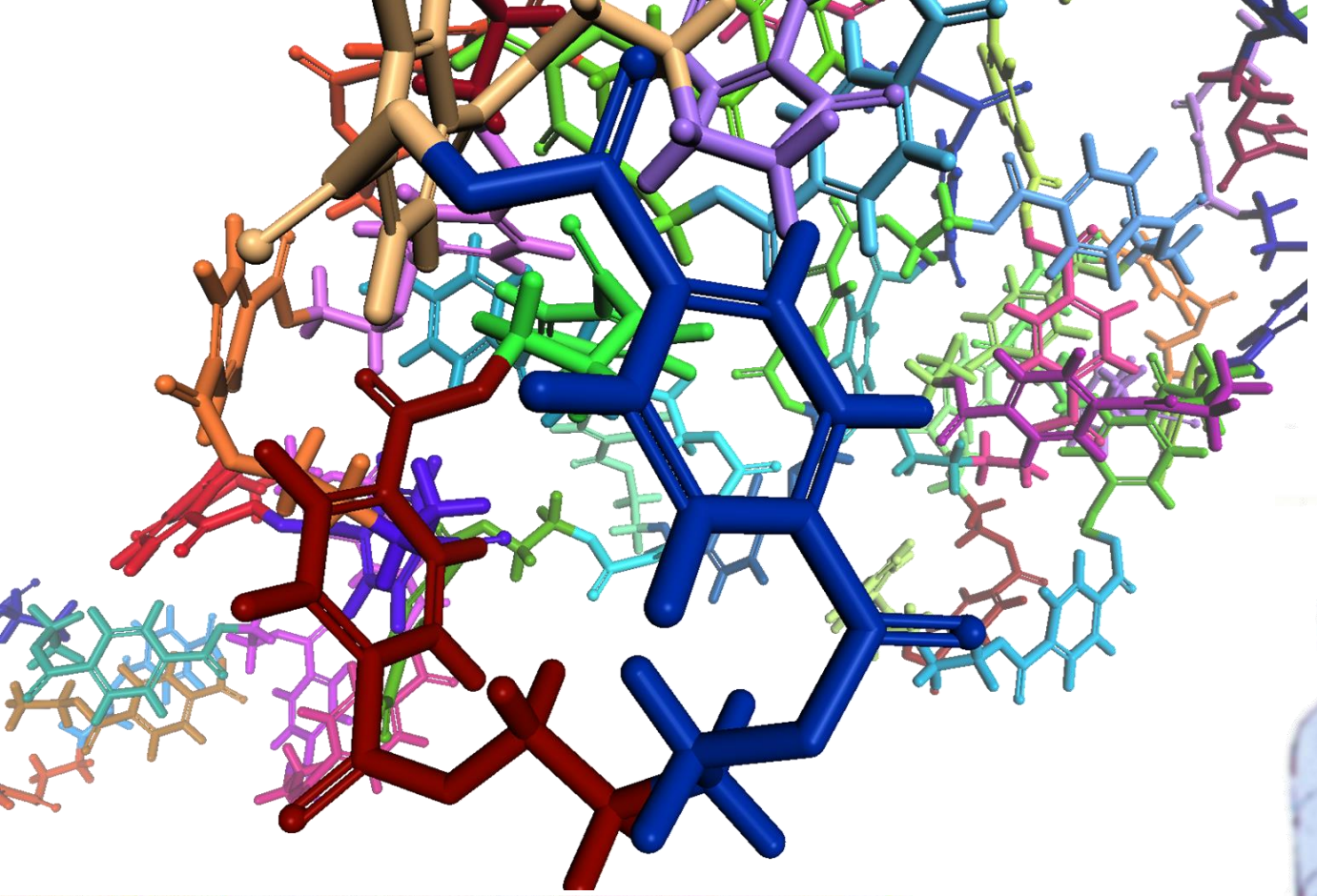
| PVC (Polyvinyl chloride) | | |
|---|---|---|
| | • Inertia • Good stretchability • Machinability • Excellent memory • Resistance to stress-cracking • Transparency | • Tray containers • Boxes • Bottles • Flasks • Blister packs • Sheets for thermoforming • Food-contact films |



## EVOH
polyvinyl alcohol

| Complexes (Combination of materials using PE, PP, PVC, PET, EVOH, PVDC, aluminium, paper or cardboard). | Structure adapted to application: complementary properties • Barrier to aroma, perfume and gas | • Flexible and rigid packaging with special barrier properties • Closures for heat sealing • Tubes • Packing in modified atmosphere or vacuum |
|---|---|---|

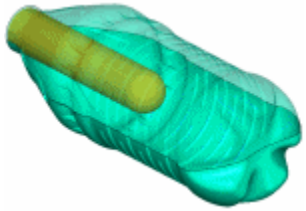





**PET**

(Polyethylene terephthalate)

- (A)PET (amorphous):
  - Transparent • Perfume compatible
  - Shiny • Impact resistant
  - Resistant to internal pressure
  - Resistant to stress-cracking
  - Gas barrier
  - Tray containers • Boxes • Bottles
  - Lids
  - Thermoforming sheets
  - Films • Flasks • Pots
- (C)PET (crystallised):
  - same properties as (A)PET but not transparent
  - Temperature resistant to 220° C
  - Oven trays (220°C)
  - Blister packs • Bottles
  - Films • Flasks • Pots
- PETG (glycol): amorphous, same properties as (A)PET
  - Tray containers • Lids
  - Thermoforming sheets



**PET/PEN copolymer**

- Gas barrier
- UV barrier
- Bottles
- Flasks

# PET

## Polyethylene terepthalate

# CONTROVERSY O OF PACKAGING MATERIA

**Nat. Rev. Endocrin. 6 (2010), 237**


**Water Research 46(2012), 571-583**


## Editorial

Nature Reviews Endocrinology 6, 237 (May 2010) |

Subject Category: Epidemiology

## The perils of plastic

Vicky Heath About the author

A 'round-robin' spam e-mail that is circulating on servers worldwide claims that drinking bottled water that has been left in a warm car can cause breast cancer. Is this warning just an urban myth or does it hold a grain of truth? The FDA, it seems, is erring on the side of caution; earlier this year, the organization revised its position on the safety of bisphenol A (BPA), a chemical used in the manufacture of plastics. Previously deemed safe for food-contact use, the FDA has now expressed "some concern" about the potential health risks that BPA poses to fetuses, infants and young children.

"The plastics industry has a responsibility to ensure that its products are safe..."

Is society compromising its health for the conveniences of modern living? Industrial chemicals, such as BPA, are literally everywhere: in homes, in the workplace, even the great outdoors. They cannot possibly all be avoided. Given the current recommendations of the FDA and the Endocrine Society, a multidisciplinary approach is clearly needed—one that involves scientists, clinicians, policy makers and the chemicals industry—with the aim of gathering reliable data to form the basis of national and international public-health policies. In the meantime, the use of plastics and other man-made substances should be closely monitored in groups known to be at the greatest risk. Perhaps that e-mail is not spam after all.

**[…]**

**Genotoxic and estrogenic activities in PET-bottled water have been reported. Chemical mixtures in bottled water have been suggested as the source of these toxicological effects. […]**

**Formaldehyde, acetaldehyde and antimony are clearly related to migration from PET into water. However, several studies have shown other theoretically unexpected substances in bottled water. The origin of these compounds has not been clearly established (PET container, cap-sealing resins, background contamination, water processing steps, NIAS, recycled PET, etc.).**

**[….]**

# ESTROGENIC COMPOUNDS FROM PET??

**2 RECENT STUDIES (Italian and German) on drinking water**

1) **involving a recombinant yeast–based in vitro assay** (March 2009 in *International Journal of Hygiene and Environmental Health*) ➔**estrogenic activity was assessed in 30 PET–bottled mineral water samples. Ninety percent of the samples tested negative for estrogenic activity. Of the remaining samples, most showed measurements corresponding to a range of 14–23 ng/L estradiol equivalents—similar to the estrogen burden posed by treated drinking water derived from groundwater and river water (15 and 17 ng/L estradiol equivalents, respectively).**

2) **Involving mud snails (*Potamopyrgus antipodarum*) (10 March 2009, *Environmental Science and Pollution Research*) ➔ PET-housed snails produced up to twice as many embryos as glass-housed snails..**

**Reference = glass bottle water with same water.**


epidemiologist at the University of Rochester School of Medicine and Dentistry in New York.

"This is coming at a good time because the use of bottles for consuming water is getting very bad press now because of its carbon footprint," she says. "It's just another nail in the coffin of bottled water, the way I see it."

Wagner and a colleague used genetically engineered yeast to analyse 20 samples of mineral water. Nine samples came out of glass bottles, nine were bottled in PET plastic and two were in cardboard, juice-like boxes.

The specialised yeast, which change colour in the presence of estrogen-like compounds, revealed estrogenic activity in seven of the nine plastic bottles (and both cardboard samples), compared with just three of the nine glass ones.

Overall, Wagner says, levels of these compounds in the water were surprisingly high.





ENVIRONNEMENT | 04.05.2009 | 10h00

Perturbateurs endocriniens : restons vigilants»

Deux études montre
bouteilles plastique
reproduction. Dange

Qu'est ce qu'un per
Jean-Pierre Cravedi

peut mimer une horm
observé des problème
Depuis les années 19
molécules sur d'autre
thyroïde qui seraient
batraciens. On se de
lipides ne pourrait pa

l'augmentation du niveau d'obésité dans les populations occidentales. Plusieurs centaines de substances sont actuellement classées parmi les perturbateurs endocriniens.

**Où les trouve-t-on ?**

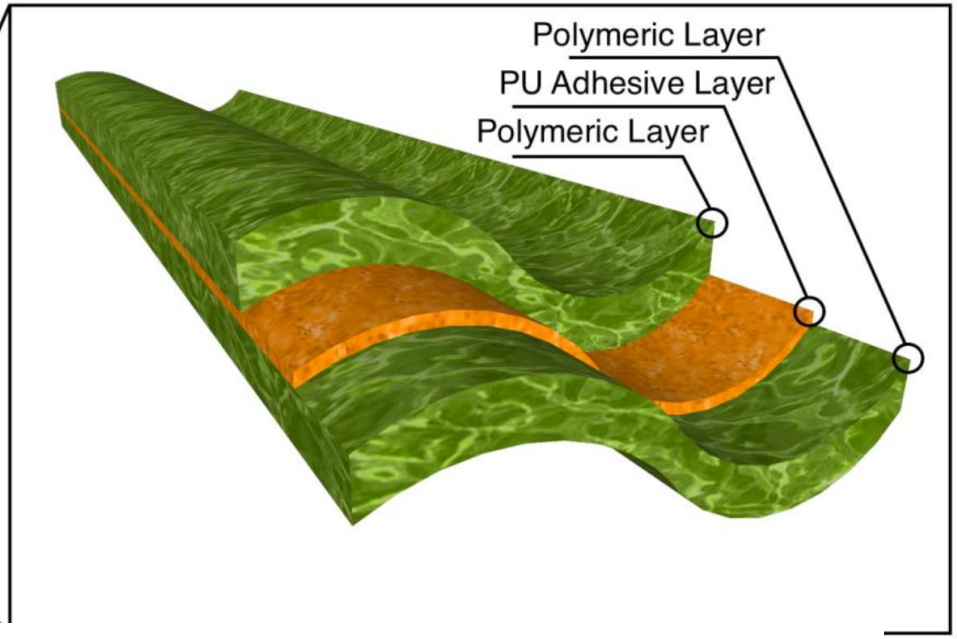
Ces molécules sont principalement détectées dans l'eau, puis dans toute la chaîne alimentaire. De plus, comme viennent de le montrer Martin Wagner et Jörg Oehlmann de l'université Goethe de Frankfort [1], peut-être aussi dans le plastique des bouteilles d'eau minérales en polyéthylène téréphtalate (PET).

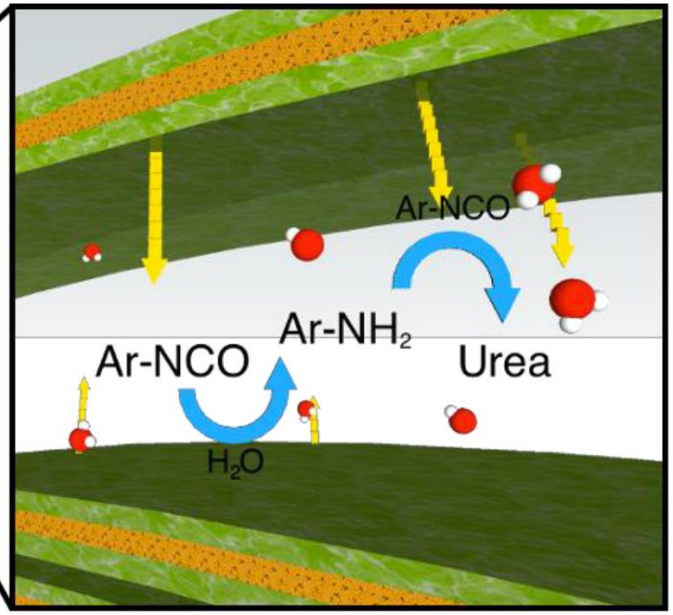
# CONTAMINATION SOURCES

Polyurethane based
Sylil terminated polyether based
Butyl rubber based
Natural rubber water-based adhesives
Carboxylated-SBR water-based adhesives
Epoxies
Modified acrylics
Cyanoacrylates

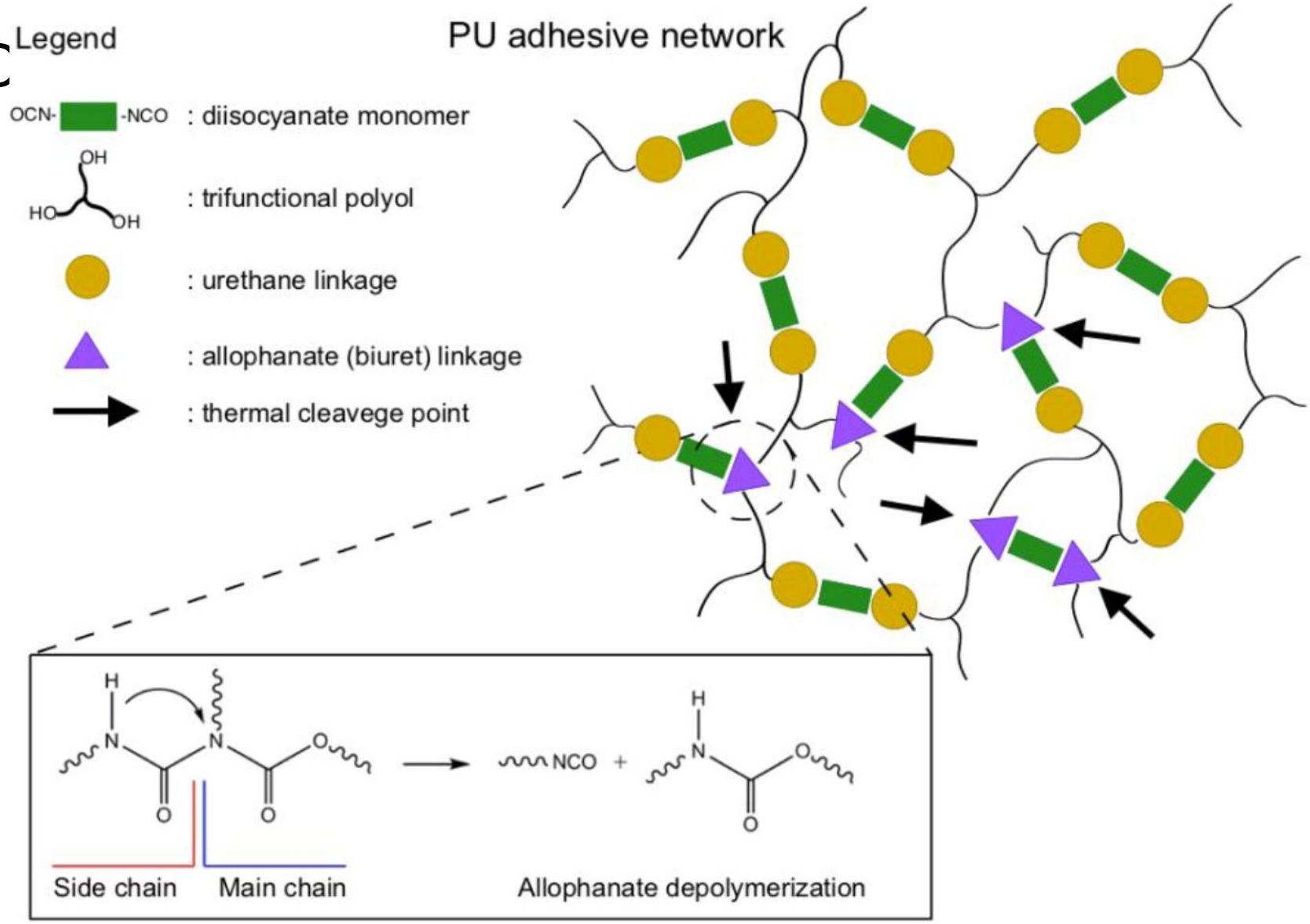

| Component | Formulation level | Exposed contact surface | Interaction with food | Contamination risk |
|---|---|---|---|---|
| **Plastic layer in contact withfood** | +++ | +++++ | + to +++ | +++++ |
| **Layer non-intented to be in contact with food** | +++ | +++++ | - | +++ |
| **Cap, lid** | +++ | ++ | - to + | ++ |
| **Gasket** | +++++ | + | - to + | + to ++ |
| **Varnish** | +++ to +++++ | +++++ | - | +++ |
| **Ink** | +++++ | + to +++ | - | + to +++ |

La

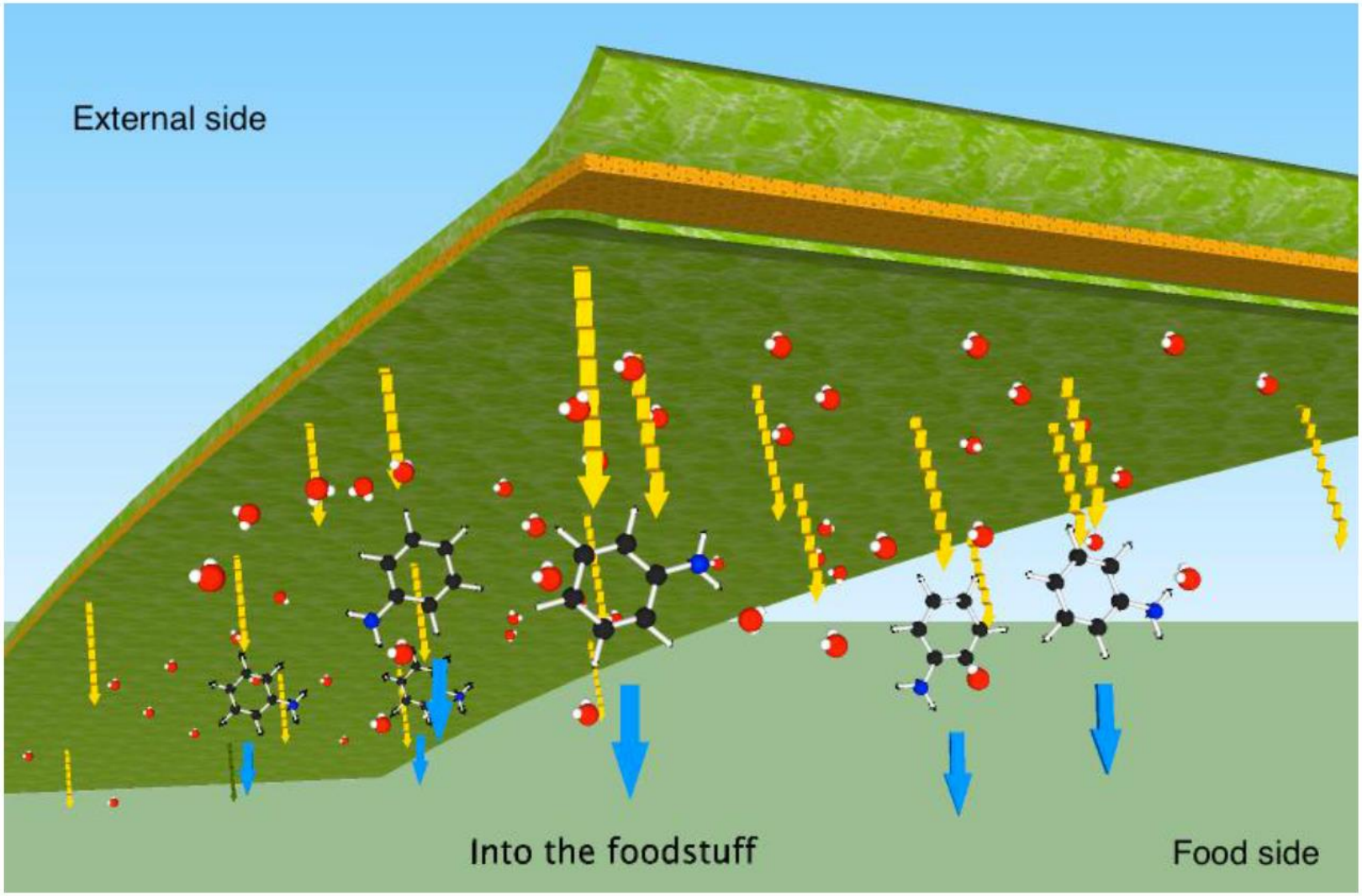

Polymeric Layer
PU Adhesive Layer
Polymeric Layer


Ar-NCO
Ar-NH2
Urea
Ar-NCO
H2O

Pc


Legend
OCN-
-NCO
: diisocyanate monomer
OH
HO
OH
: trifunctional polyol
: urethane linkage
: allophanate (biuret) linkage
: thermal cleavege point
PU adhesive network
H
N
N
O
O
O
NCO
+
H
N
O
O
Side chain
Main chain
Allophanate depolymerization

M



_03

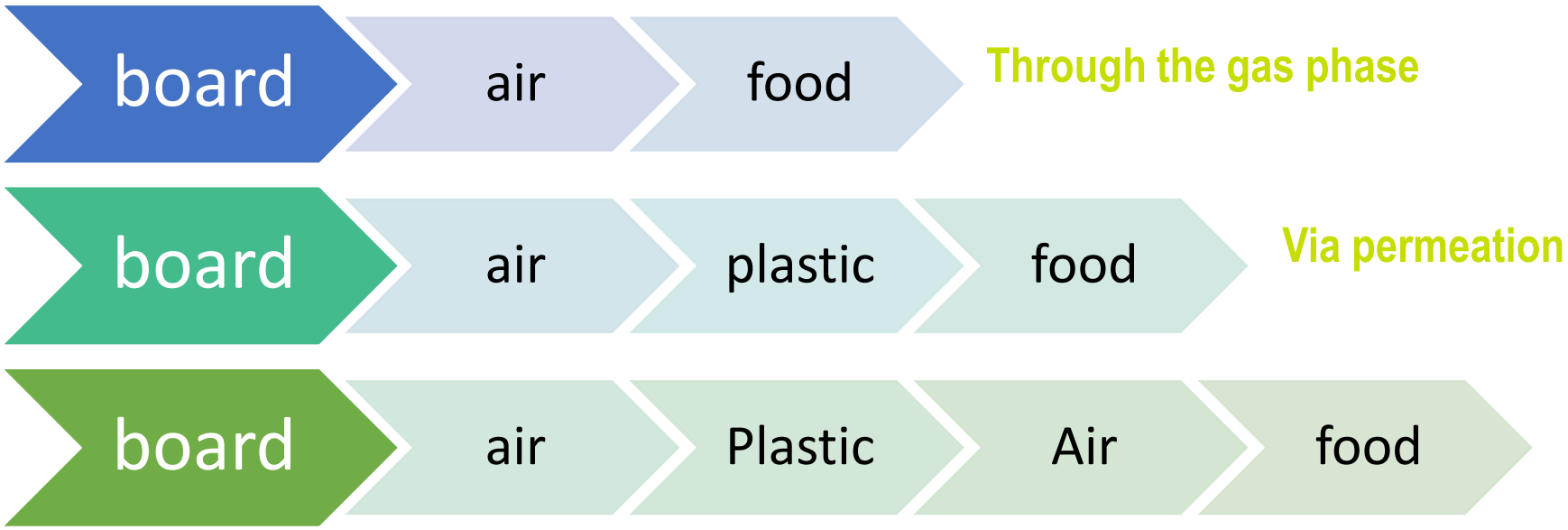
# CONTAMINATION WITHOUT DIRECT CONTACT

## WITHOUT BARRIER

## WITH BARRIER

INRA
SCIENCE & IMPACT

# MIGRATION PATHWAYS



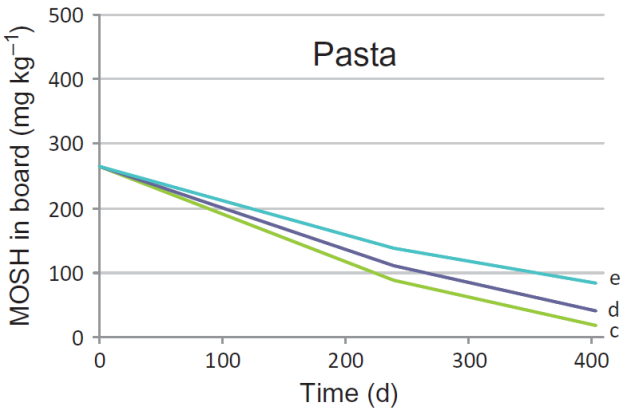


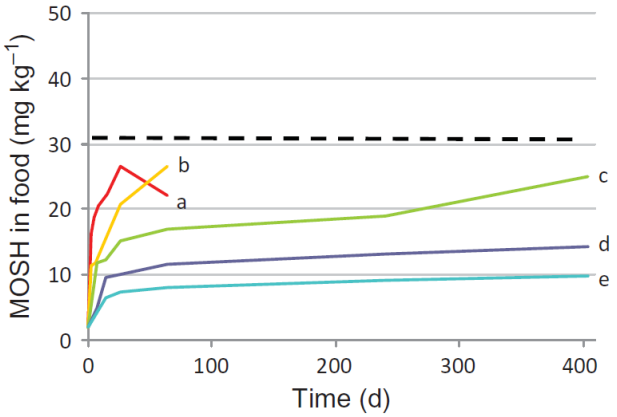

Lorenzini et al. Food Additives & Contaminants, Part A 2013, 30(4), 760-770

# KINETICS OF MIGRATION IN REAL FOOD

## Pasta

board | air | food



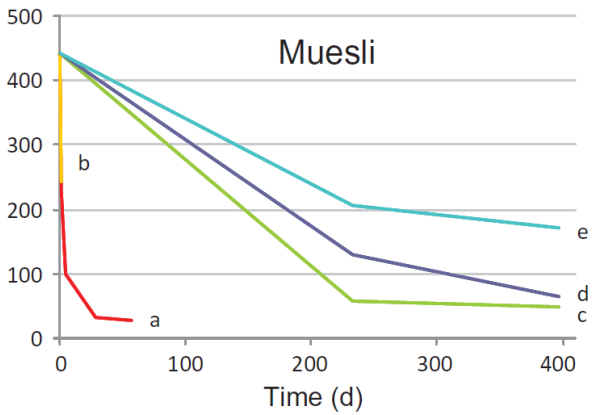

Board desorption

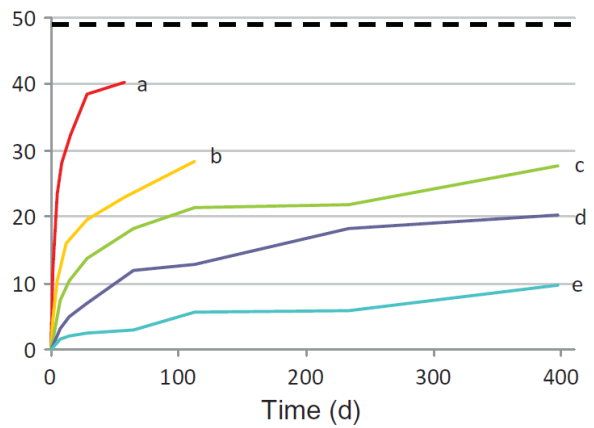
60°C
40°C
30°C
20°C
4°C

Food sorption

## Cereals

board | air | plastic | food





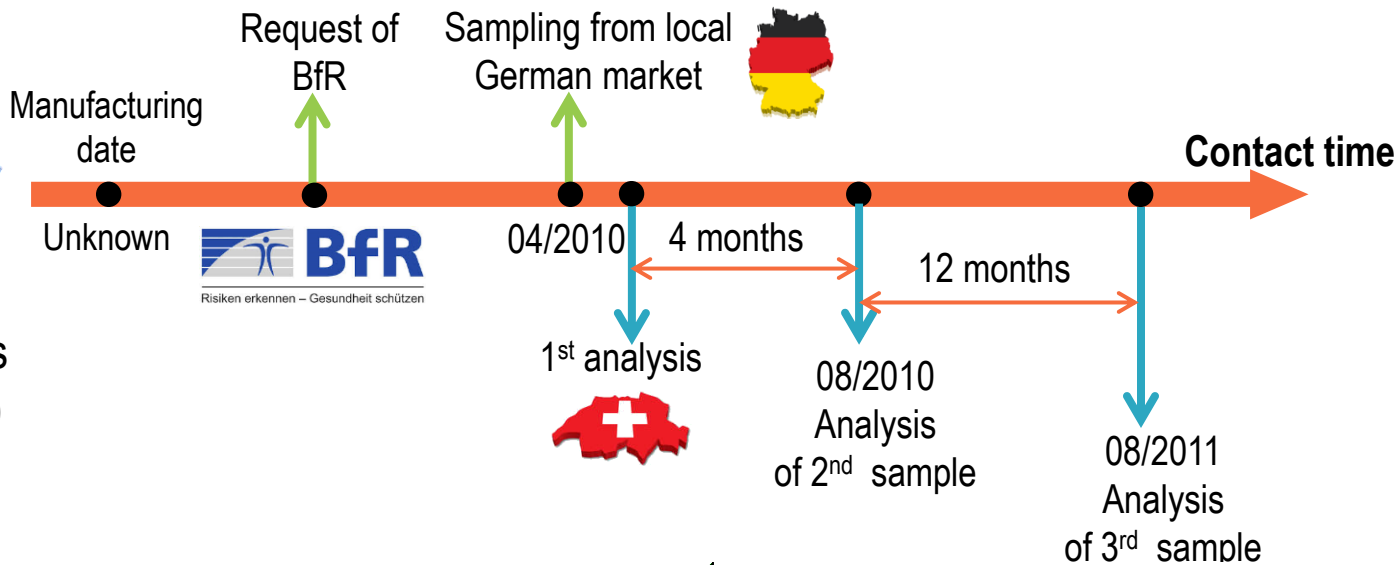

Lorenzini et al. Food Additives & Contaminants, Part A 2013, 30(4), 760-770

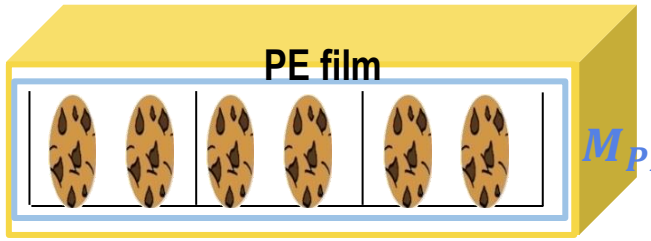
# CONTAMINATION FROM CARDBOARD+PRINTING INK

## HOW TO ASSESS THEM ?

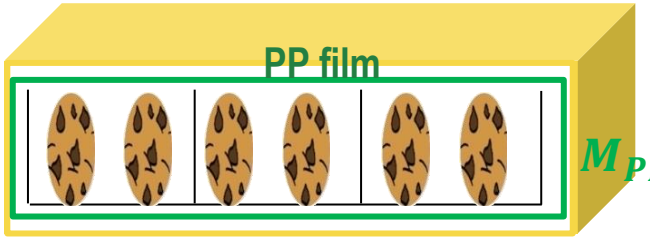
# CONTAMINATION KINETICS OF REAL DRY FOOD PRODUCTS


119 dry food products
(3 samples/category)

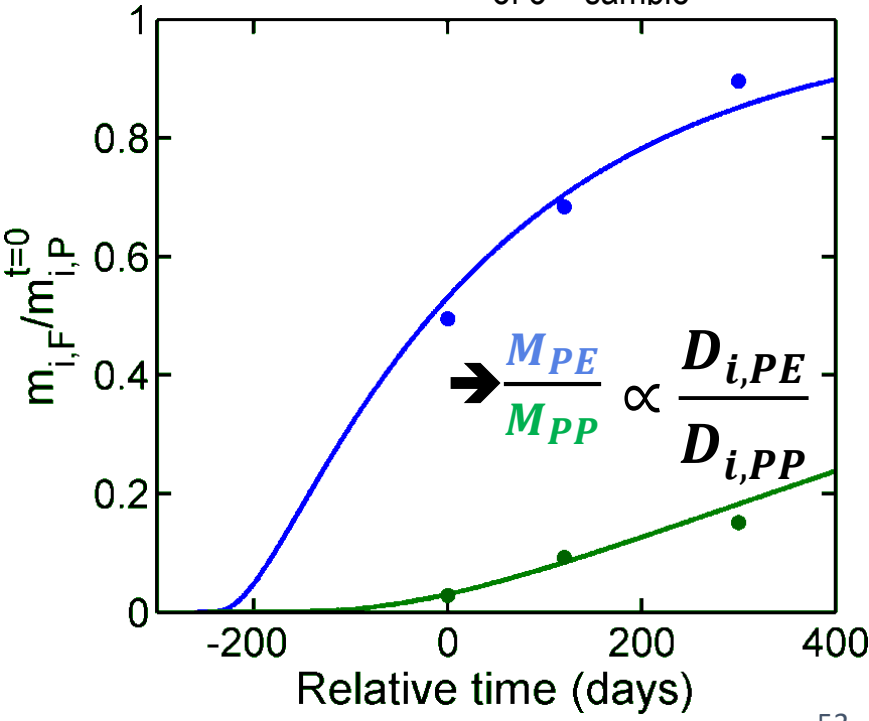



$$M_{PE} = \frac{m_{i,F}^{PE}(t_0, t_1 \text{ et } t_2)}{m_{i,P}^{t=0}}$$




$$M_{PP} = \frac{m_{i,F}^{PP}(t_0, t_1 \text{ et } t_2)}{m_{i,P}^{t=0}}$$

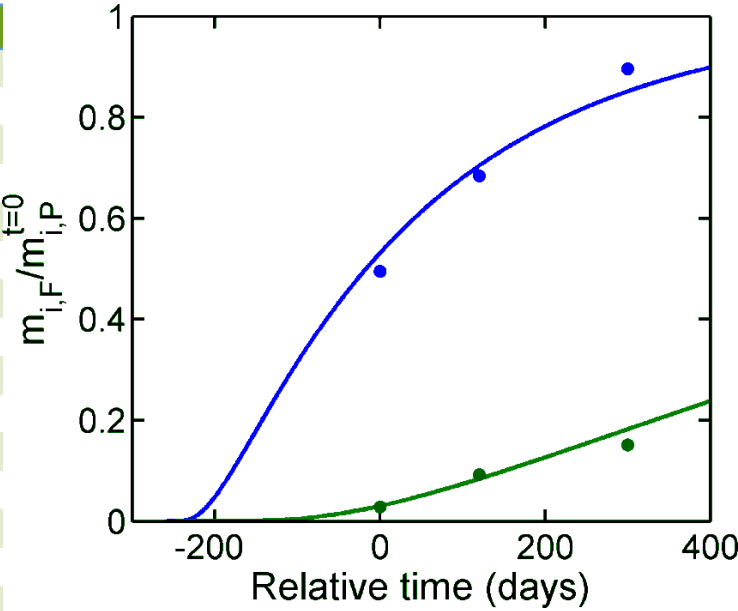



Biedermann et al. (2013)

# CONTAMINATION TROUGH THE GAS PHASE

**EXAMPLE OF DRY FOOD packed within a 50 µm thick BOPP 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 |




**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**



*Food Additives and Contaminants* **2017, Doi: 10.1080/19440049.2017.1315777.**

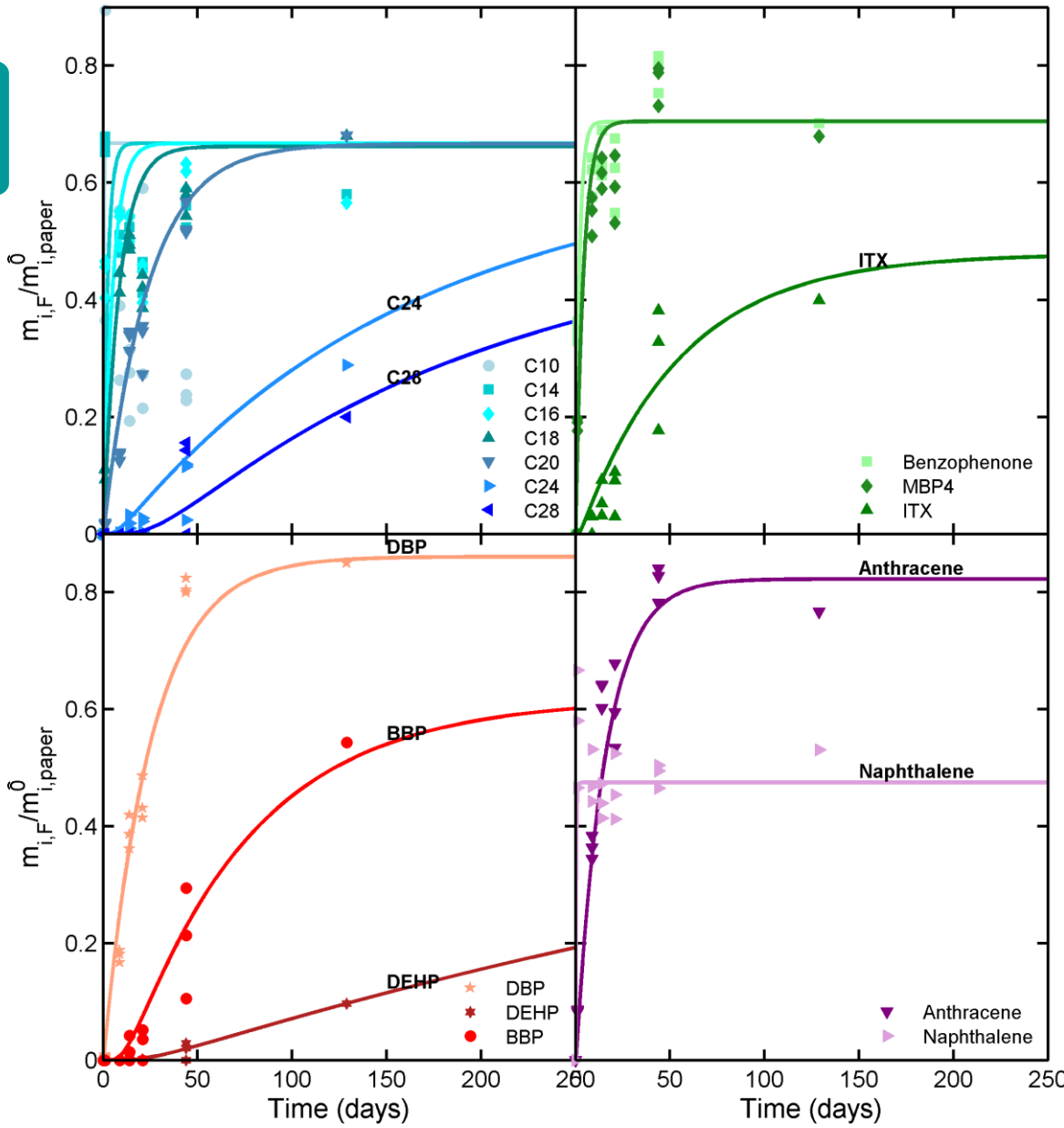
# PREDICTIONS vs EXPERIMENTS

Nguyen *et al*. 2016, submitted to I&EC, FAC

**Experimental results** at 60°C, *i*=1…15 → **Detailed modeling with FMECAengine**

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

**0 to 120 days**


https://github.com/ovitrac/FMECAengine

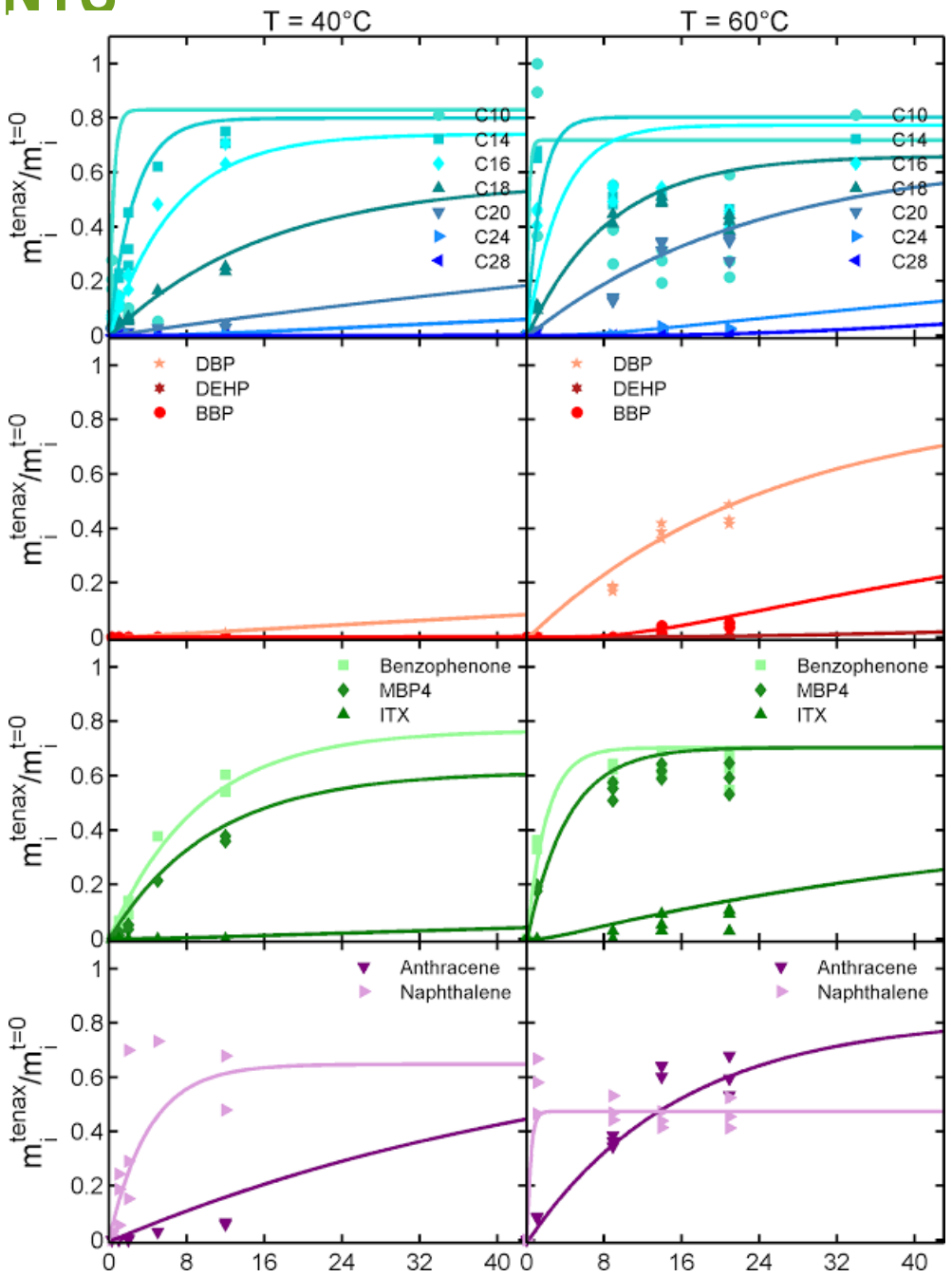
# PREDICTIONS vs EXPERIMENTS

Nguyen *et al*. 2016, submitted to I&EC, FAC

**Experimental results** at 60°C, *i*=1…15 → **Detailed modeling with FMECAengine**

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

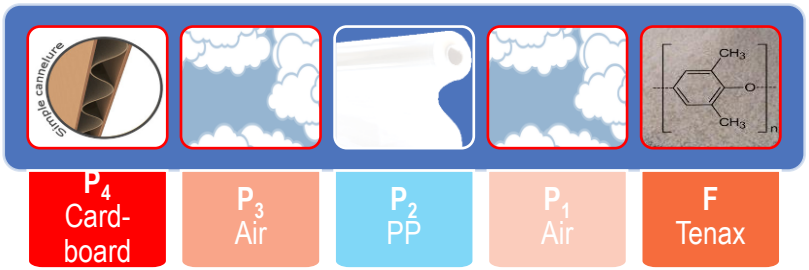
**0 to 40 days**


https://github.com/ovitrac/FMECAengine

# TWO EXTREME CASES

## Type 1 : desorption in gaseous phase (exponential without delay)



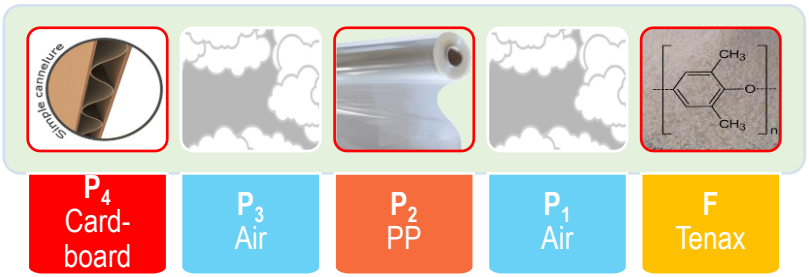

$$\frac{C_{i,P_4}^{t=0} - C_{i,P_4}(t)}{C_{i,P_4}^{t=0} - C_{i,P_4}^{eq}}$$

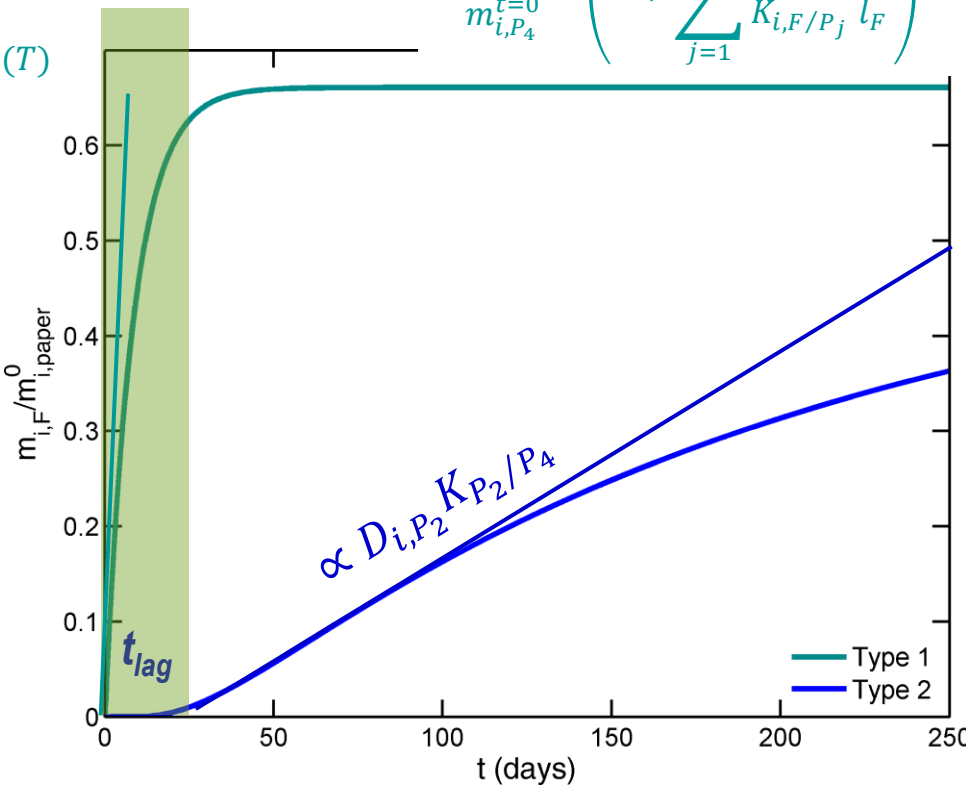
$$\xrightarrow[t\to 0]{} \frac{P_i^{vsat}(T) V_i \gamma_{i,P_4}^{v}(T) h_e}{(1-\varepsilon_{P_4}) RT l_{P_4}} \left(1 + K_{P_4/F} L_{P_4/F}\right) t$$

$$\frac{dm_{i,F}(t)}{dt}\Big|_{t\to 0} \propto P_i^{vsat}(T)$$

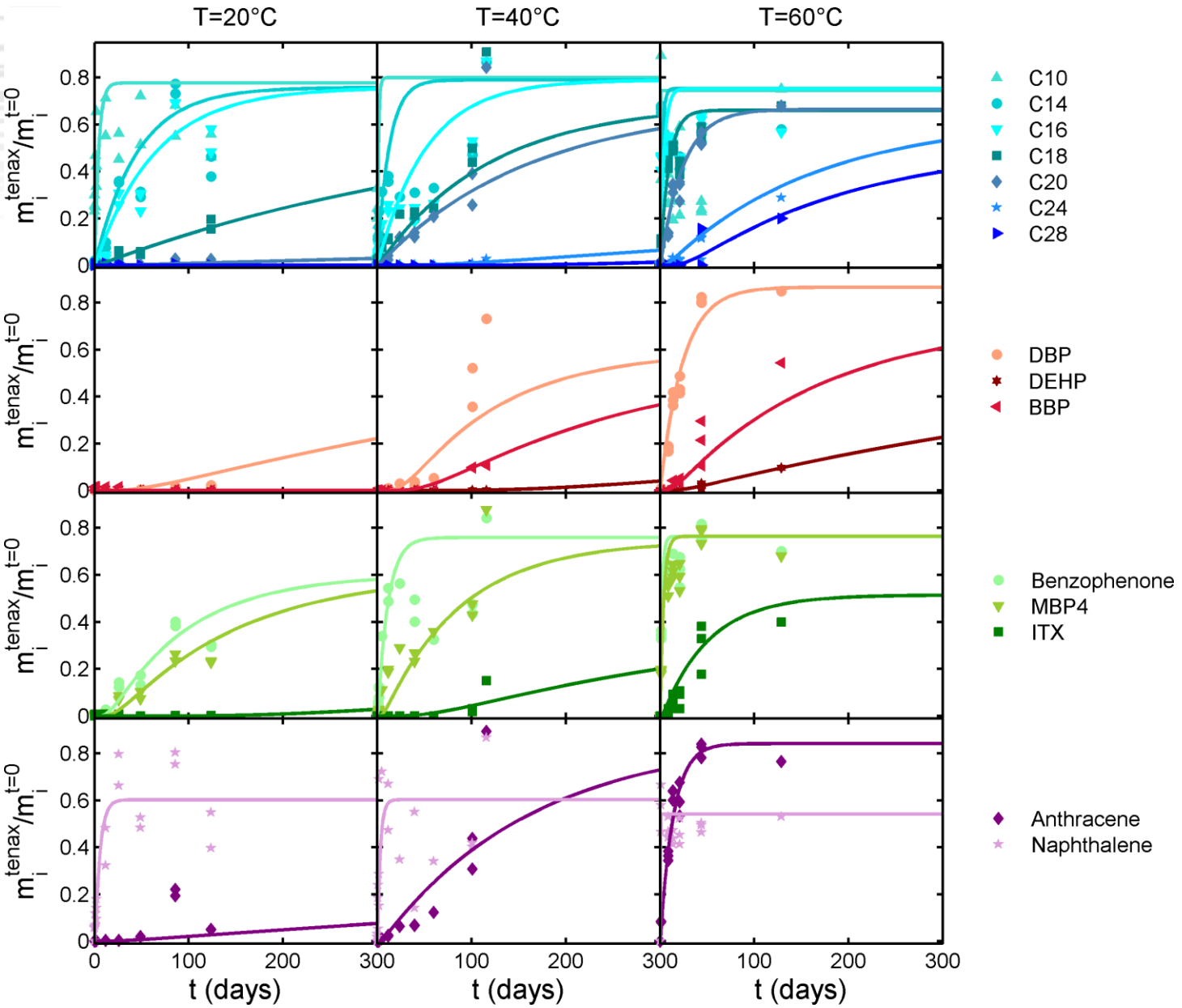
$$\frac{m_{i,F}^{eq}}{m_{i,P_4}^{t=0}} = \left(1 + \sum_{j=1}^{4} \frac{1}{K_{i,F/P_j}} \frac{l_{P_j}}{l_F}\right)^{-1}$$

## Type 2 : diffusion through the PP layer



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

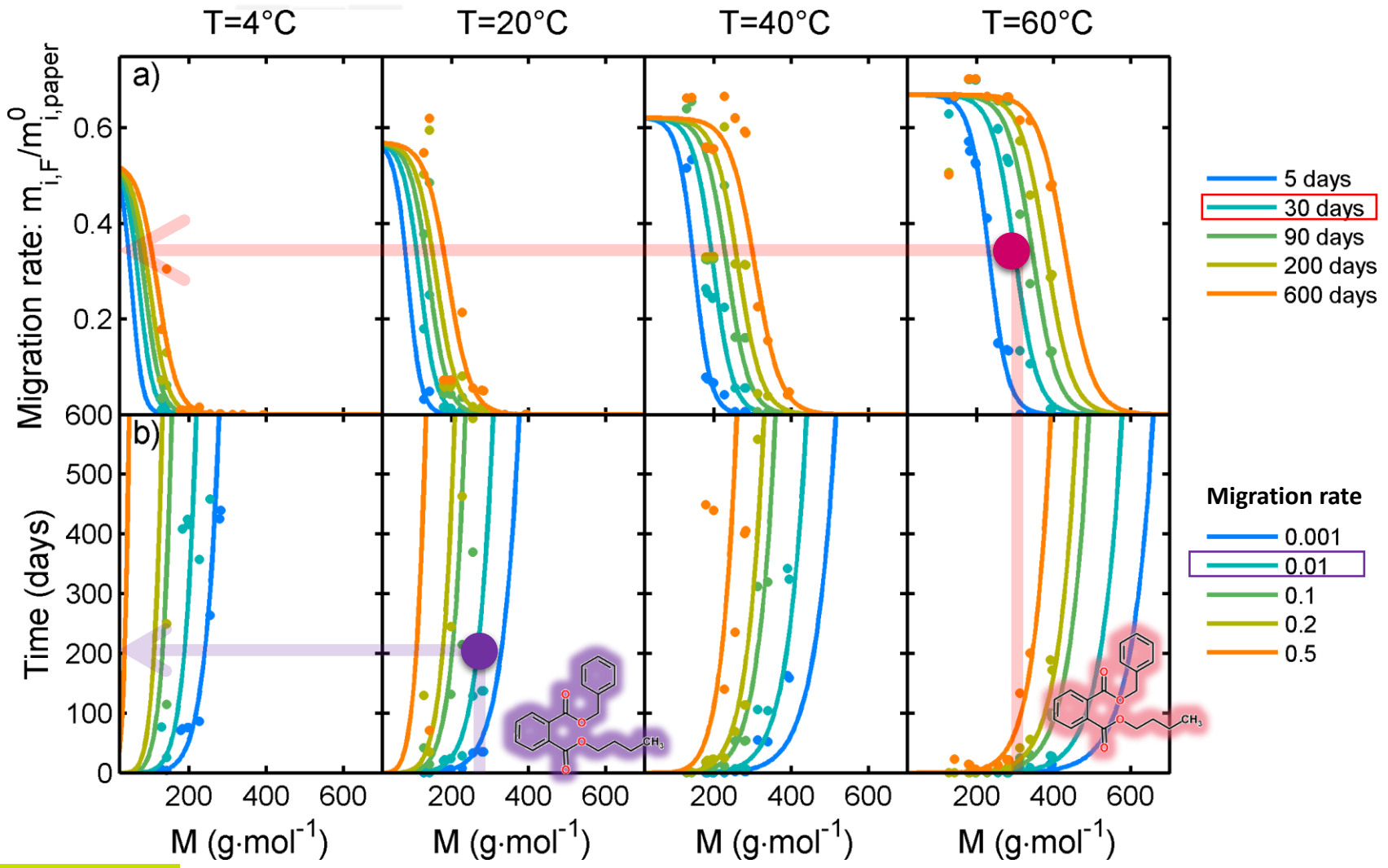






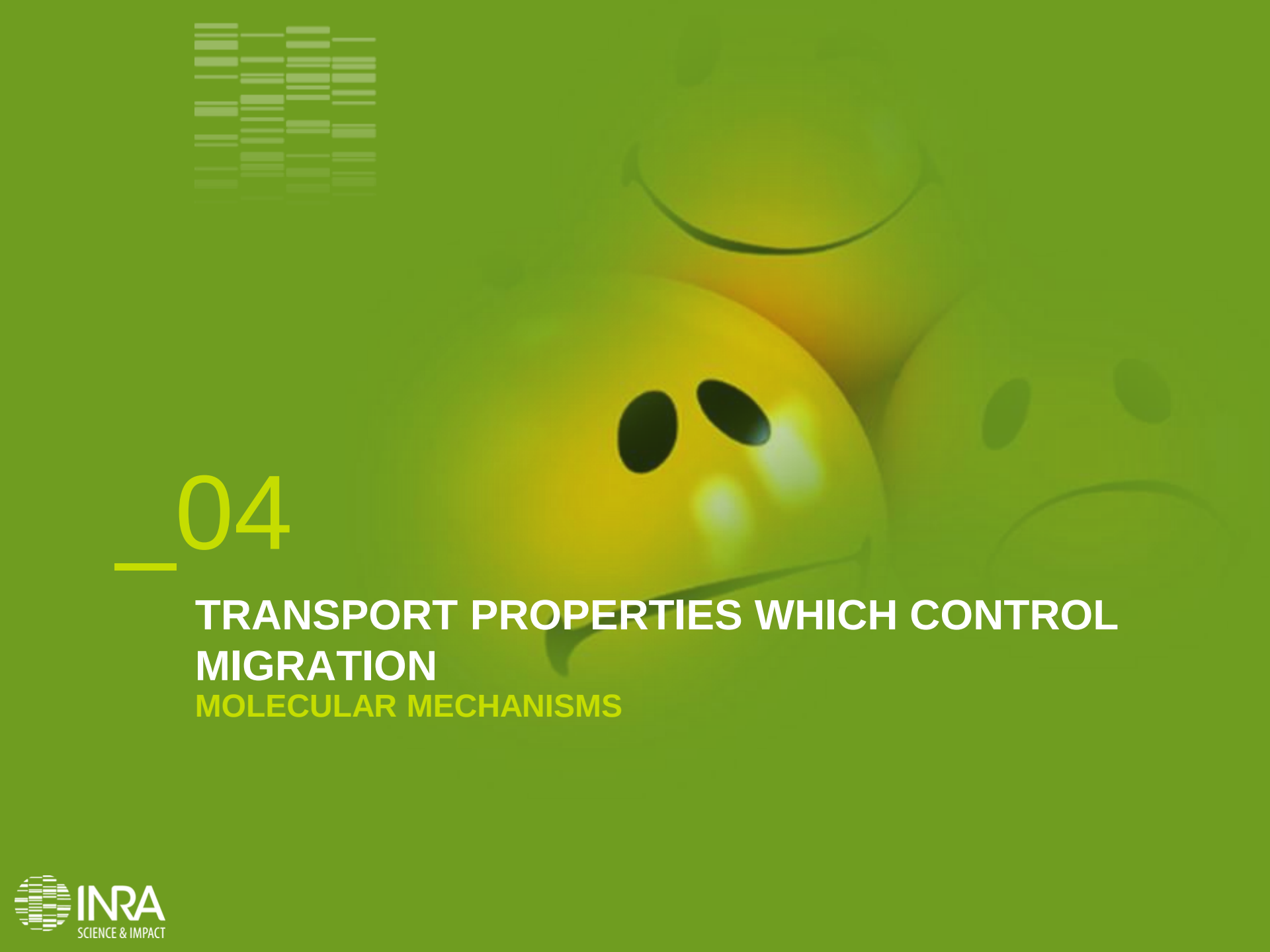
*Food Additives and Contaminants* **2017, Doi: 10.1080/19440049.2017.1315777.**

# ISO-TIME: CONTAMINATION x TEMPERATURE x M
# ISO-MIGRATION: TIME x TEMPERATURE x M






Example: benzyle butyle phtalate (M = 313 g·mol$^{-1}$)



# _04

# TRANSPORT PROPERTIES WHICH CONTROL MIGRATION

## MOLECULAR MECHANISMS

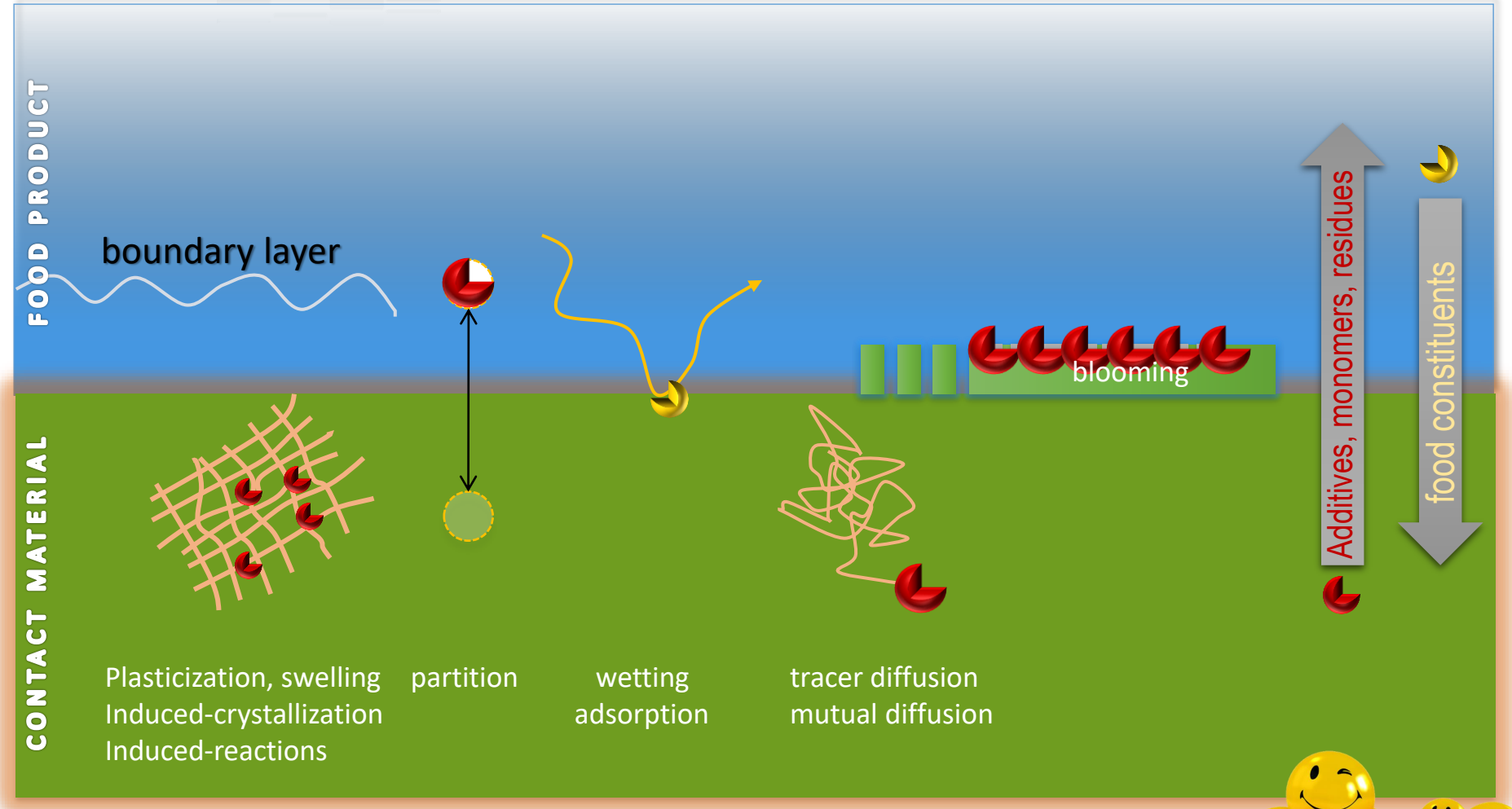
INRA
SCIENCE & IMPACT

additive

food constituent

# MIGRATION ISSUES

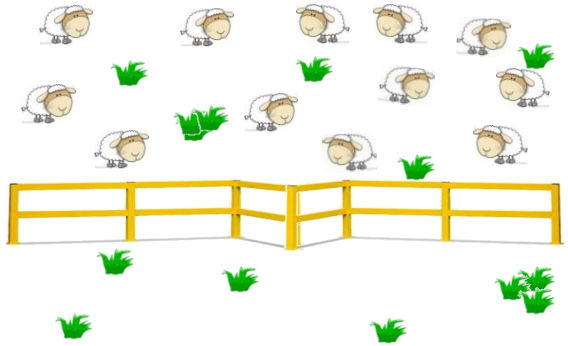
## CROSSED MASS TRANSFER OF FOOD CONTACT MATERIALS AND FOOD CONSTITUENTS

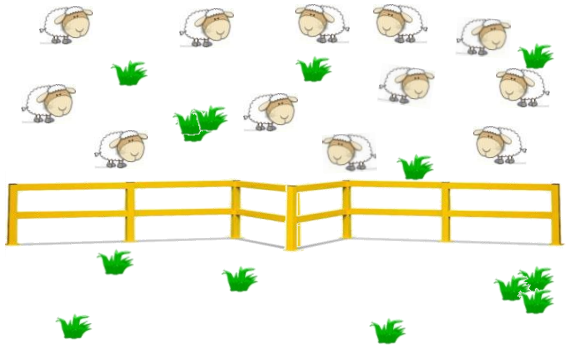


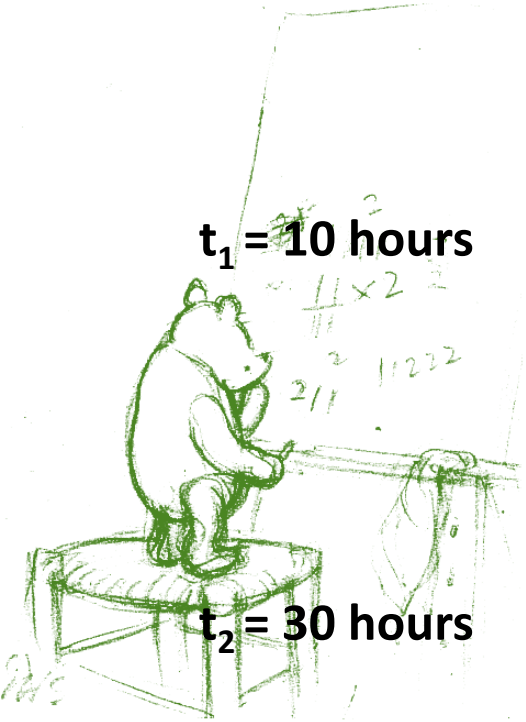

**D small**

**D large**

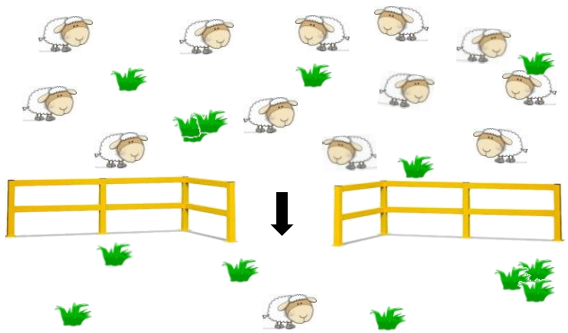
$t_0$ = 0 hour

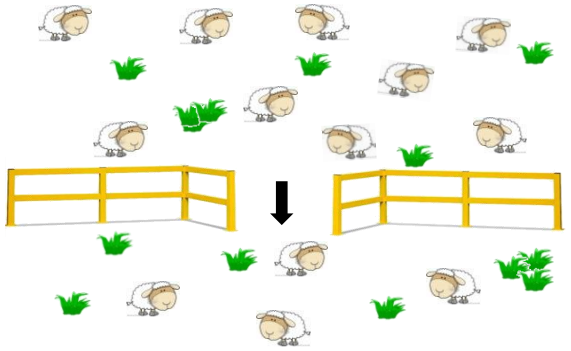




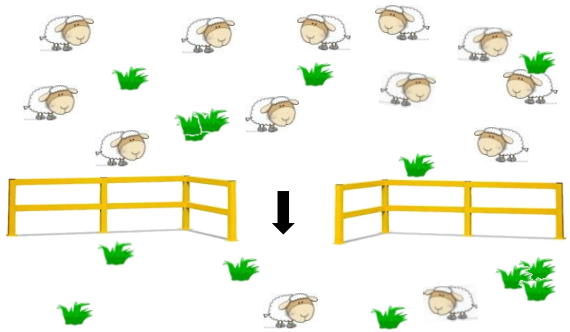


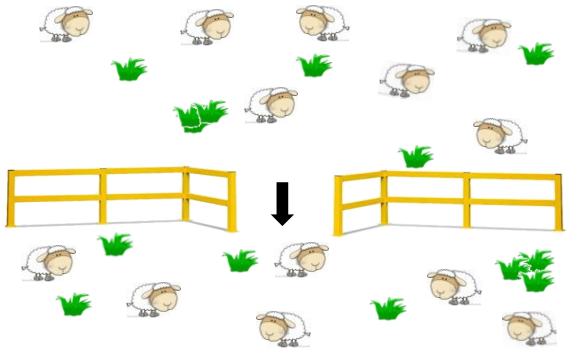
$t_1$ = 10 hours





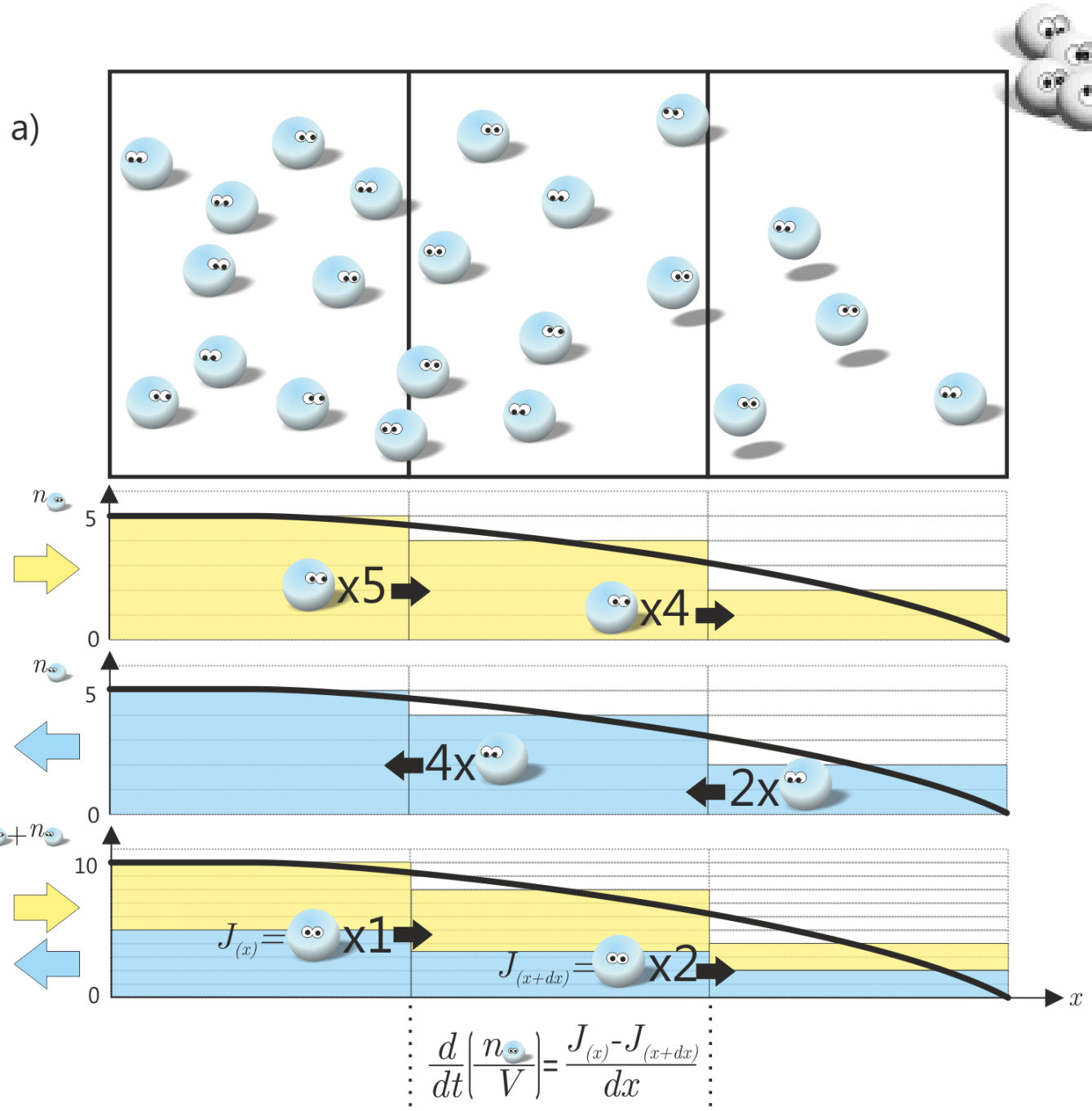
$t_2$ = 30 hours





$$\frac{\partial C}{\partial t} = \frac{\partial}{\partial x}\left(D\frac{\partial C}{\partial x}\right)$$

# MOLECULAR DIFFUSION

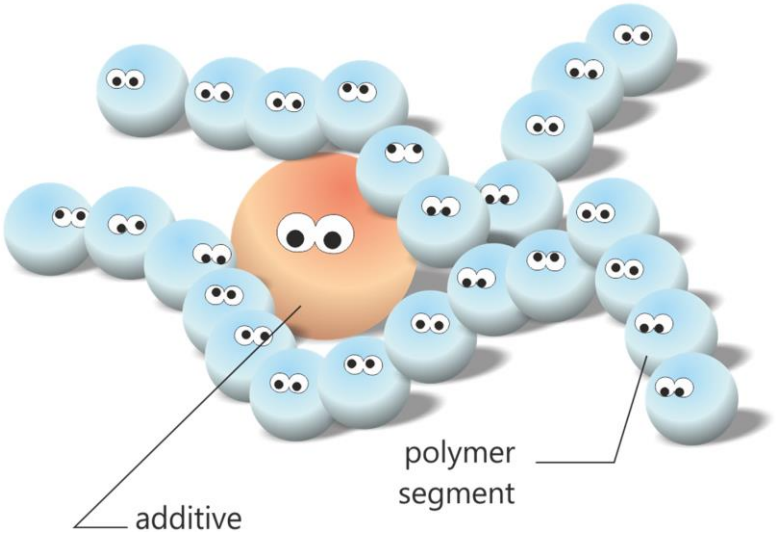


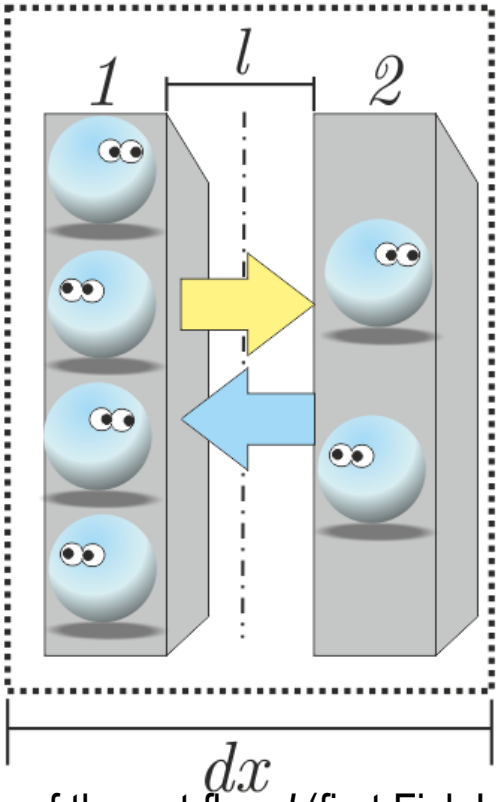

Molecules are represented as jumping beads. They have equal probabilities to hop to left and right directions.

The direction of the next hop at microscopic scale is indicated by the direction towards beads are staring.

# MICROSCOPIC RANDOM-WALK

Mutual diffusion of additive
Among polymer segments




$$j_{\rightarrow} = \nu \cdot n^1_{\bullet} = \frac{1}{2} \cdot \nu \cdot n^1_{\bullet}$$

$$j_{\leftarrow} = \nu \cdot n^2_{\bullet} = \frac{1}{2} \cdot \nu \cdot n^2_{\bullet}$$

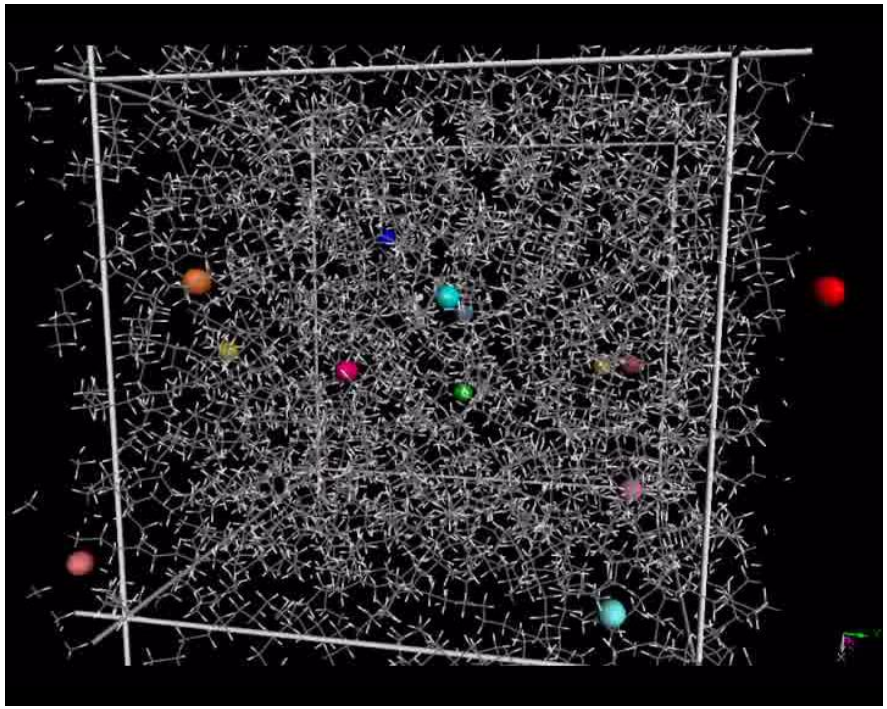
$$\frac{d}{dx} c_{\bullet} = \frac{n^2_{\bullet}/l - n^1_{\bullet}/l}{l}$$

$$J = j_{\rightarrow} - j_{\leftarrow} = -\underbrace{\frac{1}{2} \cdot \nu \cdot l^2}_{D} \cdot \frac{d}{dx} c_{\bullet}$$

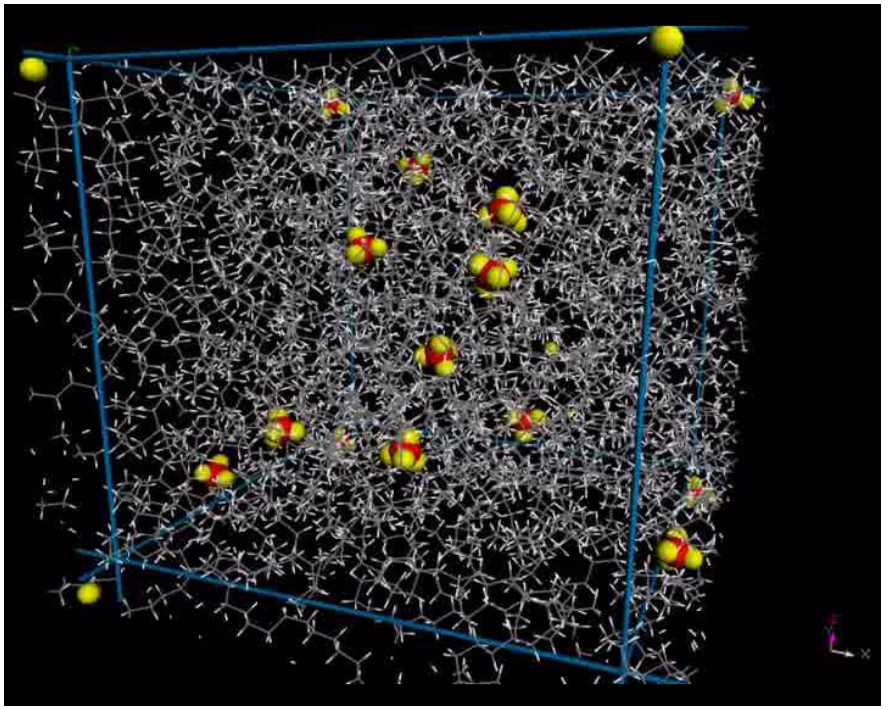
Interpretation of the net flux *J* (first Fick Law) as the microscopic exchange of molecules at frequency *v* between states 1 and 2 separated by a distance *dx*.

# DIFFUSION IN POLYETHYLENE (0.5 NS SIMULATION, T=298 K)

## 10 molecules of helium

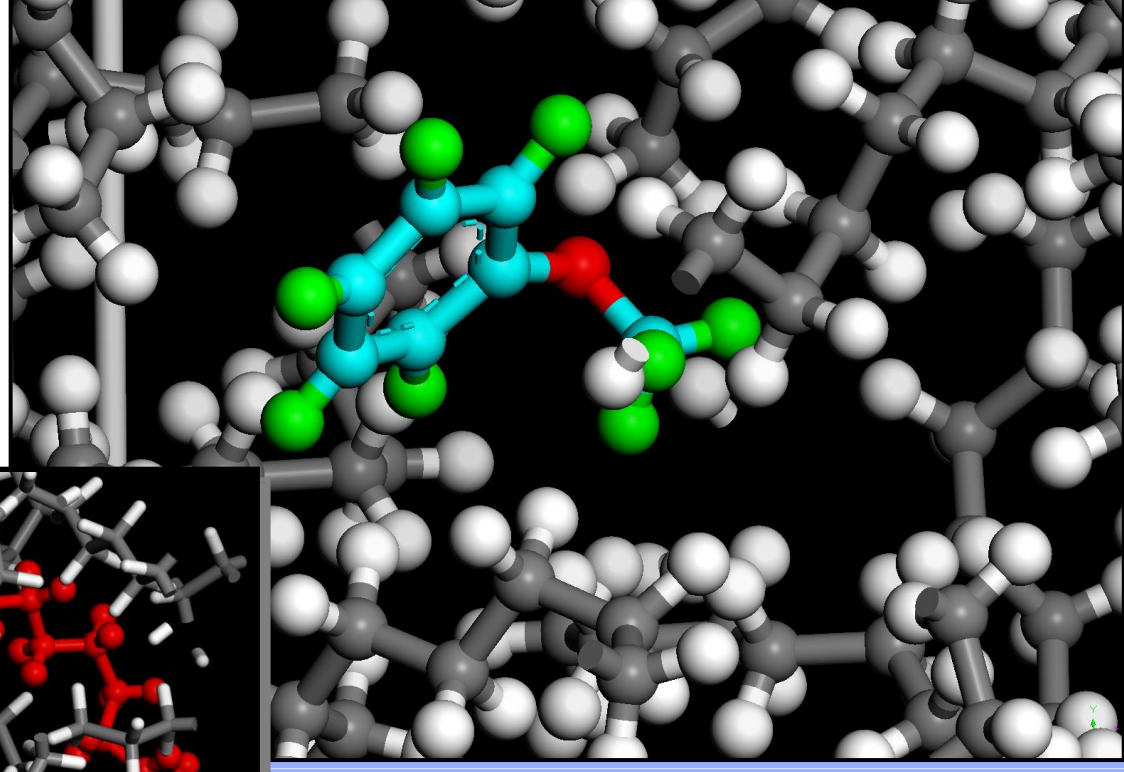


## 10 molecules of methane

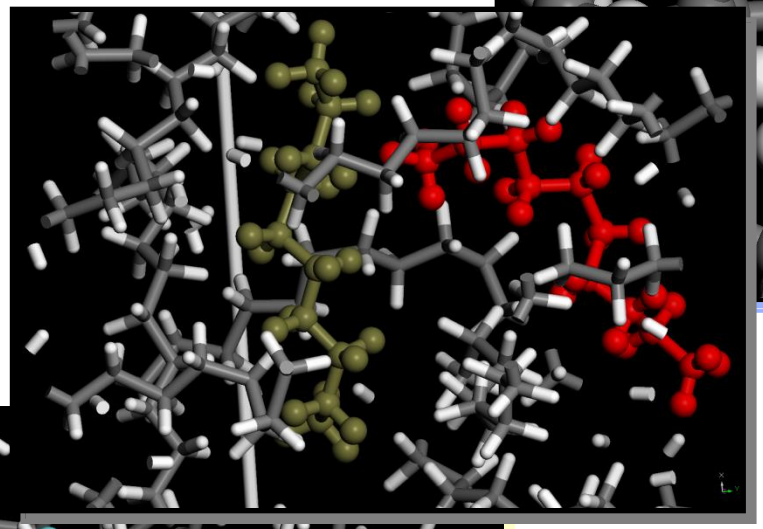


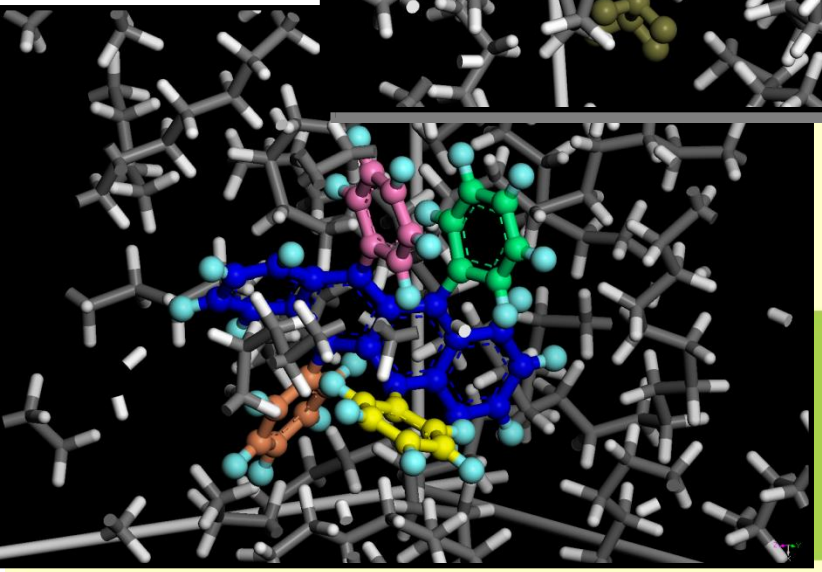
$$D \approx \frac{1}{6}\frac{\partial}{\partial t}\langle \boldsymbol{x_{CM}}(t) - \boldsymbol{x_{CM}}(0)\rangle^2$$

ANISOLE
108 g·mol$^{-1}$



DECANE
142 g·mol$^{-1}$

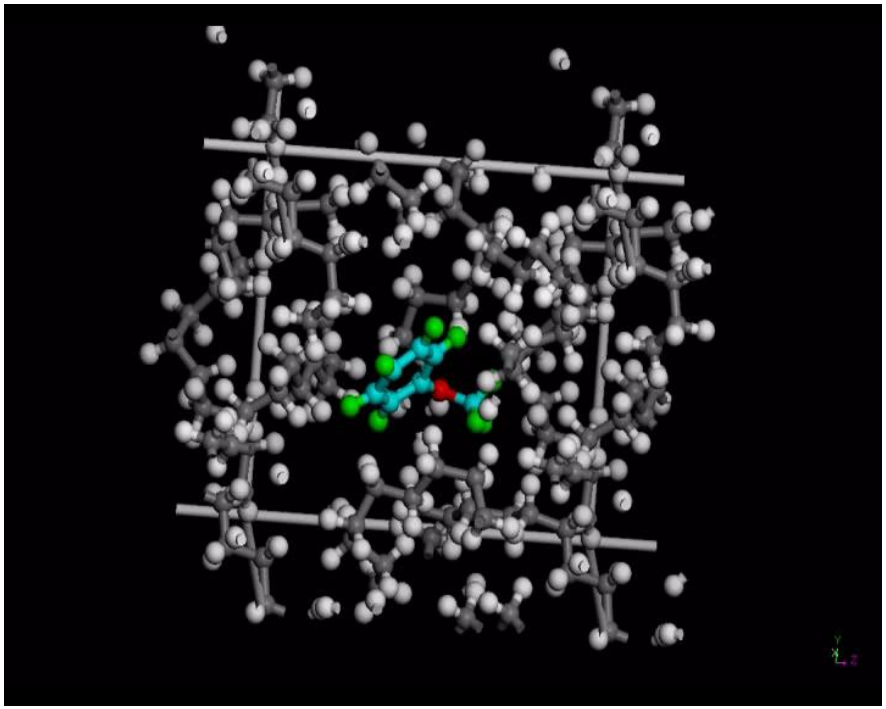




RUBRENE
532 g·mol$^{-1}$

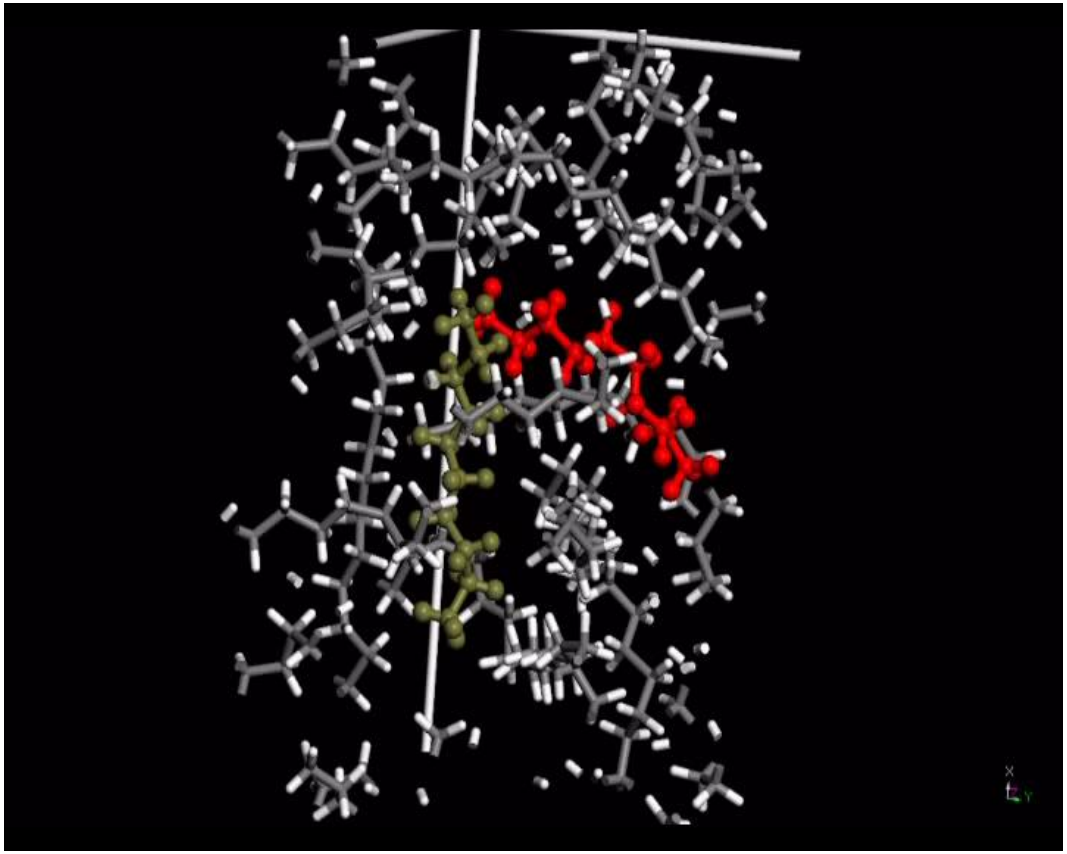
# DIFFUSION OF ANISOLE IN POLYETHYLENE (T=298 K)

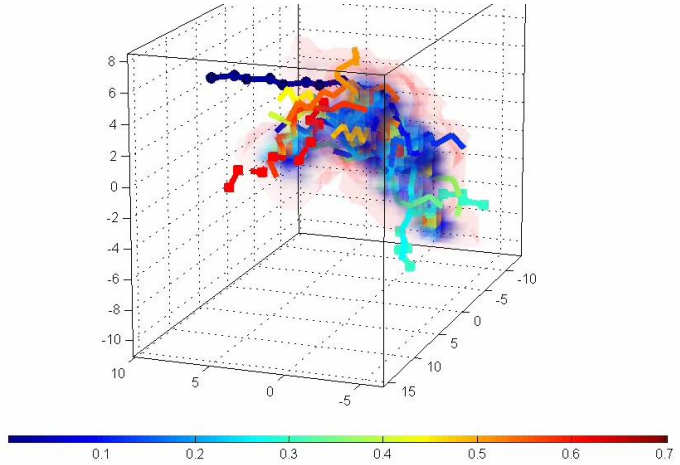
## 0.5 ns at 298 K (details)

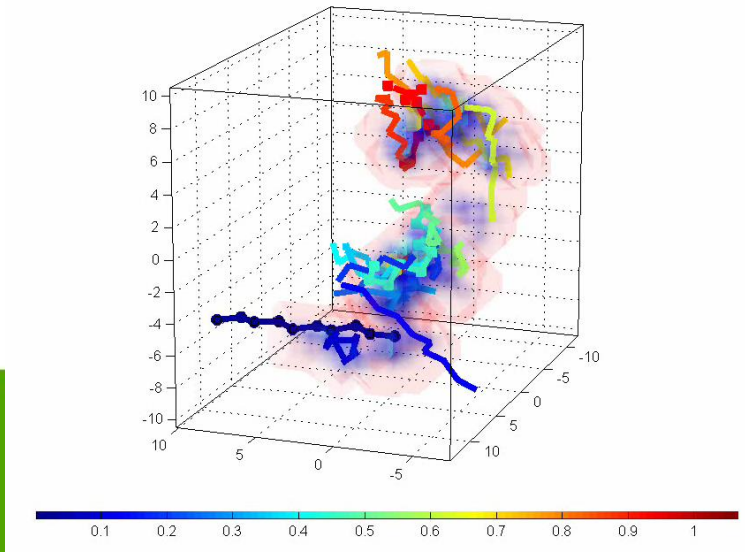


## 20 ns full trajectory

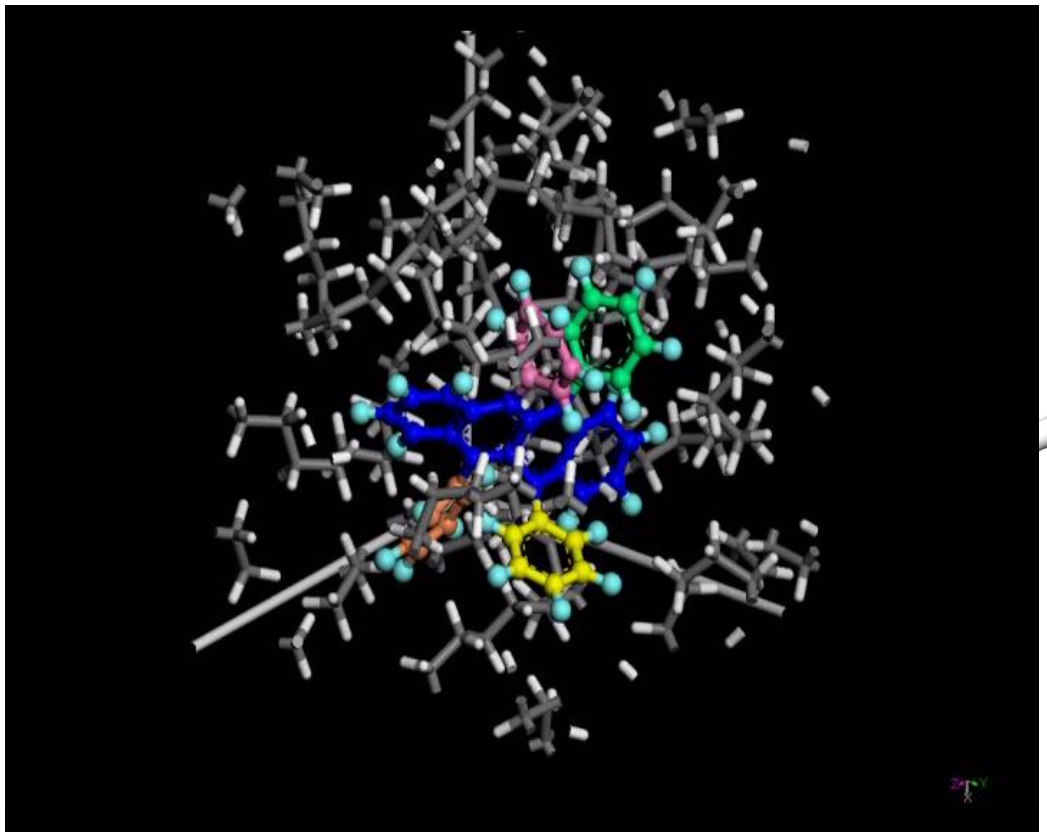
# Decane

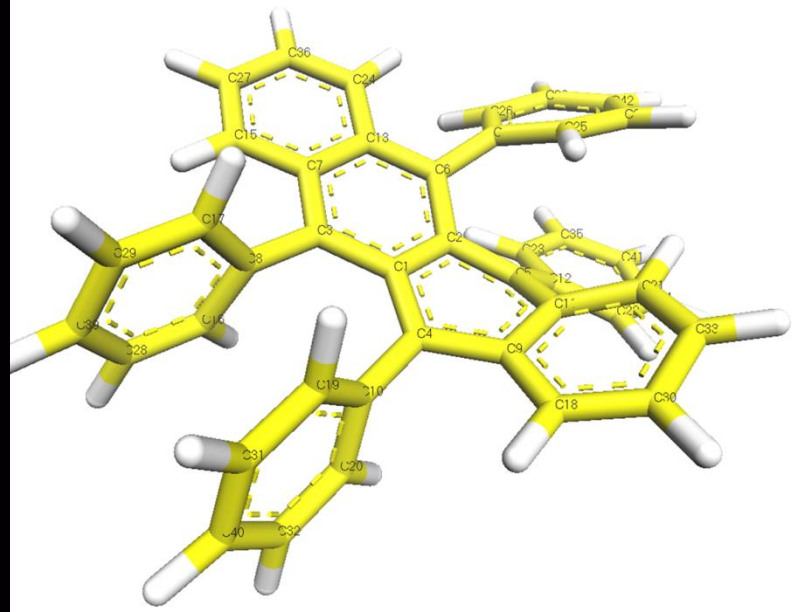



8
6
4
2
0
-2
-4
-6
-8
-10
10
5
0
-5
-10
-5
0
5
10
15
0.1
0.2
0.3
0.4
0.5
0.6
0.7


10
8
6
4
2
0
-2
-4
-6
-8
-10
10
5
0
-5
-10
-5
0
5
10
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

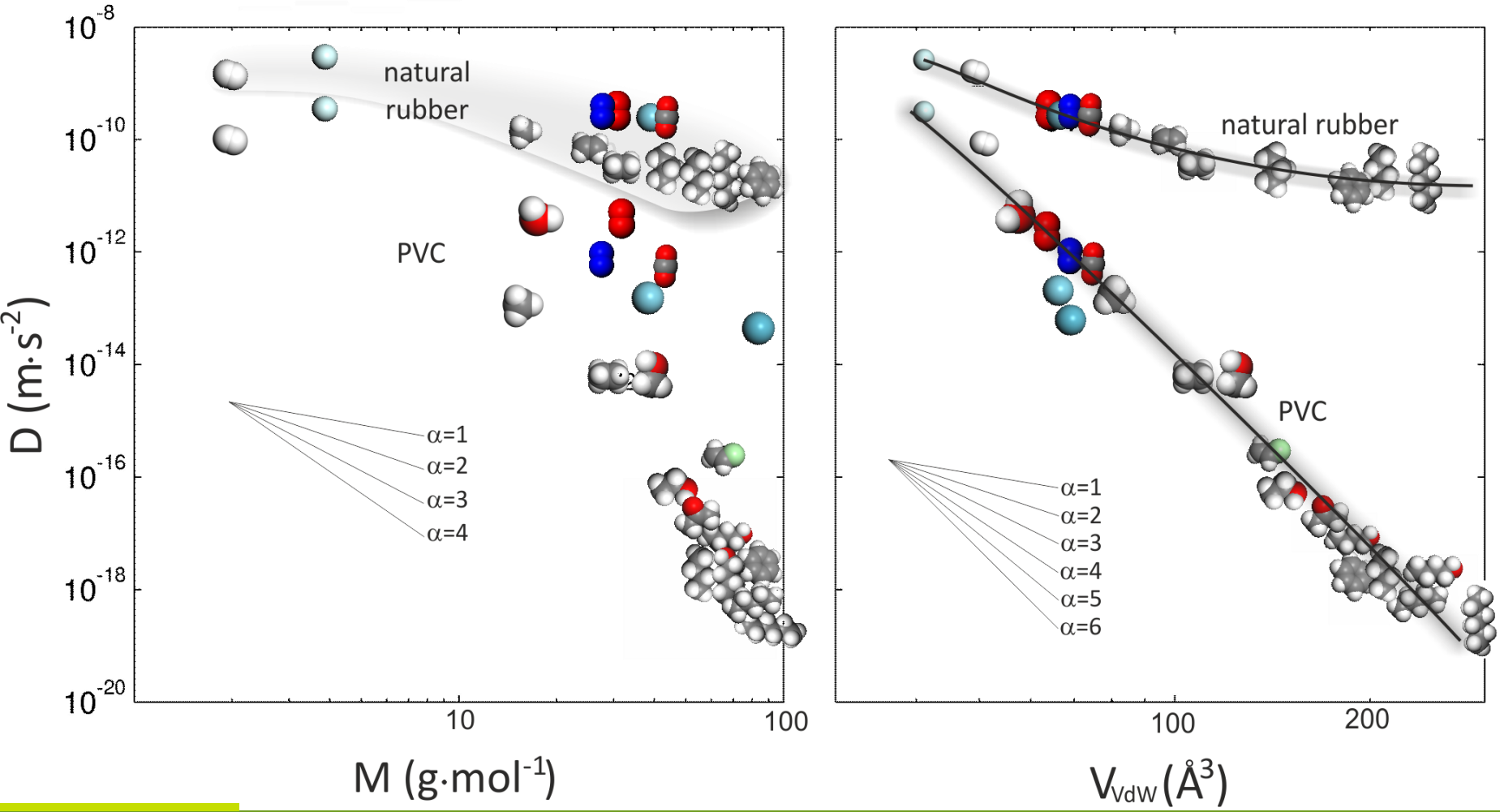
# Rubrene





# SCALING D WITH SOLUTE SIZE

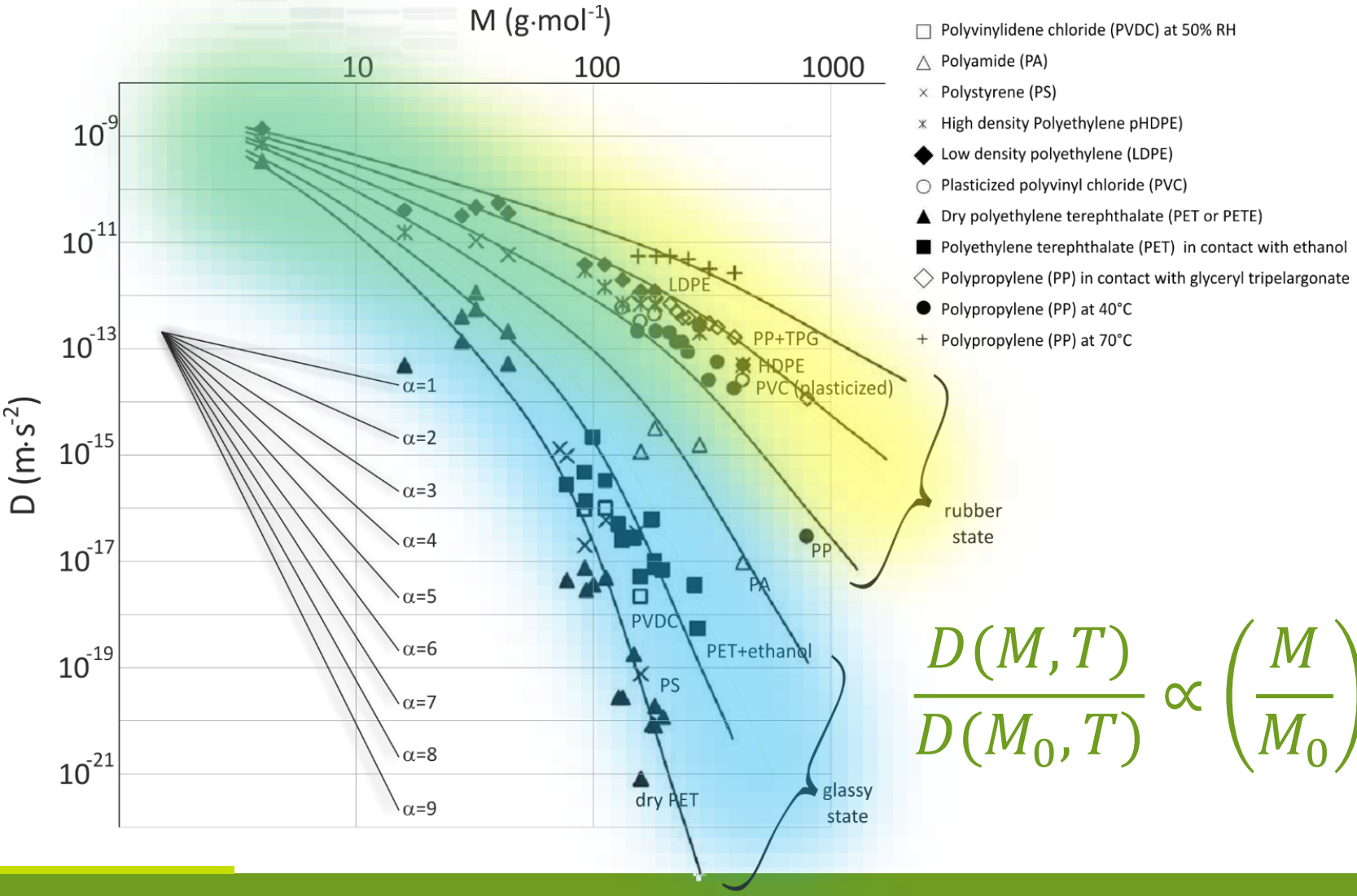
## STIFF DIFFUSANTS




From: A. R. Berens, Pure Appl. Chem., **1981**, 53, 365

# CHOOSING THE RIGHT BARRIER POLYMER

## DIFFUSION COEFFICIENTS OF ADDITIVES

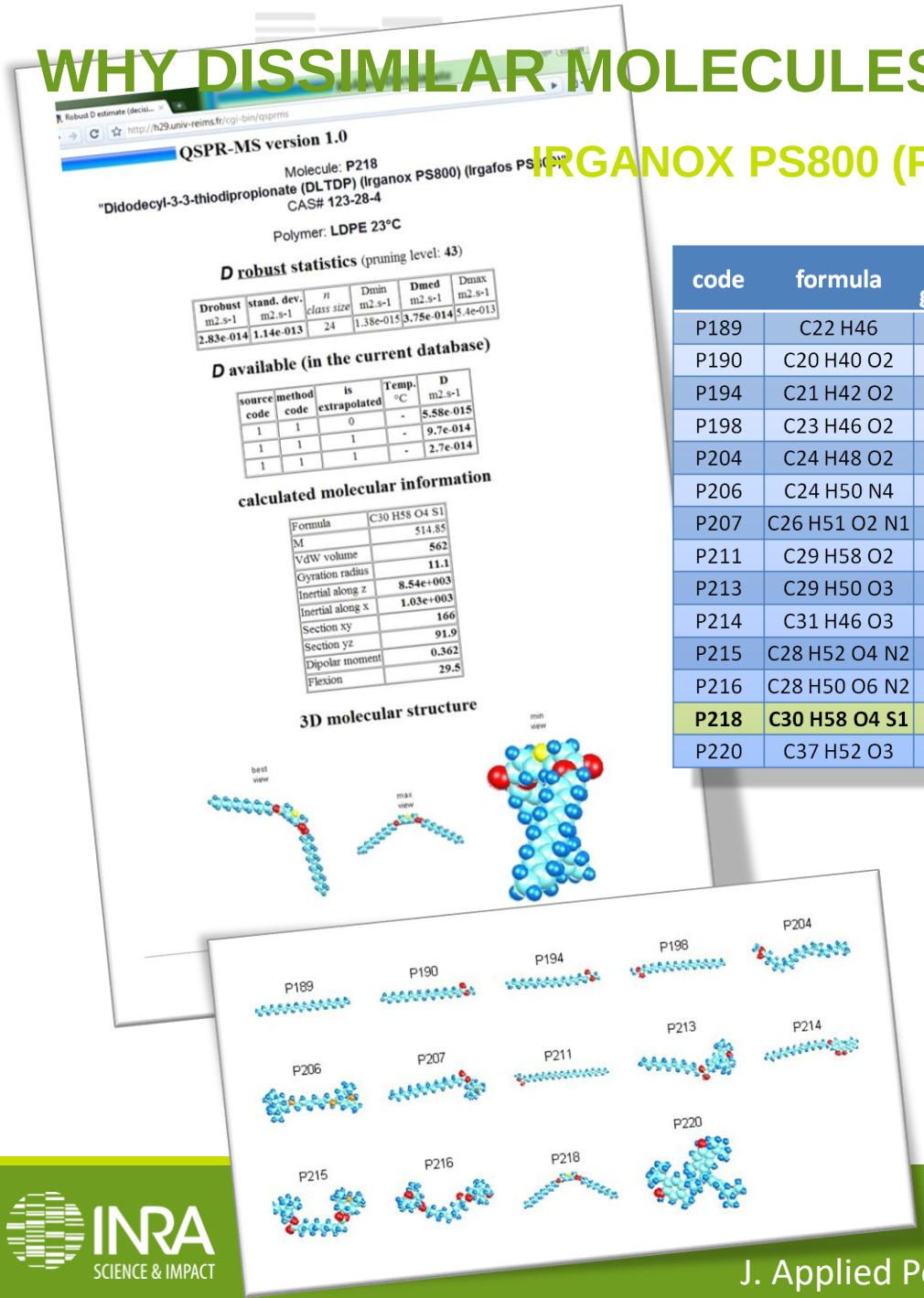


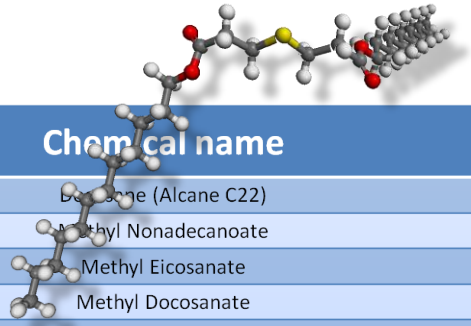

$$\frac{D(M,T)}{D(M_0,T)} \propto \left(\frac{M}{M_0}\right)^{-\alpha\left(T,T_g\right)}$$


*Journal of Chemical Physics* ***2010, 132, 194902.***
*Journal of Applied Polymer Science* ***2006, 101, 2167-218***
*Journal of Food Engineering* ***2007, 79, 1048-1064.***

# WHY DISSIMILAR MOLECULES HAVE SIMILAR D values?

## IRGANOX PS800 (PS218) in LDPE



| code | formula | M g.mol-1 | CAS # | Chemical name |
|---|---|---|---|---|
| P189 | C22 H46 | 311 | 629-97-0 | Docosane (Alcane C22) |
| P190 | C20 H40 O2 | 313 | 1731-94-8 | Methyl Nonadecanoate |
| P194 | C21 H42 O2 | 327 | NaN | Methyl Eicosanate |
| P198 | C23 H46 O2 | 355 | NaN | Methyl Docosanate |
| P204 | C24 H48 O2 | 369 | NaN | Methyl Tricosanate |
| P206 | C24 H50 N4 | 395 | NaN | 1,6-bis(2,2,6,6-tetramethyl-4-piperidinyl)hexamethylenediamine |
| P207 | C26 H51 O2 N1 | 410 | NaN | 2,2,6,6 -tetramethyl-4-piperidinol (Dastib 845) (fatty acids) |
| P211 | C29 H58 O2 | 439 | NaN | Methyl Octacosanate |
| P213 | C29 H50 O3 | 447 | NaN | Dodecylester-3-(3,5-di-tert-butyl-4-hydroxyphenyl) propionic acid |
| P214 | C31 H46 O3 | 467 | NaN | 2-Hydroxy-4-octadecane-oxy-benzophenone |
| P215 | C28 H52 O4 N2 | 481 | 52829-07-9 | bis[2,2,6,6-Tetramethyl-4-piperidinyl]-sebacate (Tinuvin 770) |
| P216 | C28 H50 O6 N2 | 511 | NaN | bis[2.2.6.6-tetramethyl-4-piperidinyl-1-oxy]sebacate |
| **P218** | **C30 H58 O4 S1** | **515** | **123-28-4** | **Didodecyl-3-3-thiodipropionate (DLTDP) (Irganox PS800)** |
| P220 | C37 H52 O3 | 545 | 1843-03-4 | 1,1,3-Tris(2-methyl-4-hydroxy-5-tert-butyl-phenyl)butane (Topanol CA) |

| $D_{robust}$ $m^2 \cdot s^{-1}$ | stand. dev. $m^2 \cdot s^{-1}$ | n class size | $D_{min}$ $m^2 \cdot s^{-1}$ | $D_{median}$ $m^2 \cdot s^{-1}$ | $D_{max}$ $m^2 \cdot s^{-1}$ |
|---|---|---|---|---|---|
| $2.83 \cdot 10^{-14}$ | $1.14 \cdot 10^{-13}$ | 24 | $1.38 \cdot 10^{-15}$ | $3.75 \cdot 10^{-14}$ | $5.4 \cdot 10^{-13}$ |

likely value

uncertainty index to be used with MIGRARISK

Full uncertainty range (pr>97.5%) without any approximation of the true distribution. Based here on 24 $D_{i,P}$ values obtained on 14 molecules homologous for diffusion.

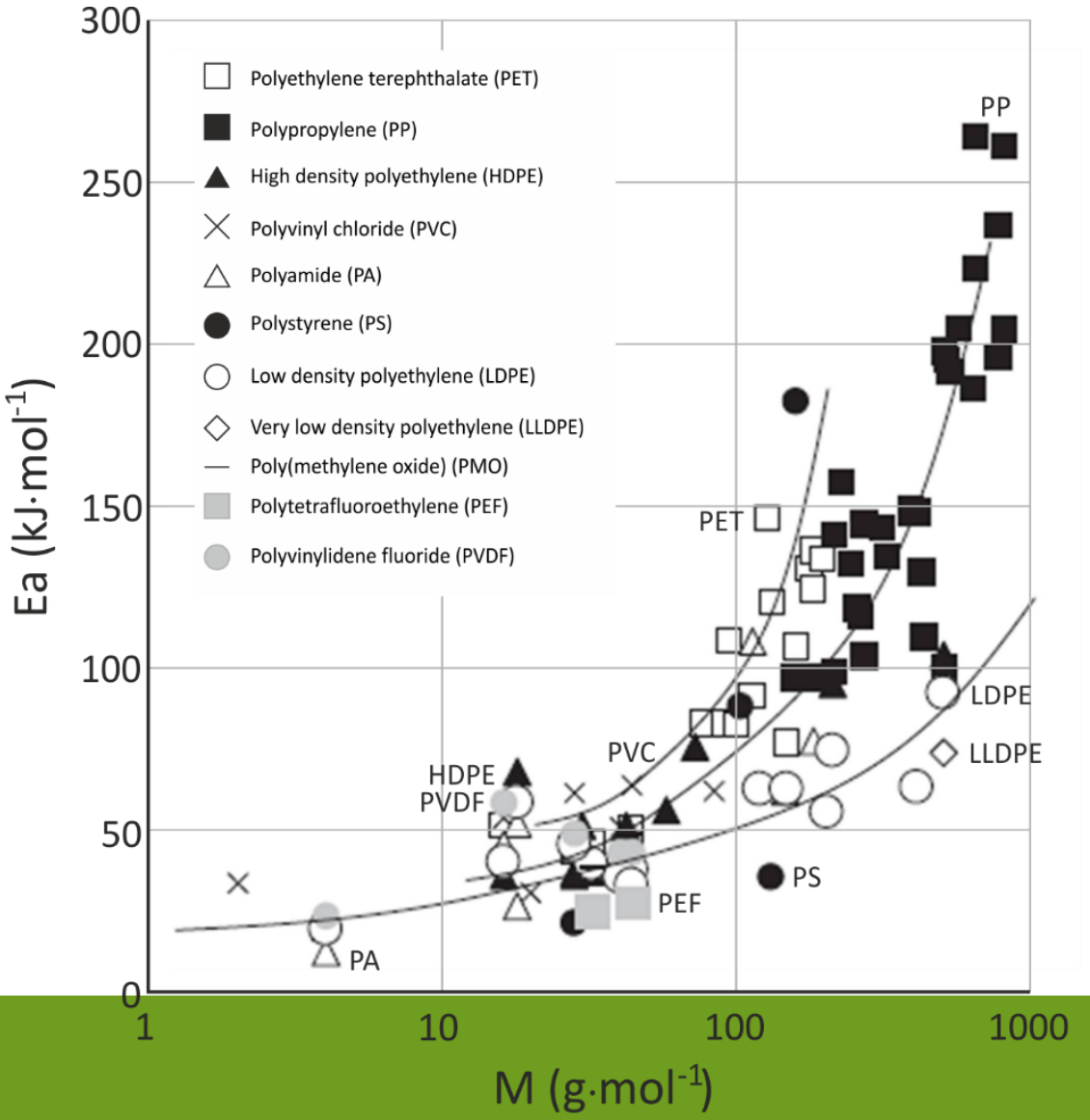


J. Applied Polym. Sci. 2006, 101(4), 2167-2186

# SCALING ACTIVATION ENERGY

## VARIOUS DIFFUSANTS IN VARIOUS POLYMERS

$$\mathrm{Ea}(M) \approx \mathrm{Ea}(M_0) + ln(M/M_0)$$

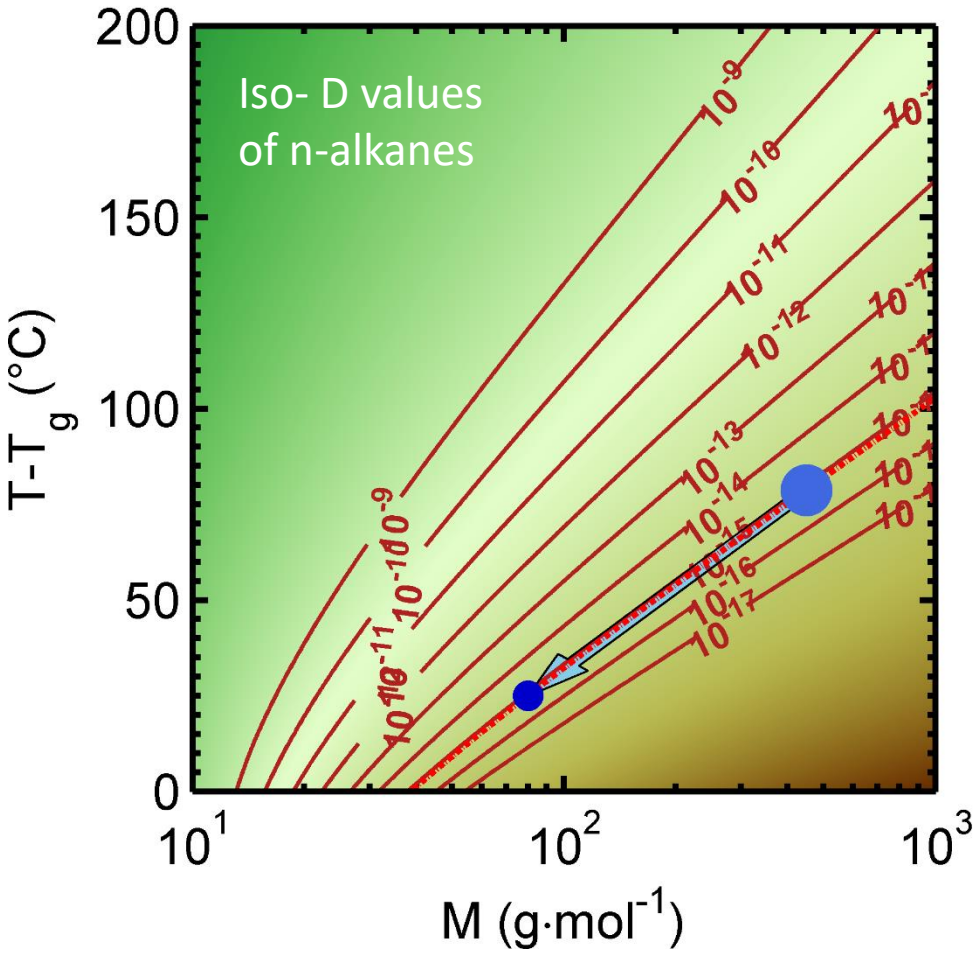



Critical Reviews in Food Science and Nutrition 2017, 57, 275-312.

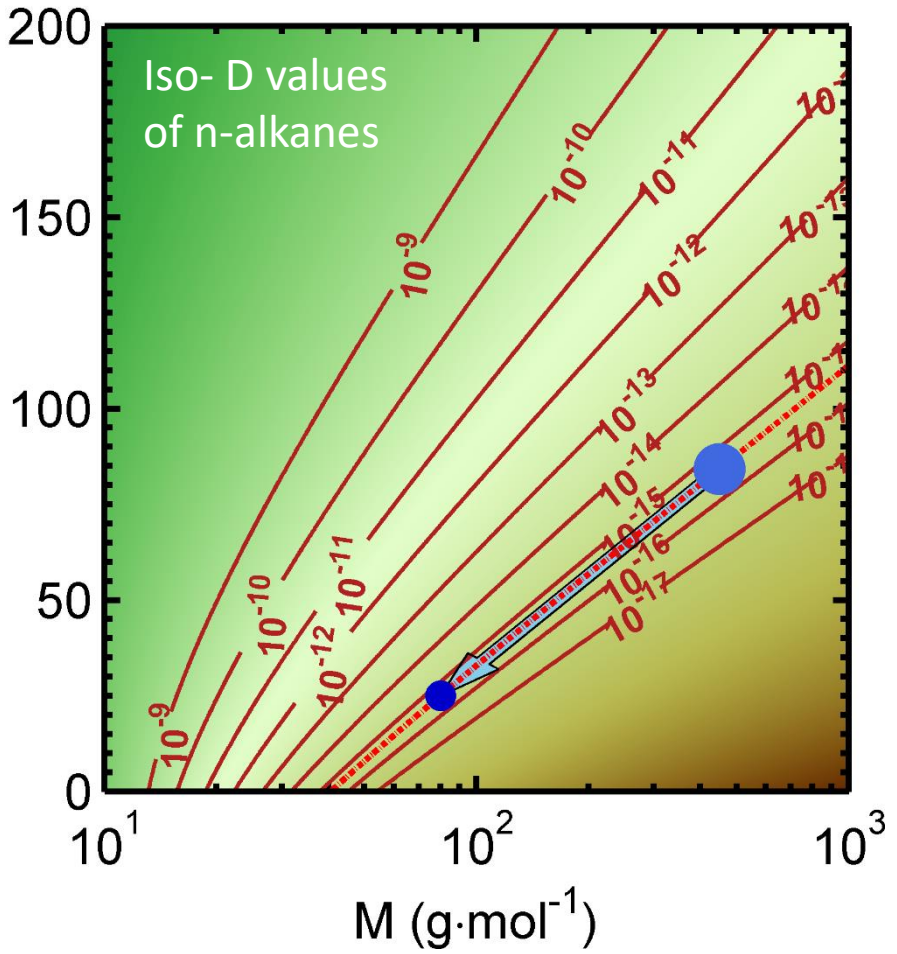
# EQUIVALENCE BETWEEN $T - T_g$ AND SIZE ($M$) EFFECTS

## CONNECTION WITH FREE-VOLUME THEORY

- "HEATING" PP

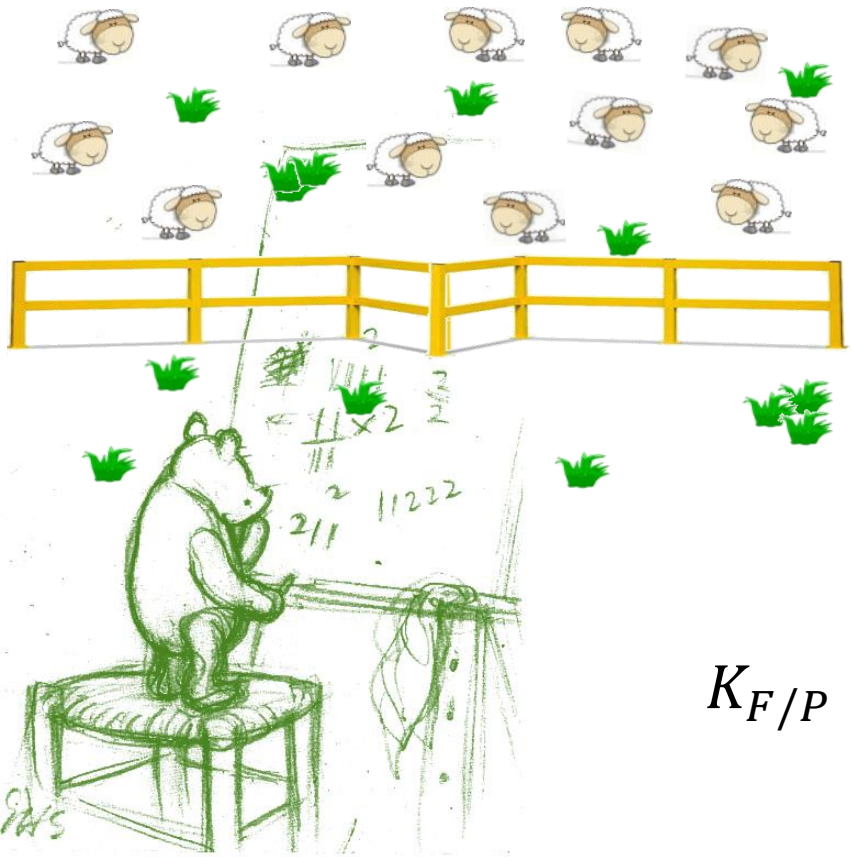



- "WETTING" PA6

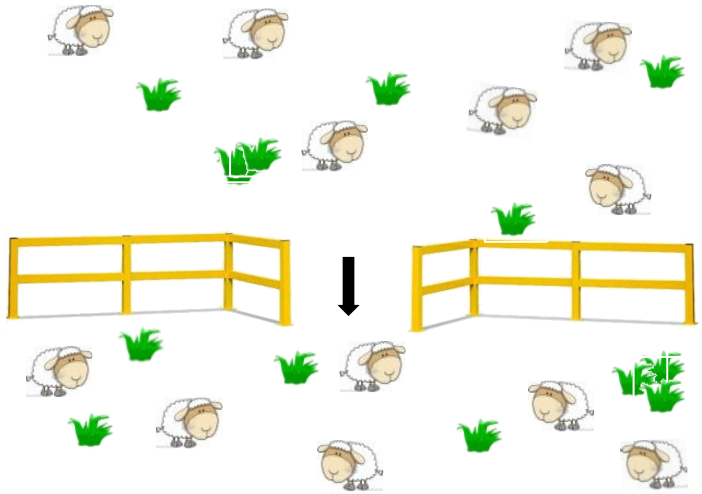


# INTUITIVE DEFINITION OF PARTITION COEFFICIENTS

initial state

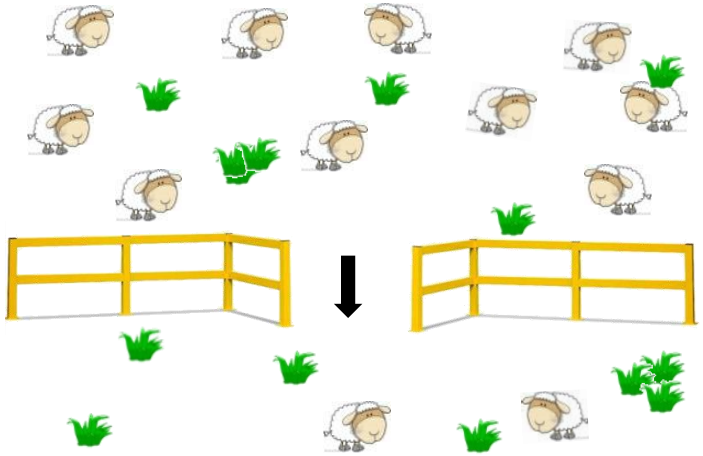


$$K_{F/P} = \frac{C_F^{eq}}{C_P^{eq}} = 1$$



thermodynamical equilibrium

$$K_{F/P} = \frac{C_F^{eq}}{C_P^{eq}} < 1$$

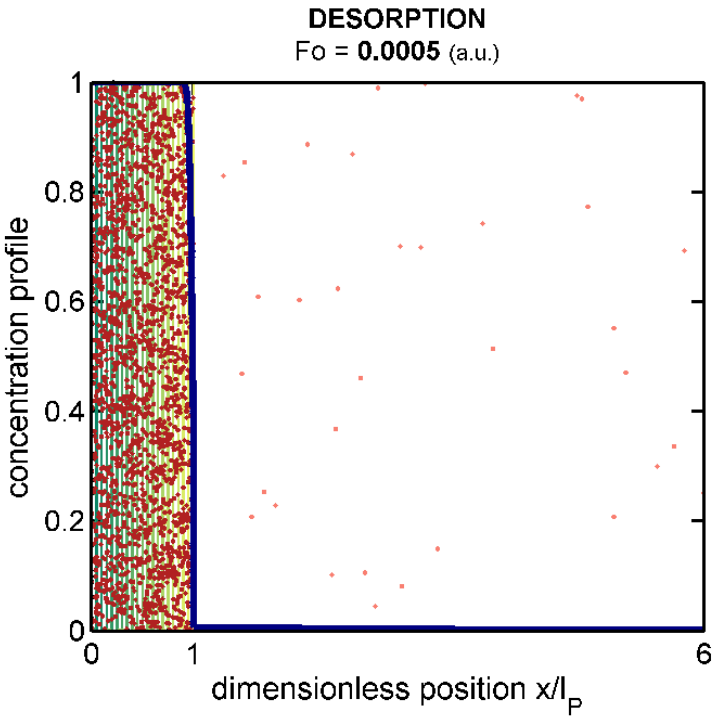


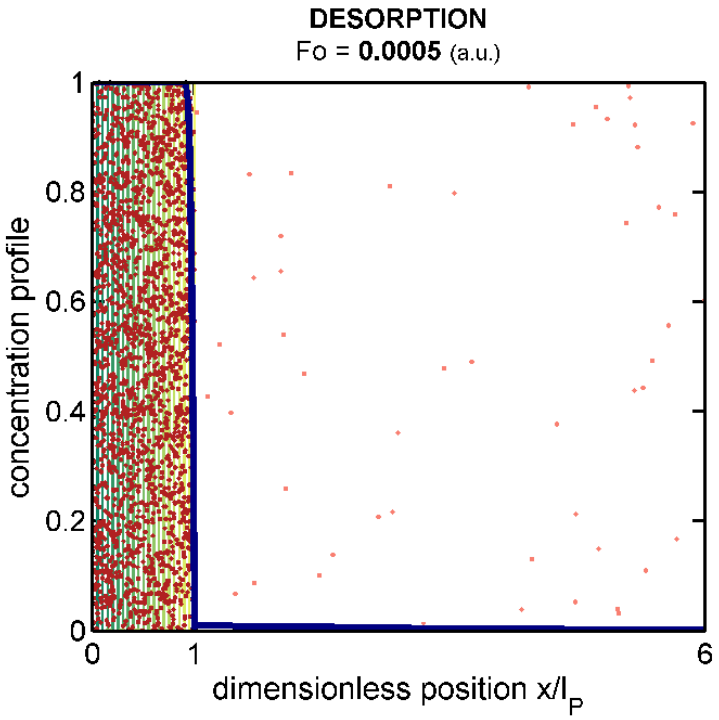
# EFFECT OF PARTITION COEFFICIENT ON MIGRATION

50 times for chemical affinity for P

50 times for chemical affinity for F

$K_{i,F/P}$ = **1/50** | **50**




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

# _05

## Preventives approaches

### PERSPECTIVES FROM RESEARCH

INRA
SCIENCE & IMPACT

# PARACELSUS PARADIGM

*Dosis facit venenum*.


THEOPHRASTI
PARACELSI
LIBRI V.
DE
Vita longa, breui, & sana.
DEQ.
Triplici corpore.
Iamdudum ab ipso authore obscurè editi, nunc verò opera & studio GERARDI DORNEI Commentarijs illustrati.
CHRISTOFF. RABE
FRANCOFORTI.
Anno M. D. LXXXIII.

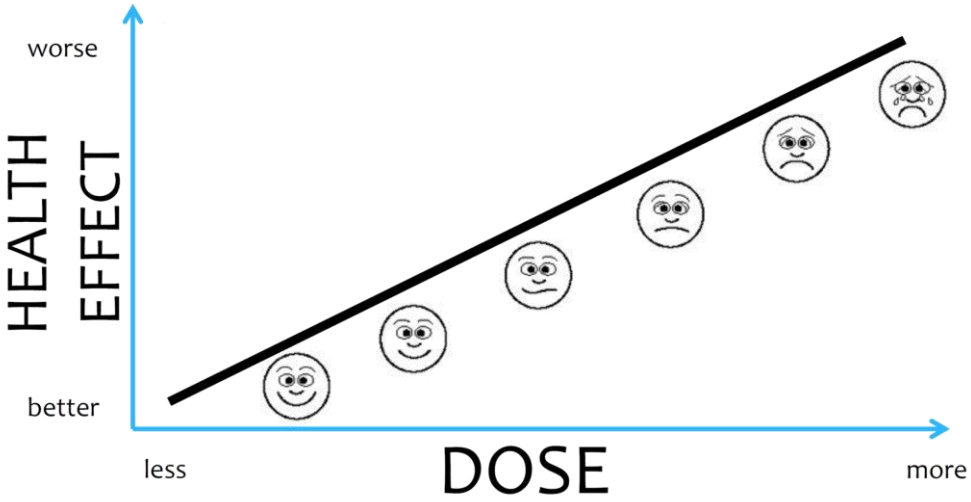
## NEW TRENDS

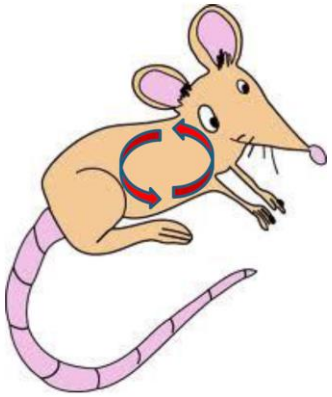

Low dose effect

Oestregenic effect

Endocrinian disruptors

# ACUTE TOXICOLOGY



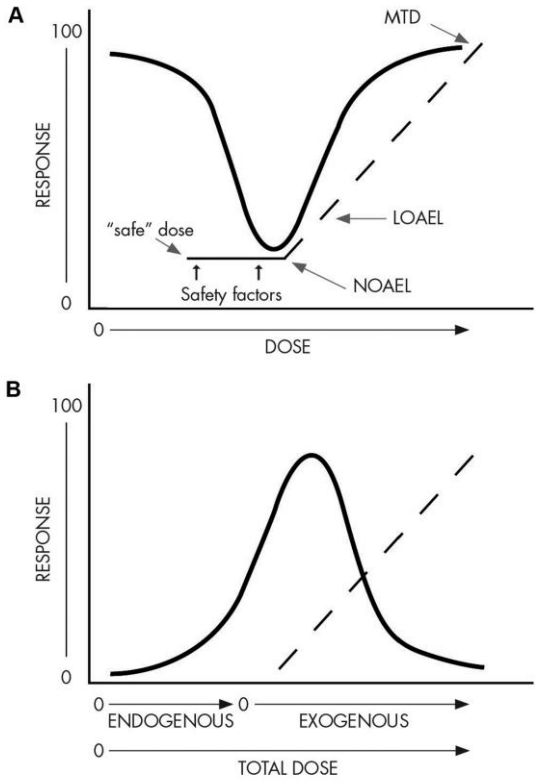
Reference Dose

LOAEL

NOAEL

Max Tolerated Intake

800 studies




# Hormones and Endocrine-Disrupting Chemicals: Low-Dose Effects and Nonmonotonic Dose Responses

Laura N. Vandenberg, Theo Colborn, Tyrone B. Hayes, Jerrold J. Heindel, David R. Jacobs, Jr., Duk-Hee Lee, Toshi Shioda, Ana M. Soto, Frederick S. vom Saal, Wade V. Welshons, R. Thomas Zoeller, and John Peterson Myers

Center for Regenerative and Developmental Biology and Department of Biology (L.N.V.), Tufts University, Medford, Massachusetts 02155; The Endocrine Disruption Exchange (T.C.), Paonia, Colorado 81428; Laboratory for Integrative Studies in Amphibian Biology (T.B.H.), Molecular Toxicology, Group in Endocrinology, Energy and Resources Group, Museum of Vertebrate Zoology, and Department of Integrative Biology, University of California, Berkeley, California 94720; Division of Extramural Research and Training (J.J.H.), National Institute of Environmental Health Sciences, National Institutes of Health, U.S. Department of Health and Human Services, Research Triangle Park, North Carolina 27709; Division of Epidemiology and Community Health (D.R.J.), School of Public Health, University of Minnesota, Minneapolis, Minnesota 55455; Department of Preventive Medicine (D.-H.L.), School of Medicine, Kyungpook National University, Daegu 702-701, Korea; Molecular Profiling Laboratory (T.S.), Massachusetts General Hospital Center for Cancer Research, Charlestown, Massachusetts 02129; Department of Anatomy and Cellular Biology (A.M.S.), Tufts University School of Medicine, Boston, Massachusetts 02111; Division of Biological Sciences (F.S.v.S.) and Department of Biomedical Sciences (W.V.W.), University of Missouri-Columbia, Columbia, Missouri 65211; Biology Department (T.Z.), University of Massachusetts-Amherst, Amherst, Massachusetts 01003; and Environmental Health Sciences (J.P.M.), Charlottesville, Virginia 22902

**TABLE 1.** Low-dose definitions and cutoff doses: BPA and DEHP as examples

| Chemical | Estimated range of human exposures | Doses below the NOAEL | Doses below the LOAEL | Administered doses (to animals) that produce blood levels in typical humans |
|---|---|---|---|---|
| BPA | 0.4–5 μg/kg · d (679) | No NOAEL was ever established in toxicological studies (38) | <50 mg/kg · d (38) | ~400 μg/kg · d to rodents and nonhuman primates (4, 253) |
| DEHP | 0.5–25 μg/kg · d (680) | <5.8 mg/kg · d (681, 682) | <29 mg/kg · d (681, 682) | Unknown |

Estimates of human exposure are made from consumer product consumption data but do not take into account that there are unknown sources of these chemicals. DEHP, Bis(2-ethylhexyl) phthalate.

Endocrine Reviews, 2012, 33(3):378–455

# Is it possible we are right or wrong?

FOOD PRODUCT DESIGN

Innovation | Ingredients | Science | Compliance

HOME | TV | CONTENT LIBRARY | BOARDROOM JOURNAL (New) | BUYER'S GUIDE | RESOURCE CENTER

## DEVELOPING RELIABLE PACKAGING FOR CHEMICAL-FREE FOOD

April 9, 2013 **0 Comments**

Posted in News, Science & Research, Food Safety, Chemicals, Bisphenol A (BPA), International, Packaging

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MASSY, France—Move over NASA. French scientists are developing an open-source software, based on a method used in aeronautics called Failure Mode Effects and Criticality Analysis (FMECA), to detect every critical point on the food packaging lifecycle where contamination could occur.

Plastic food packaging is made of multiple layers designed to act as a barrier for oxygen or bacteria. Under the SafeFoodPackDesign project coordinated by Vitrac and funded by the French National Research Agency (ANR), scientists have been addressing the issue of such potentially harmful molecules diffusing from one layer to the next in food packaging.

"Each of these layers is made by a different manufacturer. Still, at the end of the chain, the food manufacturer who sells the packaged product is the sole responsible for food safety," said Olivier Vitrac, a researcher at the Genial joint research unit of the National Institute of Agricultural Research (INRA-Agroparistech).

Food packaging is designed to preserve the content as fresh and safe as possible. Its second function is to make the product look attractive to customers, using colorful prints. The problem is the approach requires the use of potentially harmful molecules such as anti-ultraviolet radiations, anti-oxidizers, glue and pigments from inks. These substances have been suspected—albeit not always proven categorically—of being responsible for triggering cancers. They have also been accused of endocrine disruption because they contain substances like bisphenol A (BPA), which has recently been banned in France. It has also been the object of the EU-funded ENDOCEVAL project, which aims at testing new packaging that are free from bisphenol A.

The SafeFoodPack Design project goal is to build tools to help packaging manufacturers assess the diffusion risks of potentially harmful molecules, at every stage of the packaging's life; from manufacturing to final use, including transport and storage. As an example, piling up plastic cups designed to hold, for example, Chinese soup, results in putting the inked external layer in contact with the inner layer of the cup immediately underneath. As a result, ink molecules migrate towards the inner layer, which will eventually be in contact with the food. "In this case, the most critical step regarding chemical risk is with no doubt storage," Vitrac said.

The first task of the project team has been to build a database of materials used for packaging to document their molecular content. Now, they are measuring the diffusion speed of these molecules, in order to build

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## Scientists developing new software for food packaging detection in France

11 April 2013

Print Email

A new open-source software is being developed by scientists in France to detect all critical points on the food packaging lifecycle where contamination is expected to occur.

The software is based on a method used in aeronautics called failure mode effects and criticality analysis (FMECA).

A SafeFoodPackDesign project, which is underway, is coordinated by Vitrac and funded by the French National Research Agency (ANR), under which the scientists have been addressing the issue of such harmful molecules diffusing from one layer to the next in food packaging, youris.com reported.

National Institute of Agricultural Research (INRA-Agroparistech) Genial joint research unit researcher Olivier Vitrac said each of the multiple layers in plastic food packaging is made by a different manufacturer.

"Still, at the end of the chain, the food manufacturer who sells the packaged product is the sole responsible for food safety," Vitrac said.

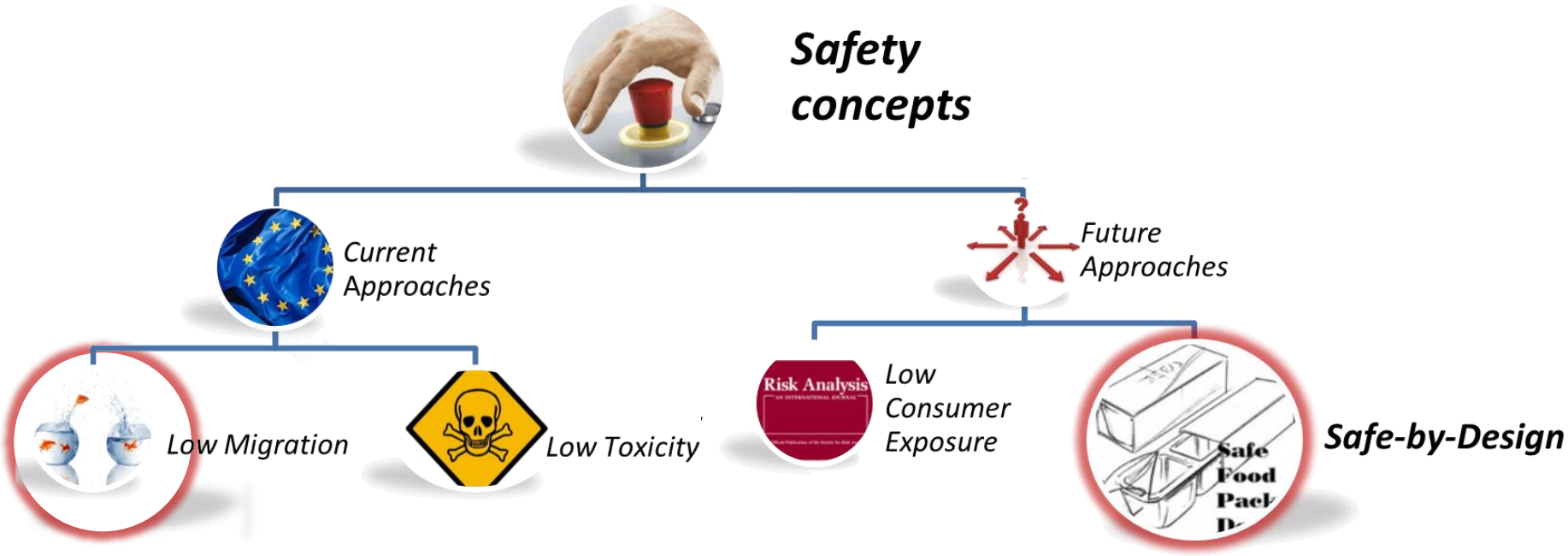
As part of the project, the scientists will build tools to help packaging manufacturers evaluate the molecules' diffusion risks, at every stage including transport and storage.

Initially, a database of materials used for packaging was built by the project team to document their molecular content, and their diffusion speed is being measured to build predictive models.

Expected to help assess the related risks, SafefoodPackDesign will provide a real increase in safety for manufacturers and consumers alike.

# TOWARDS NEW CONCEPTS

## PREVENTIVE APPROACHES OF FOOD SAFETY




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

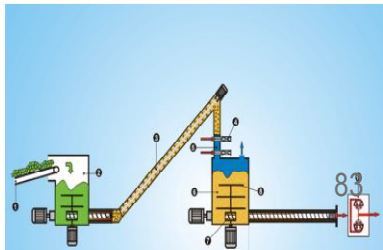
# NEW RISKS: non-authorized

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

Foodgrade HDPE milk bottles

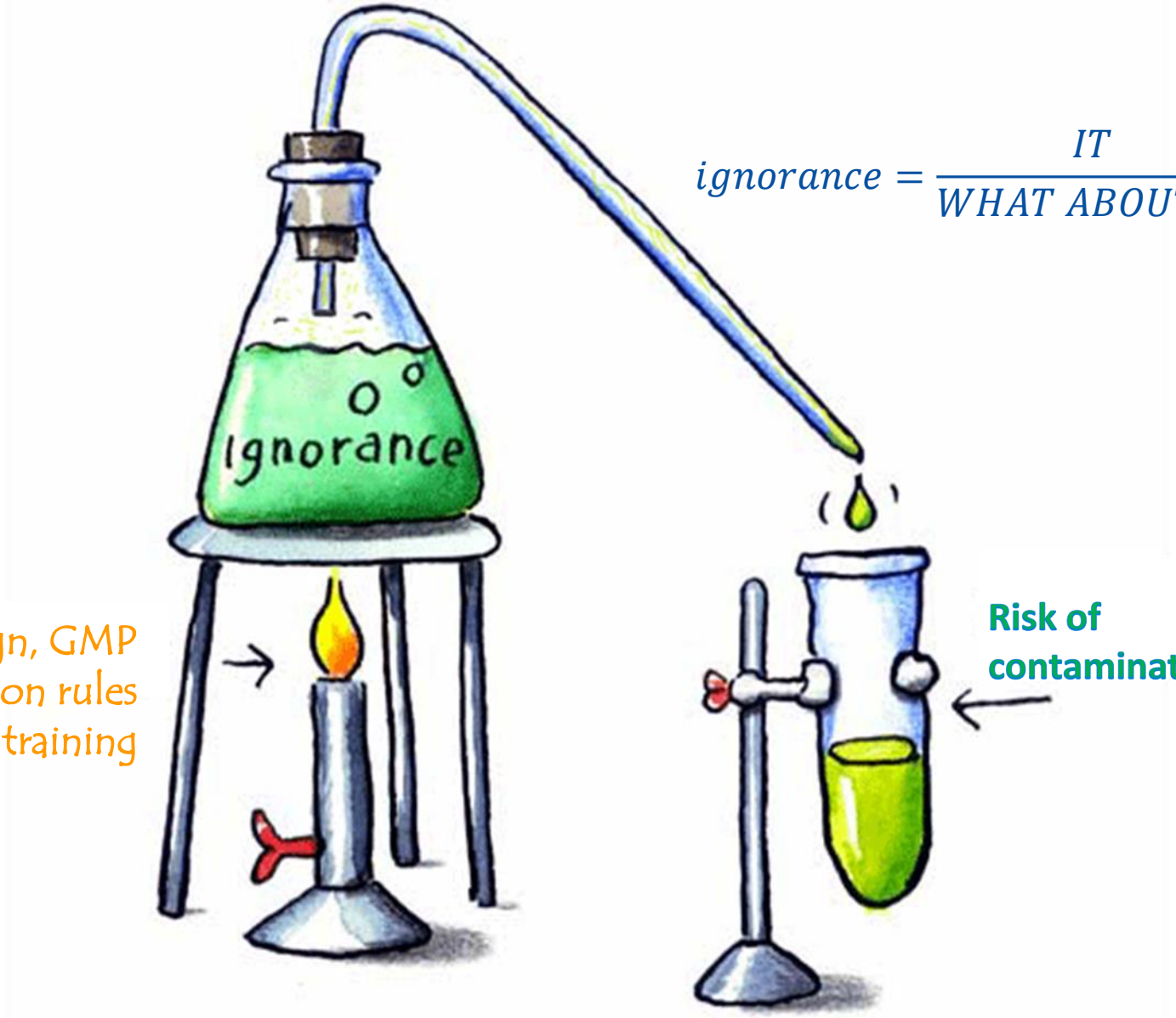
Suitable for Food Contact?

Recycling

# HUMAN RISK

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

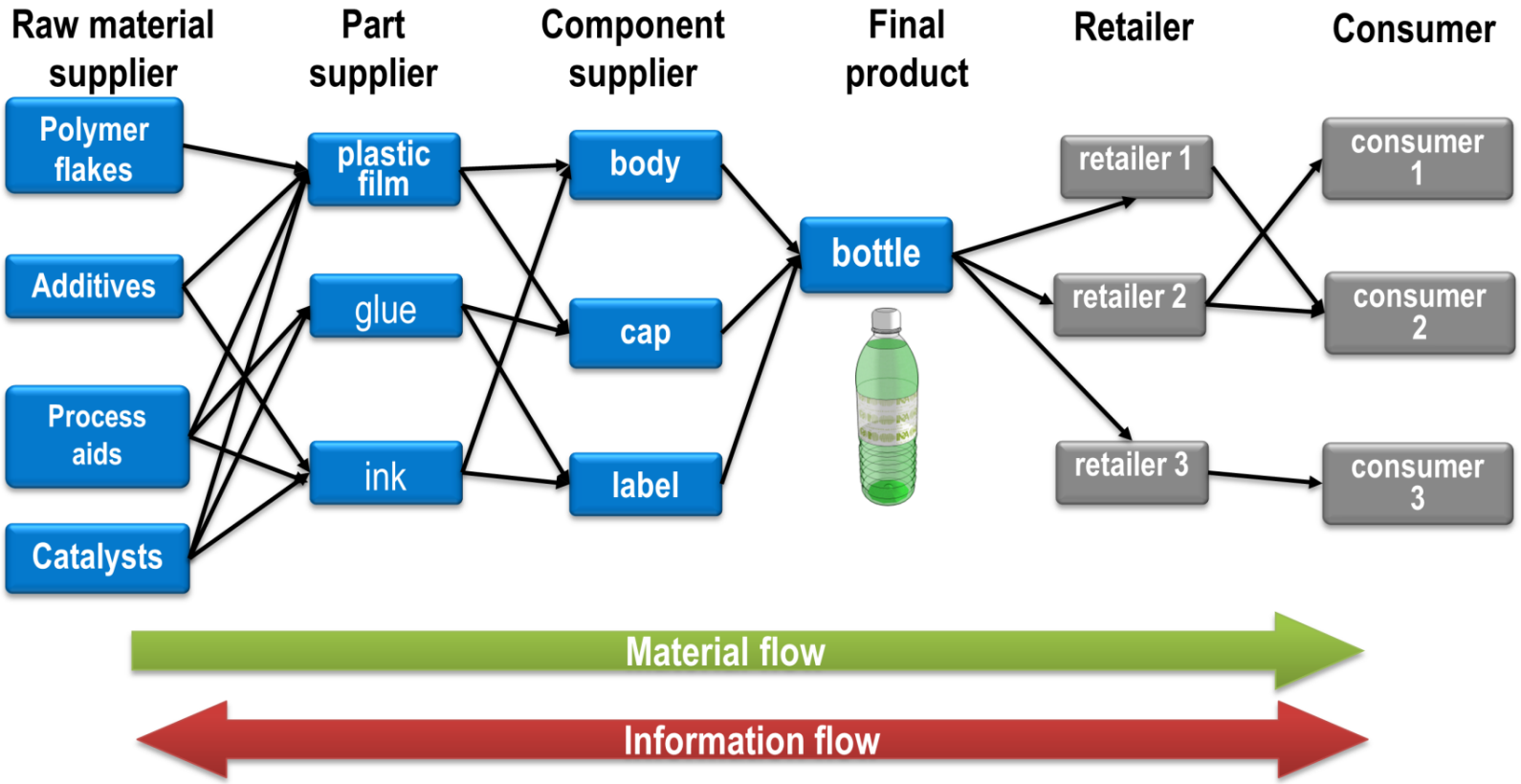



poor design, GMP
weak regulation rules
poor training

**Risk of contamination**

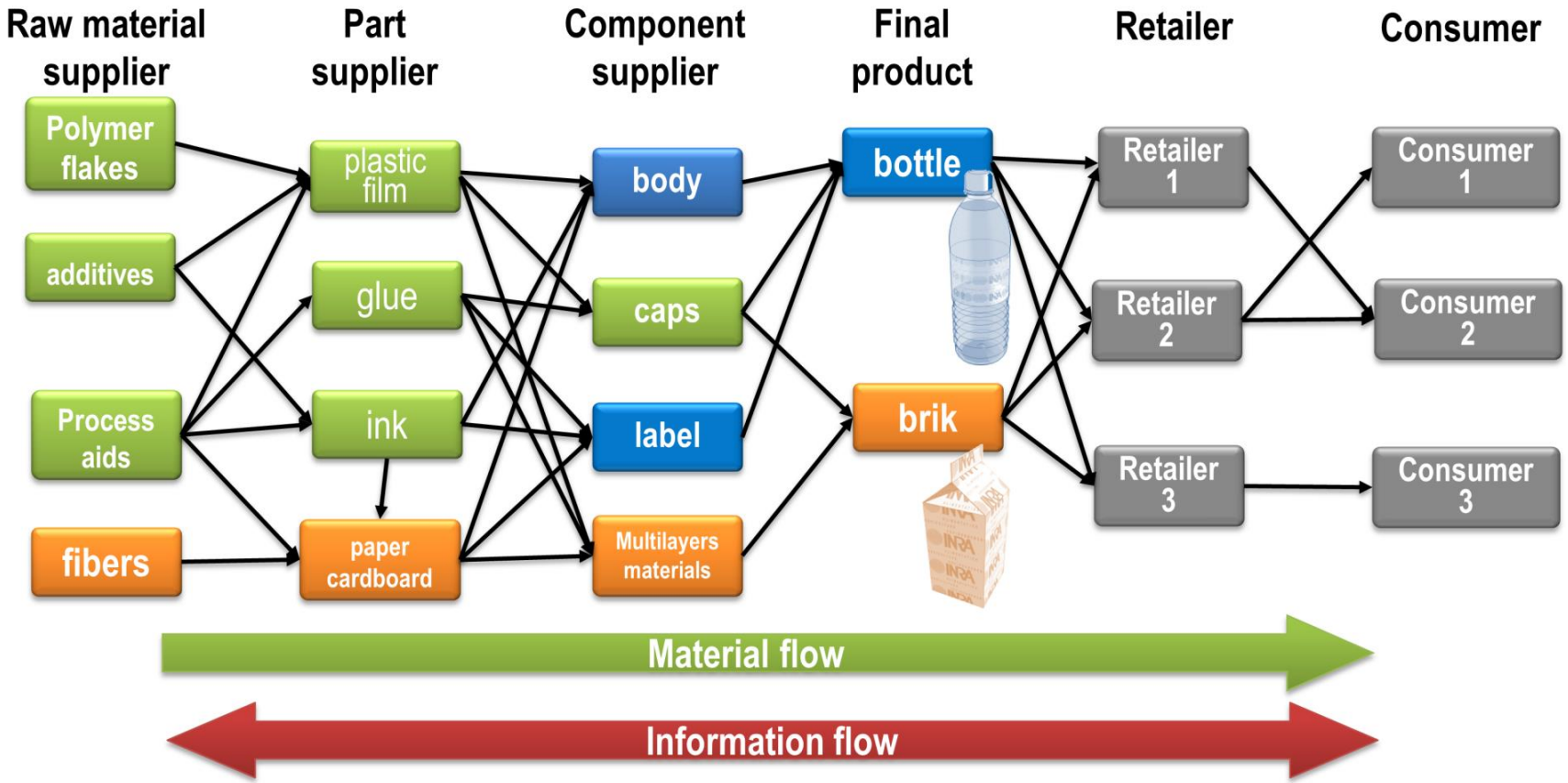

# TOWARDS NEW CONCEPTS

## DEVELOPING COOPERATION BETWEEN STAKEHOLDERS




# TOWARDS NEW CONCEPTS

## DEVELOPING COOPERATION BETWEEN STAKEHOLDERS



# MIGRATION MODELING

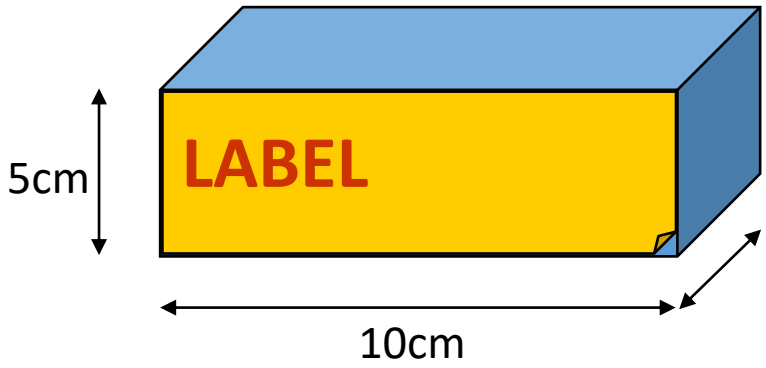
## AUTHORIZED IN EU, US, China

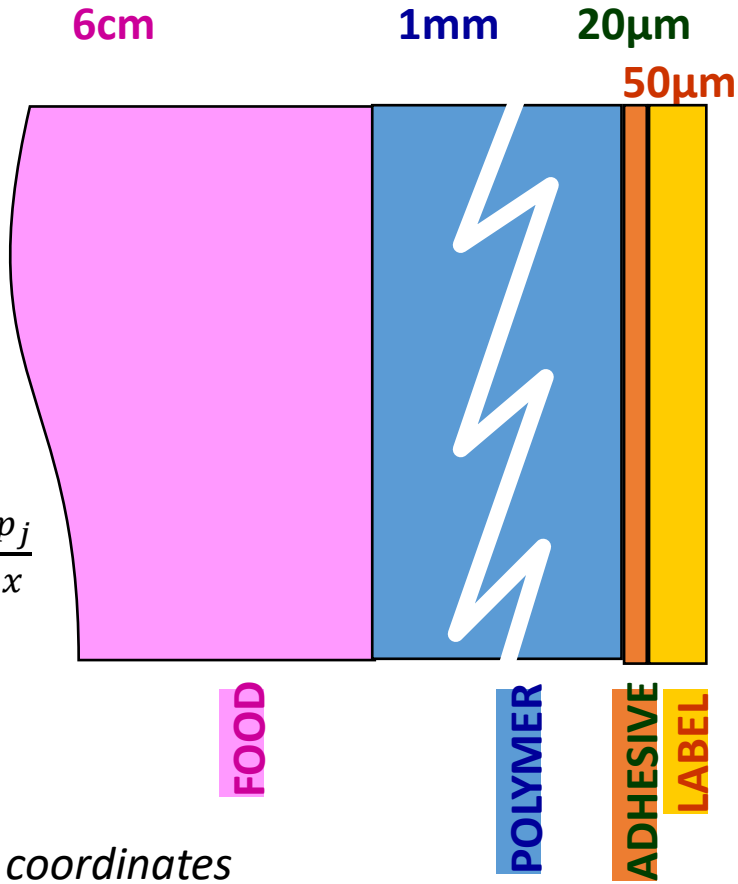
At each stage of manufacture, supporting documentation, substantiating the declaration of compliance, should be kept available for the enforcement authorities. Such demonstration of compliance may be based on migration testing. As migration testing is complex, costly and time consuming it should be admissible that compliance can be demonstrated also by calculations, including modelling, other analysis, and scientific evidence or reasoning if these render results which are at least as severe as the migration testing. Test results should be regarded as valid as long as formulations and processing conditions remain constant as part of a quality assurance system.

**To screen for specific migration the migration potential can be calculated based on the residual content of the substance in the material or article applying generally recognised diffusion models based on scientific evidence that are constructed such as to overestimate real migration.**

# MODELING EXISTS ALSO FOR

## MULTILAYERS
## ARBITRARY COORDINATE SYSTELS
## CHAINED STEPS




Henry isotherm: $p = kC$, $k$=Henry coefficient

Diffusive flux: $J_j = -D_j \cdot \rho_j \cdot \frac{\partial C_j}{\partial x} = -\frac{D_j \cdot \rho_j}{k_j} \cdot \frac{\partial p_j}{\partial x} = -\alpha_j \cdot \frac{\partial p_j}{\partial x}$

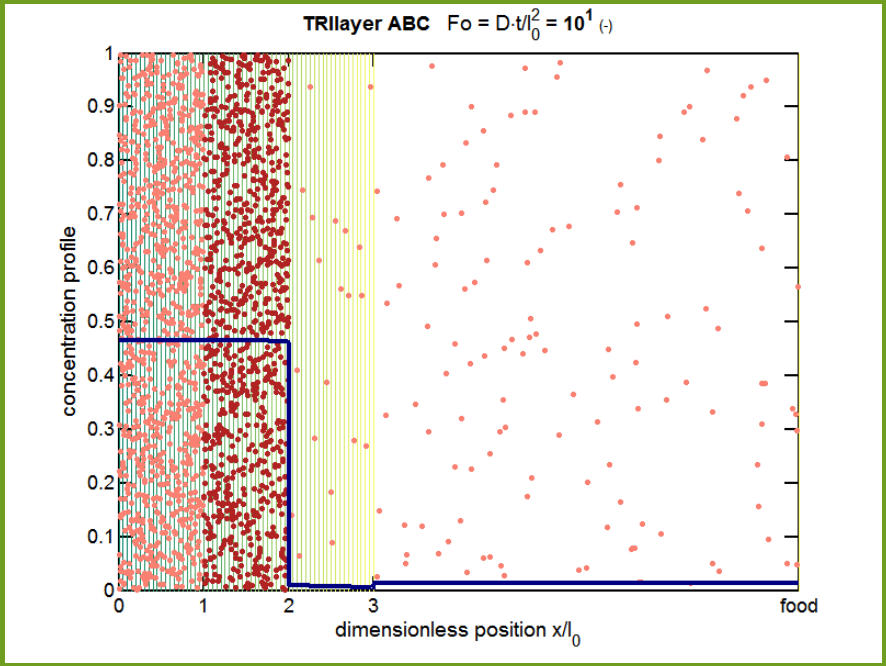
Transport equation: $\delta_j \cdot \frac{\partial p_j}{\partial t} = \frac{1}{x^m} \frac{\partial}{\partial x}\left(x^m \cdot \alpha_j \cdot \frac{\partial p_j}{\partial x}\right)$

$\alpha_j = \frac{D_j \cdot \rho_j}{k_j} = D_j \cdot \delta_j$

*cartesian ($m = 0$), cylindrical (($m = 1$), spherical ($m = 2$) coordinates*

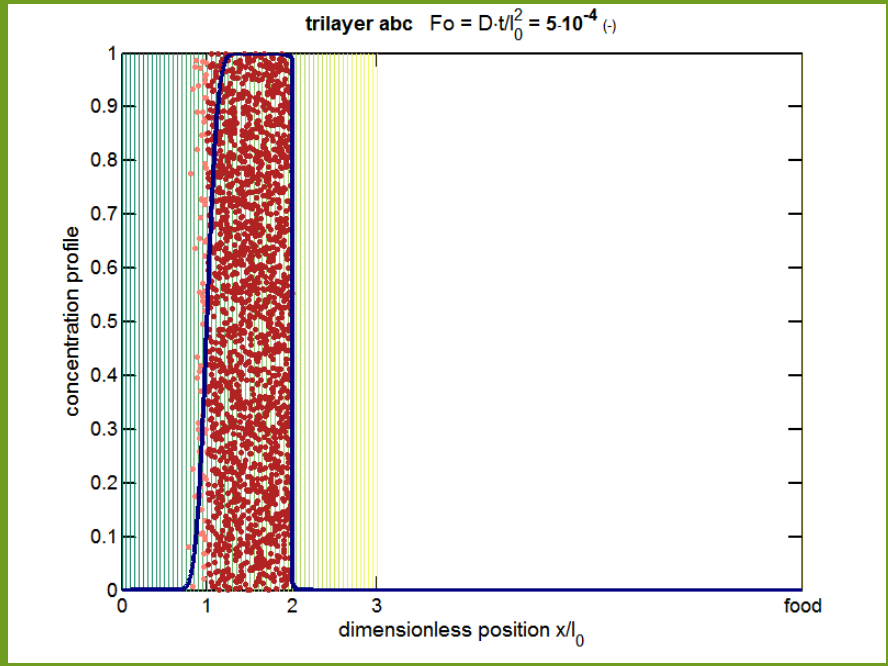
# SIMULATION OF MULTILAYER MATERIALS

## Functional barrier = barrier to diffusion + sorption




| prop | Layer 3 | Layer 2 | Layer 1 | Food |
|---|---|---|---|---|
| $C_0$ | 0 | 1 | 0 | 0 |
| $l/l_0$ | 1 | 1 | 1 | 100 |
| $D/D_0$ | 1 | 1 | 0.1 | $10^4$ |
| $k/k_0$ | 1 | 50 | 1 | 1 |

## Idem + low chemical affinity for the food

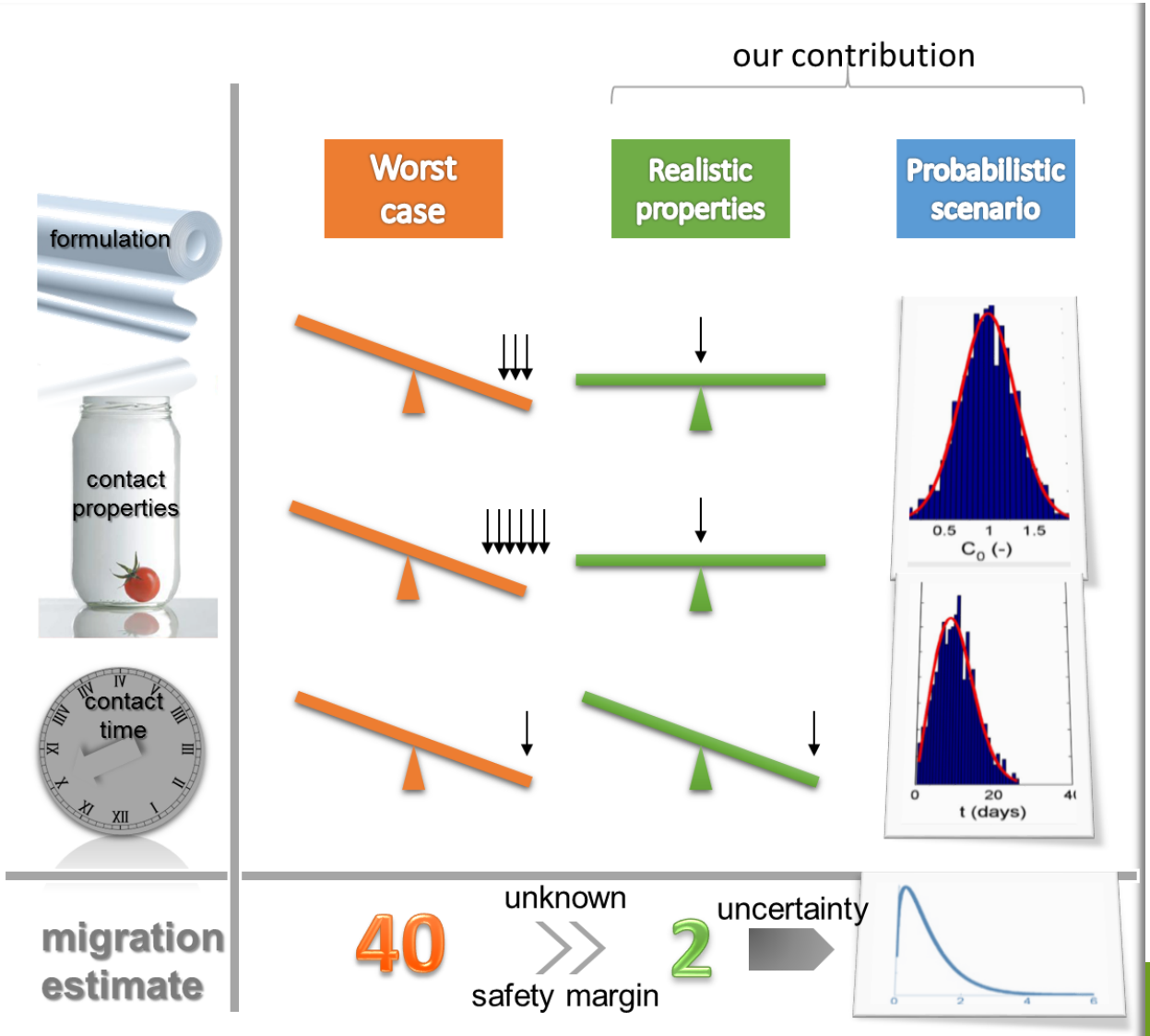


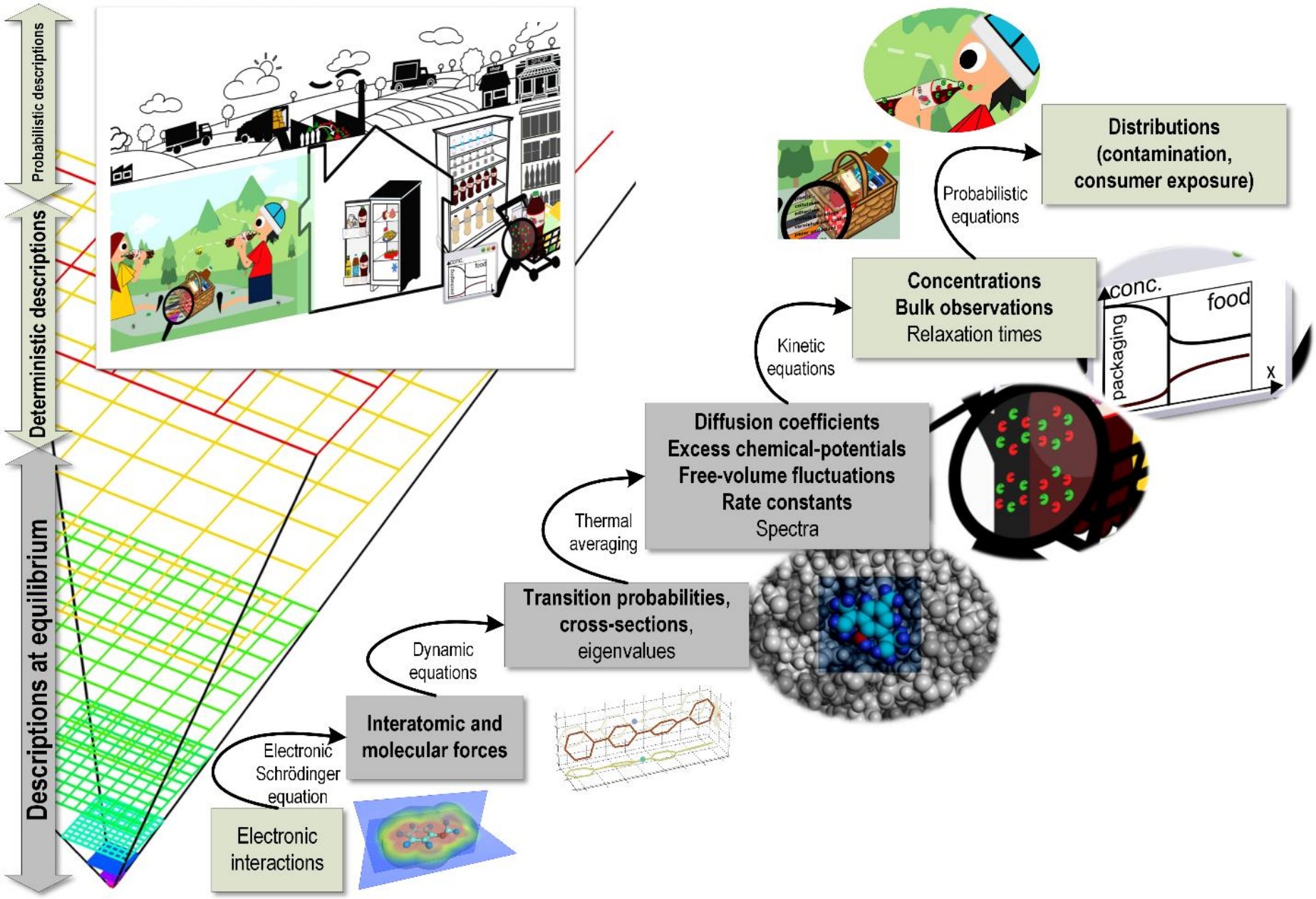

| prop | Layer 3 | Layer 2 | Layer 1 | Food |
|---|---|---|---|---|
| $C_0$ | 0 | 1 | 0 | 0 |
| $l/l_0$ | 1 | 1 | 1 | 100 |
| $D/D_0$ | 1 | 1 | 0.1 | $10^4$ |
| $k/k_0$ | 1 | 50 | 1 | 20 |

INRA SCIENCE & IMPACT

# HOW TO OVERESTIMATE MIGRATION

## MODELING CAN DEMONSTRATE COMPLIANCE BUT NOT NON-COMPLIANCE




Probabilistic descriptions
Deterministic descriptions
Descriptions at equilibrium
Distributions (contamination, consumer exposure)
Probabilistic equations
Concentrations
Bulk observations
Relaxation times
Kinetic equations
conc.
food
packaging
x
Diffusion coefficients
Excess chemical-potentials
Free-volume fluctuations
Rate constants
Spectra
Thermal averaging
Transition probabilities, cross-sections, eigenvalues
Dynamic equations
Interatomic and molecular forces
Electronic Schrödinger equation
Electronic interactions

# Méthode préventive des risques de migration


Projet « Conception raisonnée d'emballages sûrs »

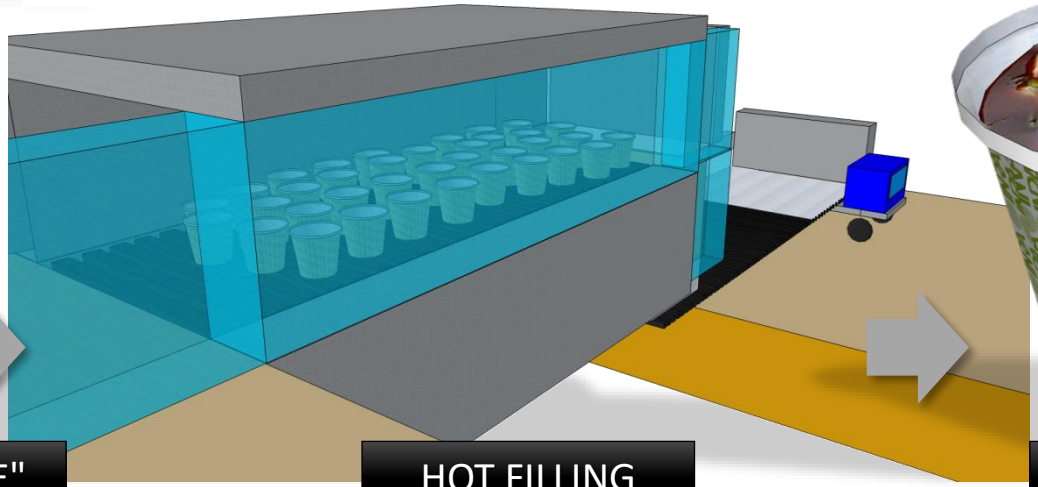
## FMECA « brique de lait infantile »

| Phase | Formulation | Design | Process | Informations | Mécanismes |
|---|---|---|---|---|---|
| |  |  |  |  |  |
| | **Formulation** | **design** | **Process** | **Informations** | **Mécanismes décrits** |
| Inventaire | • monomères (plastiques, colles)<br>• catalyseurs<br>• antioxydants<br>• lubrifiants<br>• biocides (carton, encre)<br>• huiles minérales (carton)<br>• solvants<br>• photoinitiateurs<br>• autres résidus (NIAS) | **Deux composants** :<br>• corps de la brique (4 matériaux, 5 couches)<br>• bouchon (1 matériau)<br>**Six matériaux**<br>• LDPE, PP (bouchon)<br>• feuille d'aluminium<br>• carton (origine)<br>• « colles »<br>• « encre » | • production, stockage, assemblage des matériaux<br>• assemblage et stockage des composants<br>• impression des films<br>• stockage des emballages vides<br>• conditionnement aseptique<br>• stockage et distribution des briques de lait<br>• utilisation finale de la brique: réfrigérée, ambiant, réchauffé?<br>• mode de consommation (boire au goulot) | • identité et nature des **matériaux** au sein des assemblages<br>• éléments de **formulation** des matériaux (substances règlementées spécifiquement ou non)<br>• **conditions utilisées** pour tester le risque de contamination<br>• **conditions de préparation, conditionnement, stockage, consommation** de l'aliment emballé<br>• communication des **éléments de modification** de la formulation du design, du process et de l'utilisation finale | • diffusion à travers des couches<br>• décalque<br>• contamination croisée avec d'autres matériaux ou avec l'ambiance de stockage |
| Hiérarchisation | **Fortement concentrée**<br>• antioxydants, lubrifiants, biocides<br>• huiles minérales, photoinitiateurs<br>• monomères, catalyseurs, solvants<br>• autres résidus | **Matériau barrière**<br>• feuille d'aluminium<br>**Matériaux réservoir de contaminants de faibles masses**<br>• encre<br>• colle<br>**Matériaux réservoir de contaminants de fortes masses**<br>• PP, LDPE<br>• carton | **Etapes associées à des temps longs**<br>• stockage des matériaux<br>• stockage des composants<br>• stockage des produits finis<br>**Etapes associées à des températures élevées**<br>• conditionnement aseptique<br>• Réchauffage<br>**Étapes pouvant induire à des contaminations croisées**<br>• stockage<br>• impression<br>• collage / assemblage | • **information non-documentée** ou manquante<br>• **information accessible**<br>• **information documentée** qui accompagne le composant ou le matériau<br>• **information vérifiable** et/ou auditable<br>• **fréquence de mise à jour** des informations : régulière, à l'occasion de changement, uniquement à la conception ou à l'achat,... | • transferts qui peuvent être **évalués rapidement par le calcul** : en provenance ou au travers LDPE, PP<br>• transferts qui requièrent des **essais expérimentaux** simples : décalque<br>• transferts qui requièrent une **expertise approfondie** : contamination croisée, vieillissement |

# MODELING EXISTS ALSO FOR

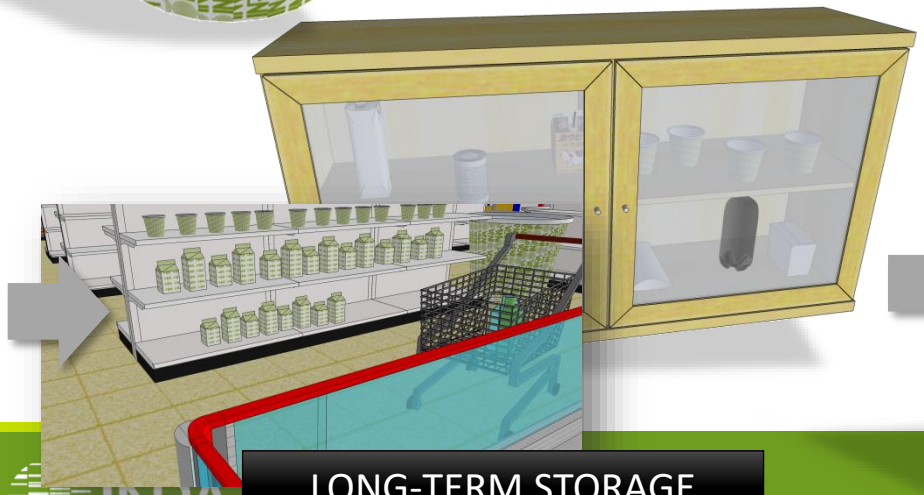
## CHAINED STEPS

STORAGE "BEFORE USE"



HOT FILLING

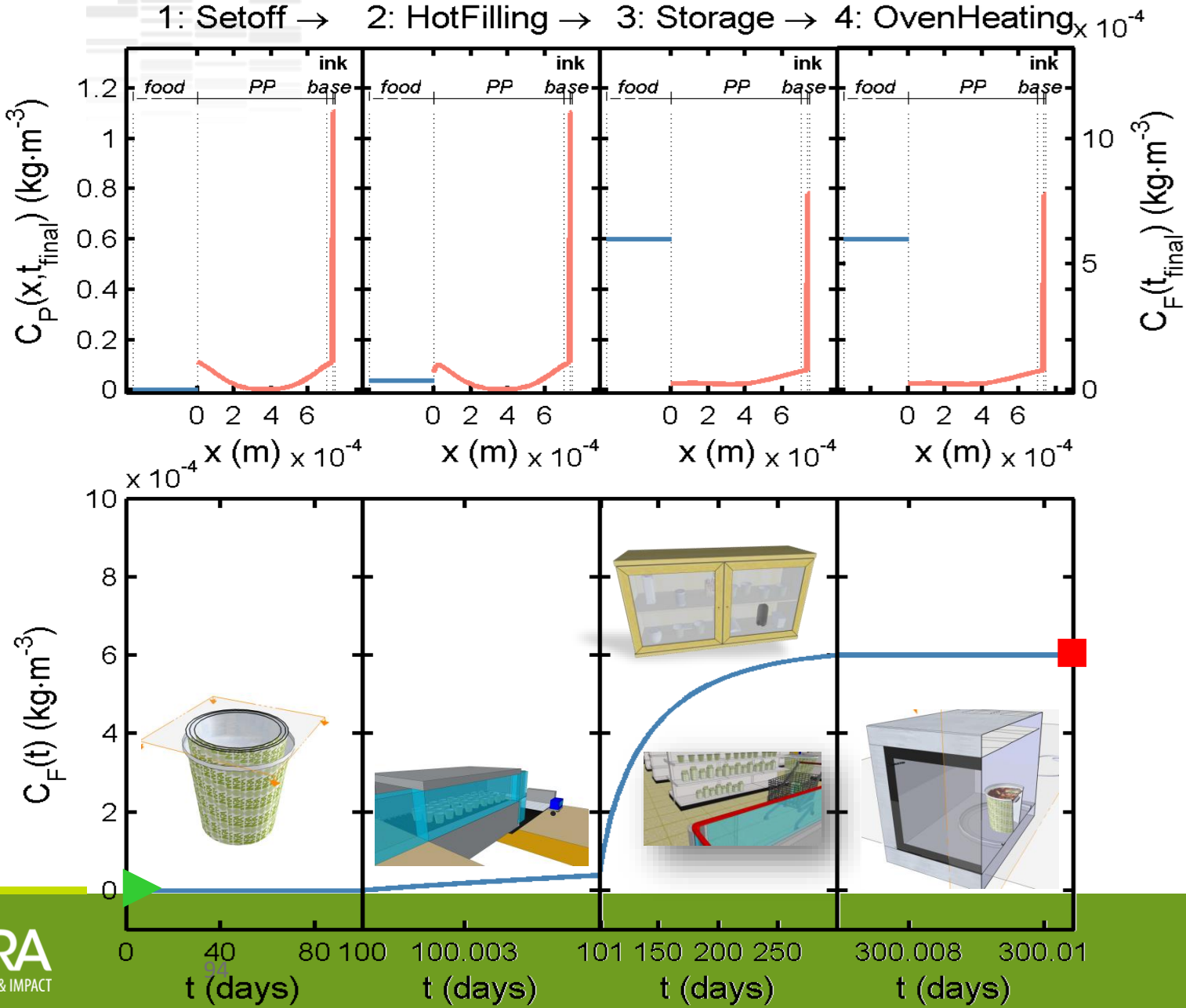
FATTY CONTACT



LONG-TERM STORAGE

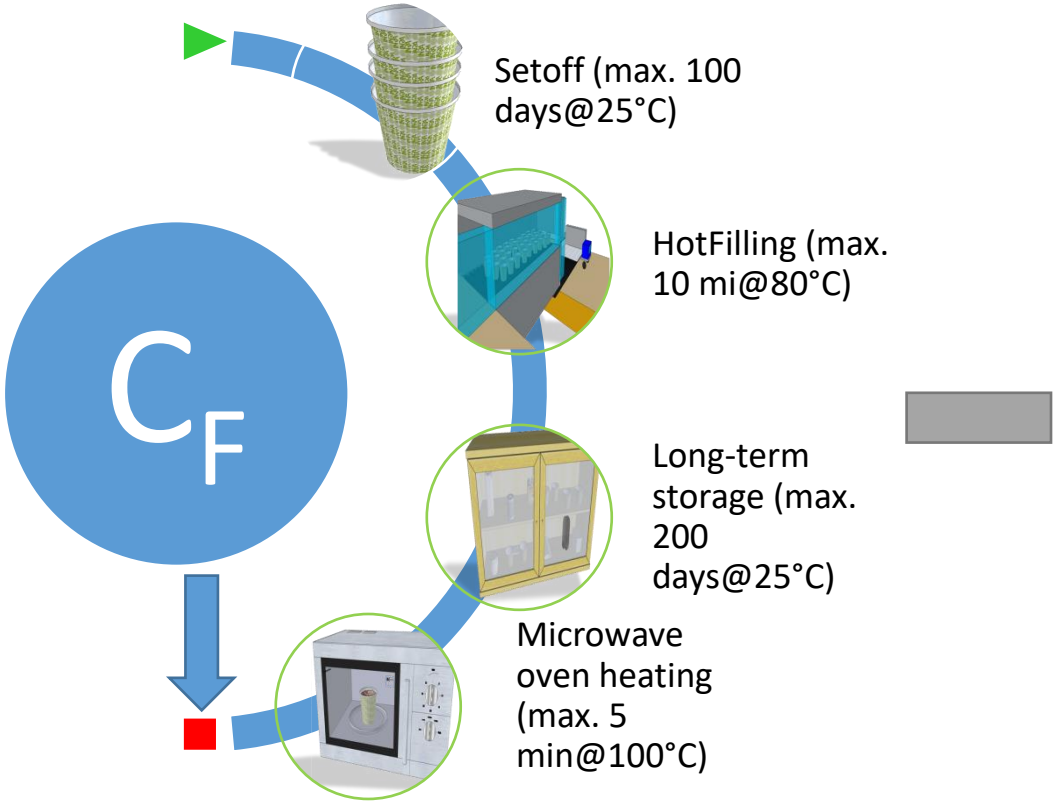
MICROWAVE OVEN HEATING

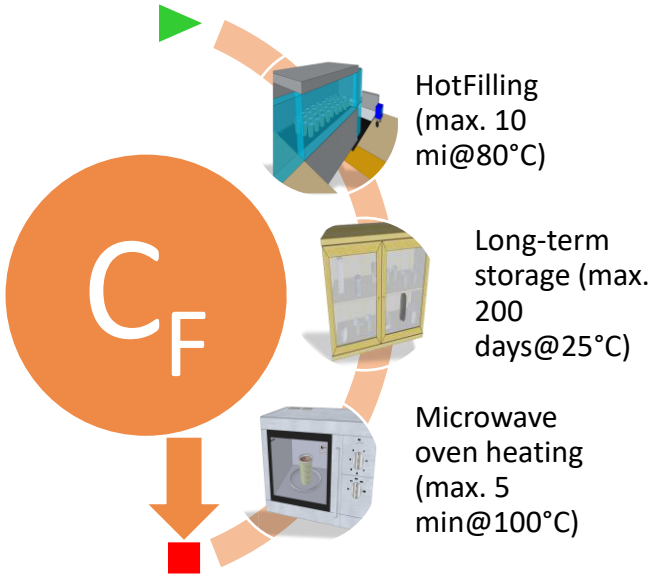
# CHAINED STEPS



# ASSESSING THE SEVERITY OF A SINGLE STEP

## CASE OF "SETOFF" STEP



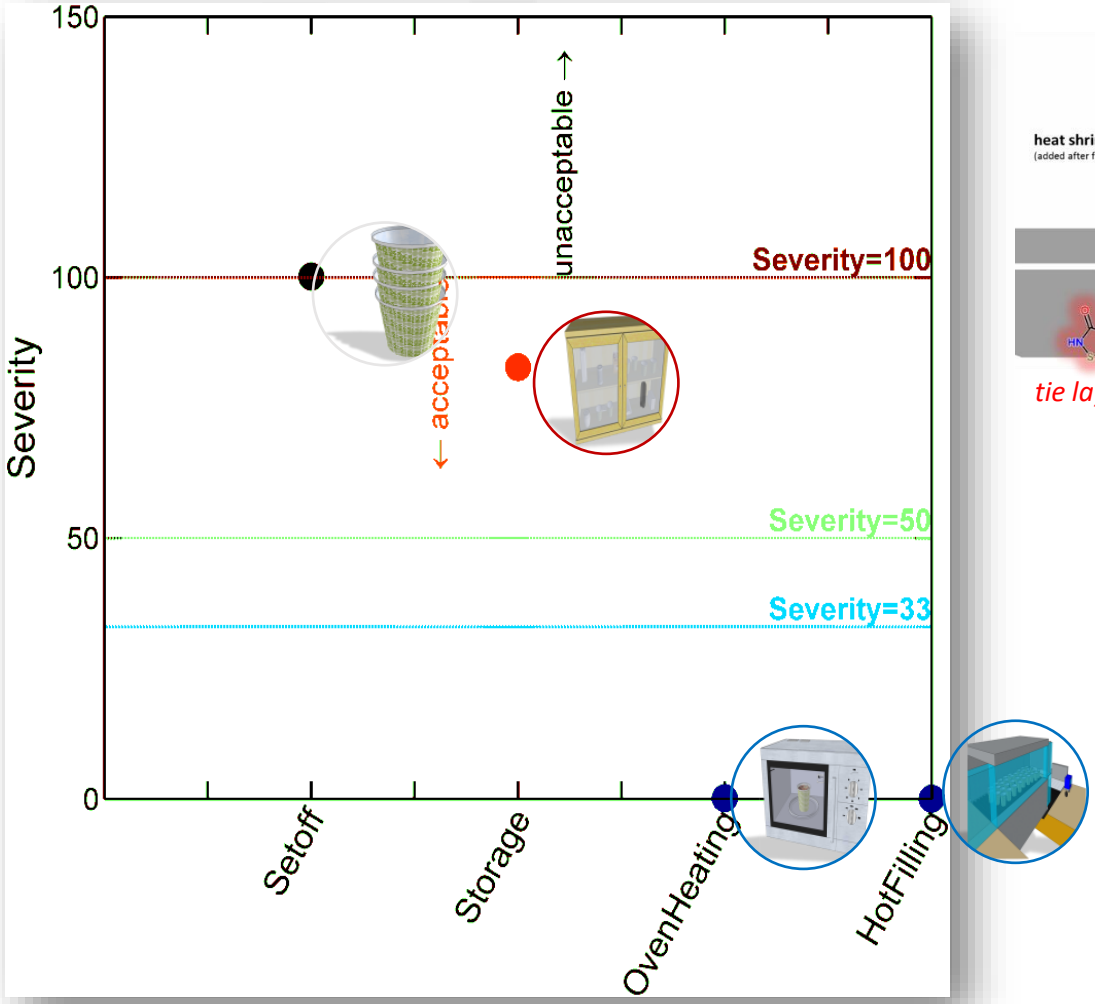



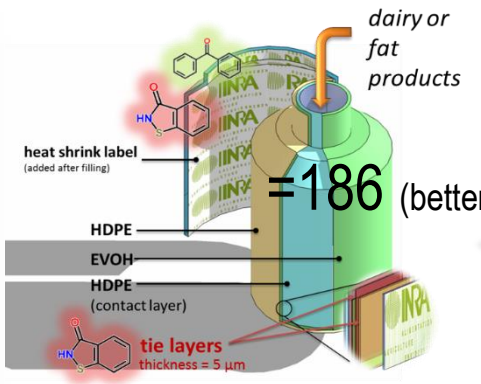

Full methodology described in *AIChE J.* 2013, **59**(4), 1183-1212

$$\text{Severity}\left(\hat{C}_F\left(\text{step}\,i\right)\right) = f\left[\max\left(\underbrace{C_{F_M}\big|_{1\to 2\to\cdots\to M} - C_{F_M}\big|_{1\to 2\to\cdots\to M/i}}_{\text{comparison with step } i \text{ removed}},\ \underbrace{C_{F_i}\big|_i}_{\text{step } i \text{ alone}}\right)\right]$$

# COMPARING THE SEVERITY OF A SEVERAL STEPS, PACKAGING DESIGNS, SUBSTANCES…

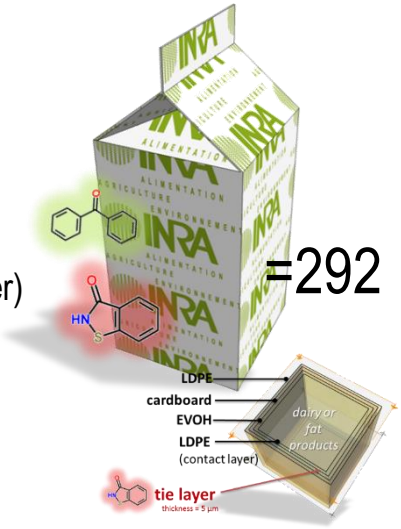
## CASE OF "SETOFF" STEP



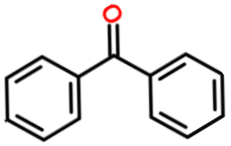




=186 (better)

*tie layer = EVA*




=292



=115
(almost acceptable)

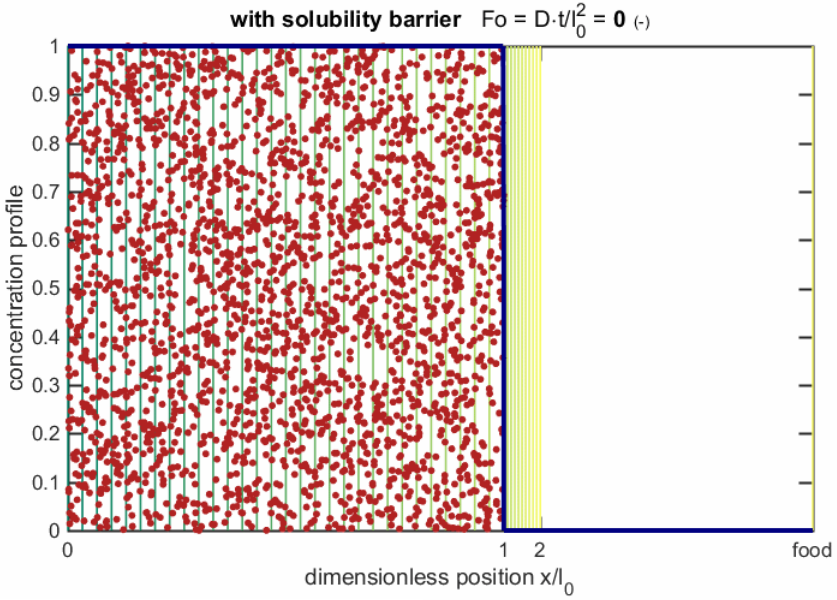

=124

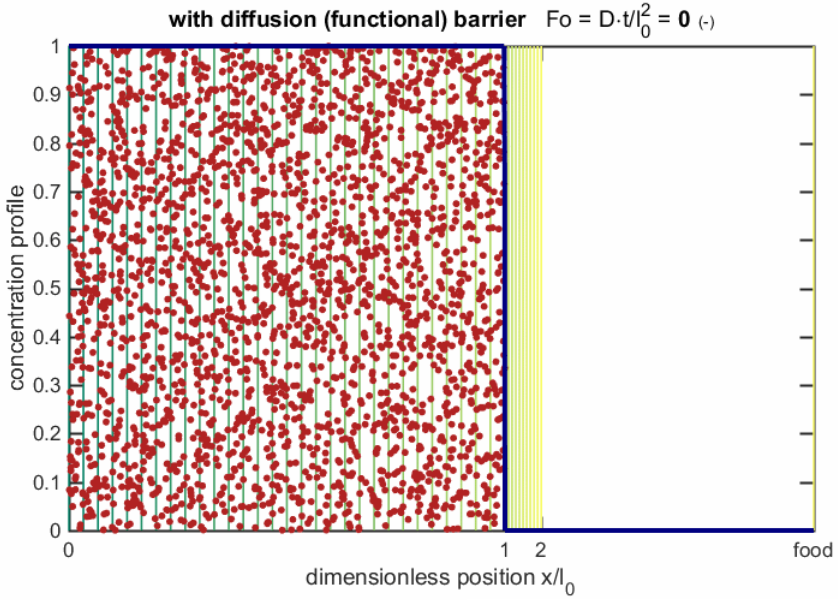


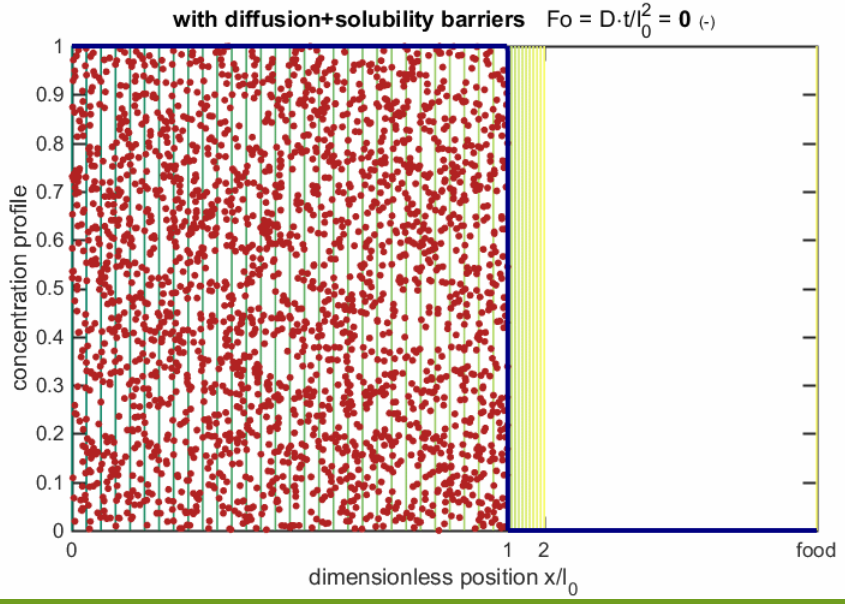
Full methodology described in *AIChE J.* 2013, **59**(4), 1183-1212

# DIFFUSION BARRIERS

## SOLUBILITY VS DIFFUSIONAL BARRIER

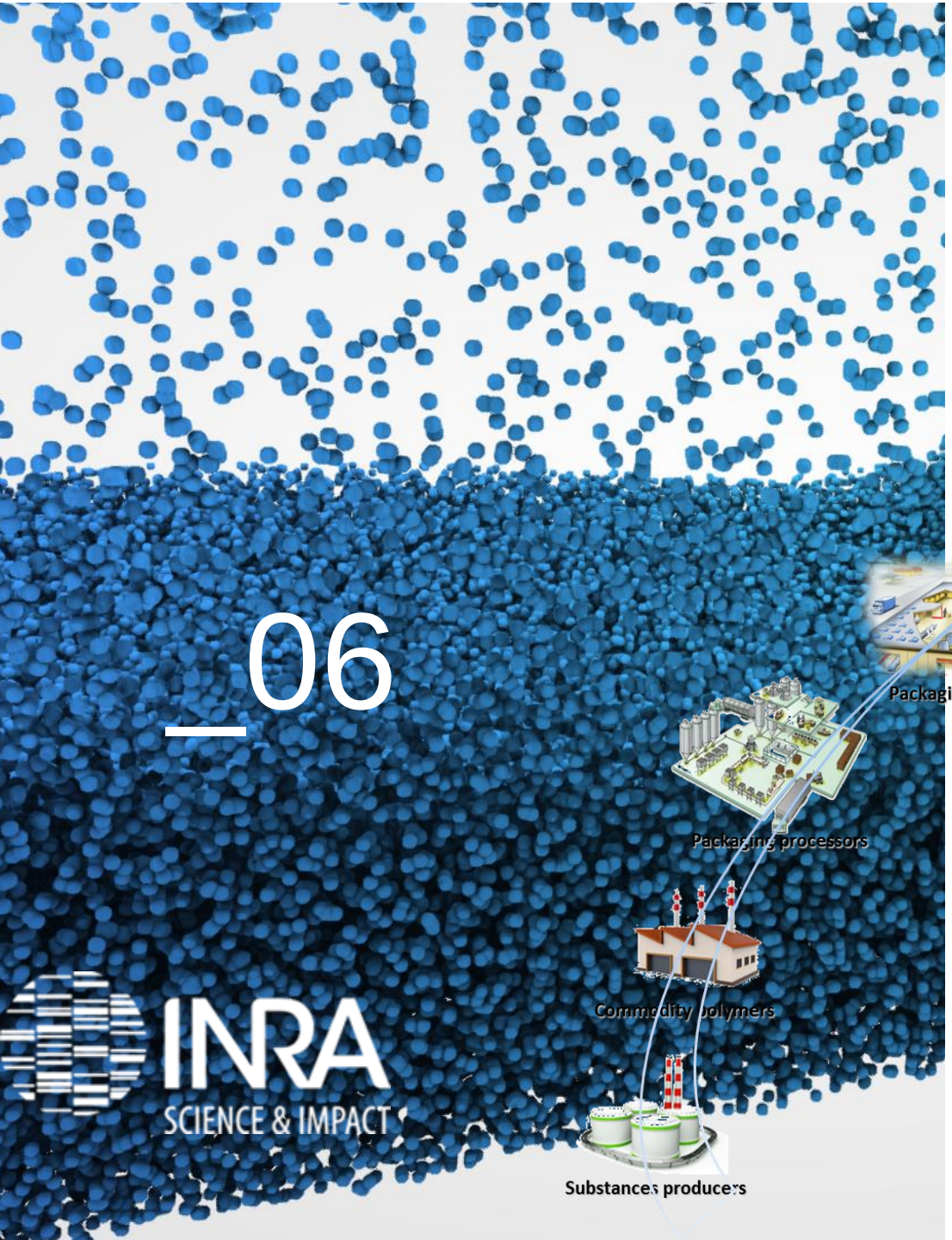


# POUR APPROFONDIR

_06

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COURS

LOGICIELS

BASES DE DONNEES

ARBRES DE DECISION

# RISK ASSESSMENT

https://www.youtube.com/watch?v=7LMnc4czpuY


| Your role | Scientifc risk assessment | Risk balancing<br>Conflict Evaluative | Risk Tradeoff<br>Conflicts<br>cognitive, evaluative, normative |
|---|---|---|---|
| Routine | Conflict: cognitive | Targets: BfR, anses, Istituto Superiore di Sanità, Food Standards Agency, efsa 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** |

# MASS TRANSPORT IN/TROUGH FOOD PACKAGING

## Advanced lectures given at the Michigan State University (MI, USA)

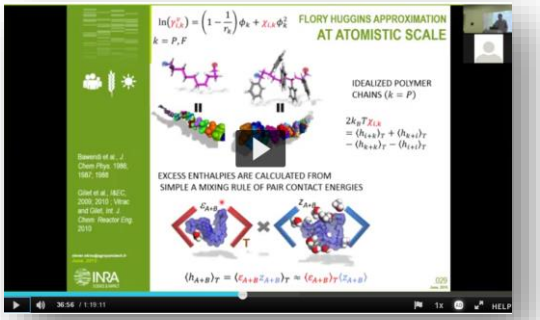
THE SCHOOL OF PACKAGING
MICHIGAN STATE UNIVERSITY

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+migrationA+beyond+conventional+estimates*/1_won1m7aw

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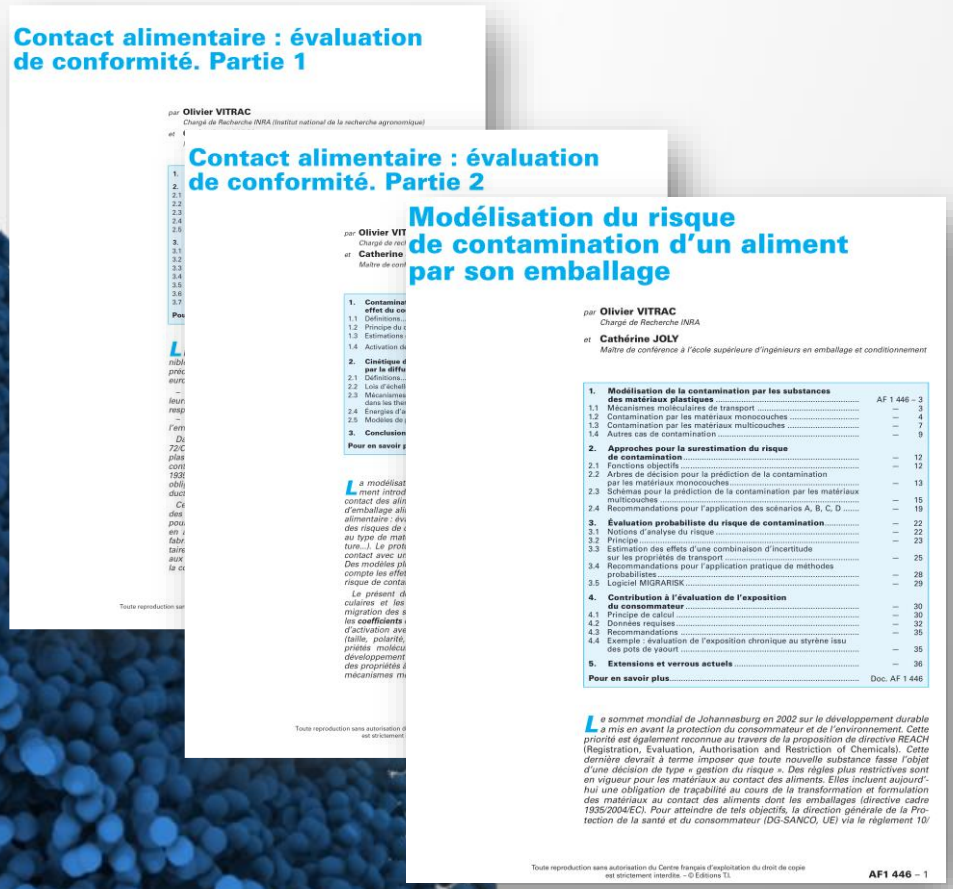
# ARTICLES IN TECHNIQUES DE L'INGENIEUR

- Vitrac O, Joly C. *Modélisation du risque de contamination d'un aliment par son emballage*. Techniques de l'ingénieur Applications des mathématiques. Vol. base documentaire : **TIB102DUO**: Editions T.I.; 2011.
- Vitrac O, Joly C. *Contact alimentaire : évaluation de conformité. Partie 2*. Techniques de l'ingénieur Chimie des milieux complexes. Vol. base documentaire : **TIB529DUO:** Editions T.I.; 2009.
- Vitrac O, Joly C. *Contact alimentaire : évaluation de conformité*. Partie 1. Techniques de l'ingénieur Chimie des milieux complexes. Vol. base documentaire : **TIB529DUO**: Editions T.I.; 2008.
-

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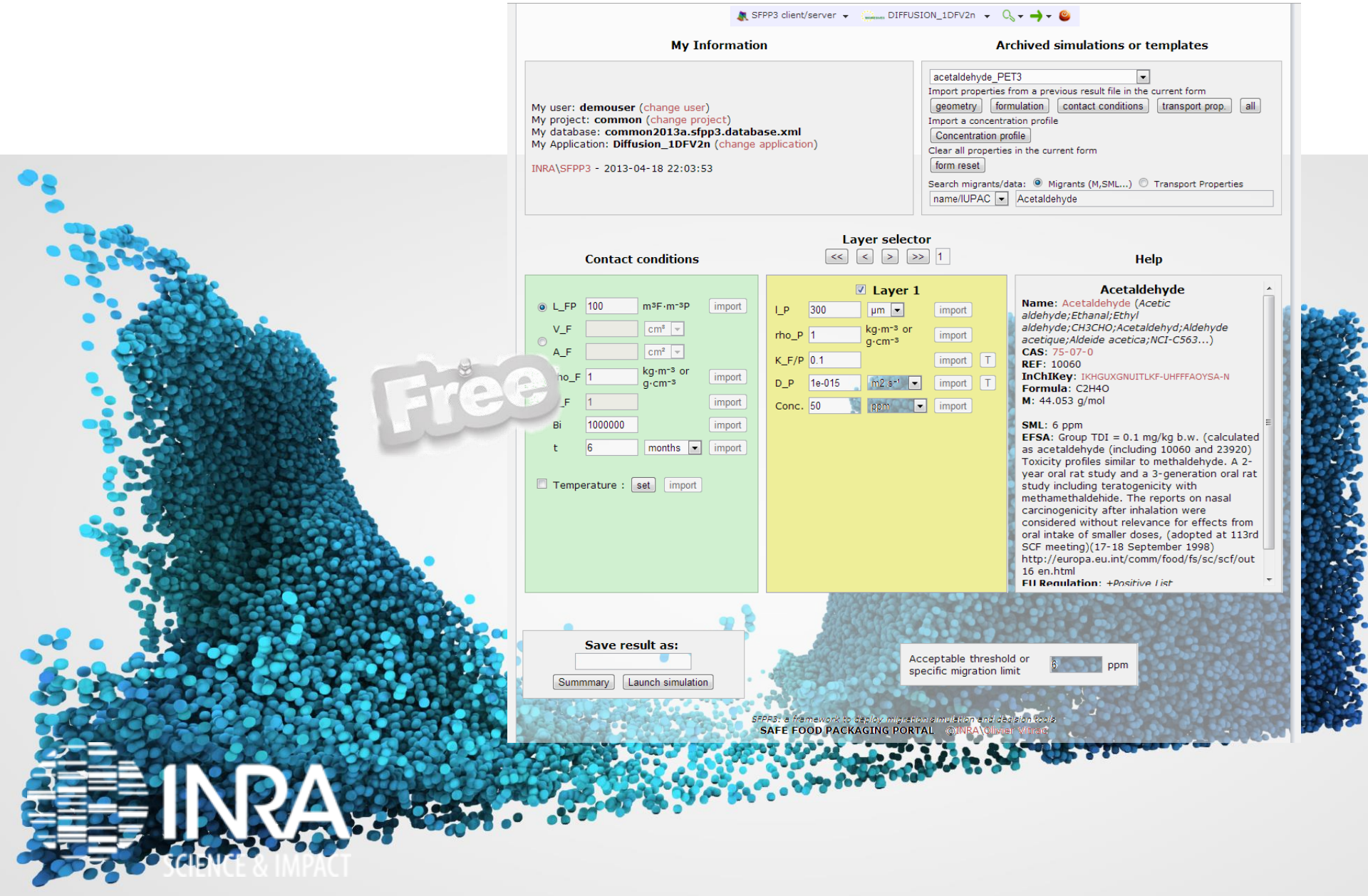
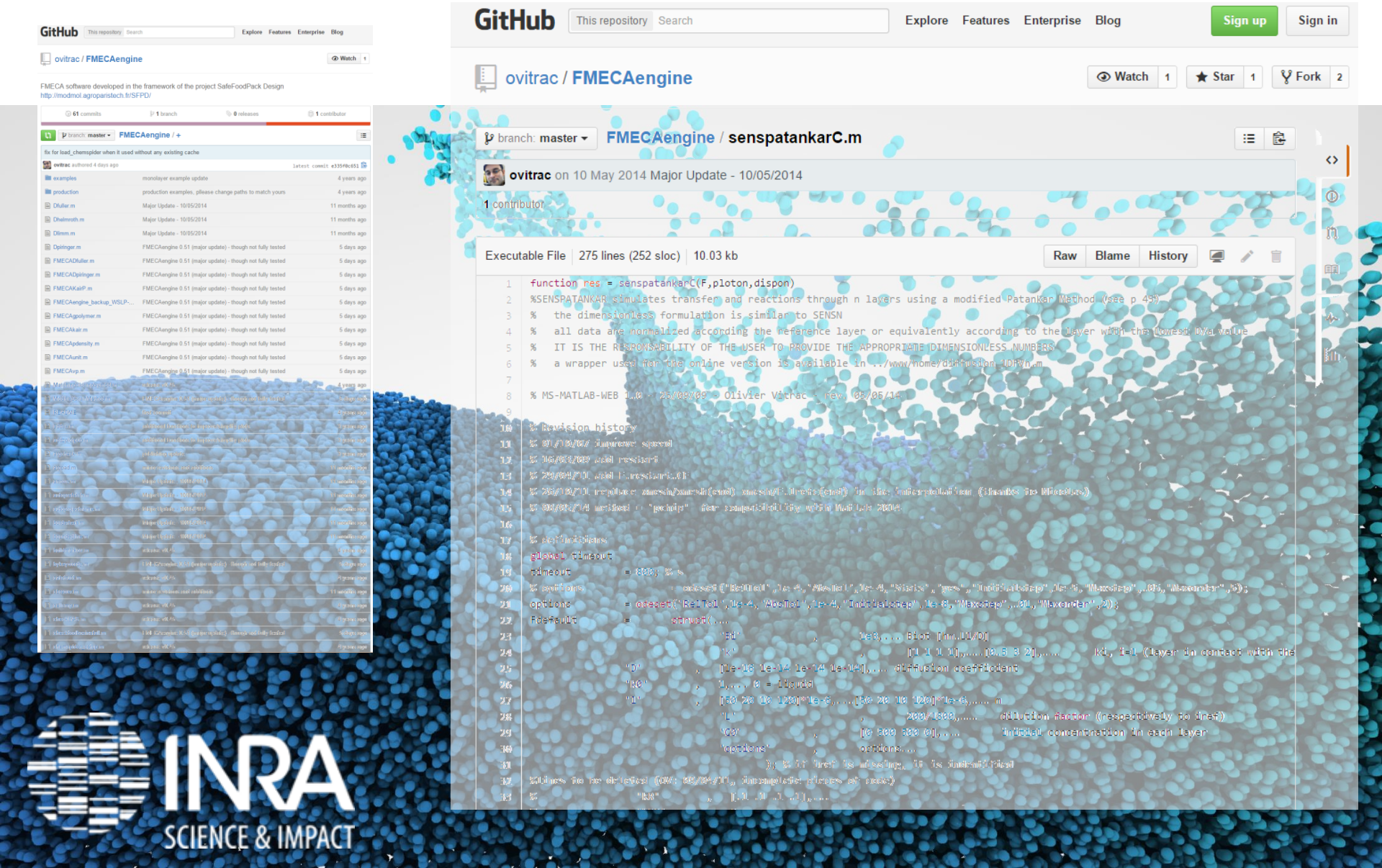
# SAFEFOODPACKAGING PORTAL

http://modmol.agroparistech.fr



# OPEN-SOURCE CODES

https://github.com/ovitrac/FMECAengine

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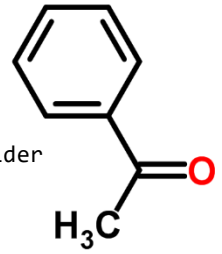
# Les outils

| OUTILS | Exemples | Avantages et limites |
|---|---|---|
| **Les inventaires** | Substances (identité, toxicologie, substances)<br>Matériaux<br>Modes de fabrication/stockage/utilisation<br>Les modes de transformation et conservation, utilisation des aliments emballés | Construits sur une base volontaire, toujours incomplets au démarrage, ils peuvent facilement être enrichis.<br>Les données sont souvent hétérogènes et incomplètes |
| **Les diagrammes** | Diagramme Fault Tree (DFT)<br>Diagramme Ishikawa (DI)<br>Diagramme de conception de l'emballage (DCE)<br>Diagramme des voies de transferts (DVT) | Simples à mettre en œuvre, intuitifs, visuels, incrémentables.<br>Ils ne sont pas uniques et pas toujours standardisés. |
| **La modélisation** | Des outils multiples | Requiert un apprentissage |
| **Les centres techniques** | centres ACTIA, RMT ProPackFood | Services mais dans une logique de prestations |
| **Des nouveaux outils** | En cours de développement ou de transfert | Requiert une expertise avancée car ils sont liés à des bases de données |

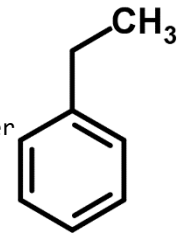
# HOW DO WE MANAGE VOLATILE SUBSTANCES?

## IMPLEMENTED METHODS

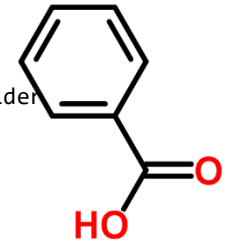
```
>> FMECAKairP acetophenone
LOAD_CHEMSPIDER          extraction of ChemSpiderID=7132 ('acetophenone') completed in 10.26 s
LOAD_CHEMISPIDER: updated cache
             7132.mat      21-sept.-2015 21:37:19      77.6 kBytes   C:\Data\Olivier\INRA\Codes\MS\cache.ChemSpider
CHEMSPIDER reuses cached data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

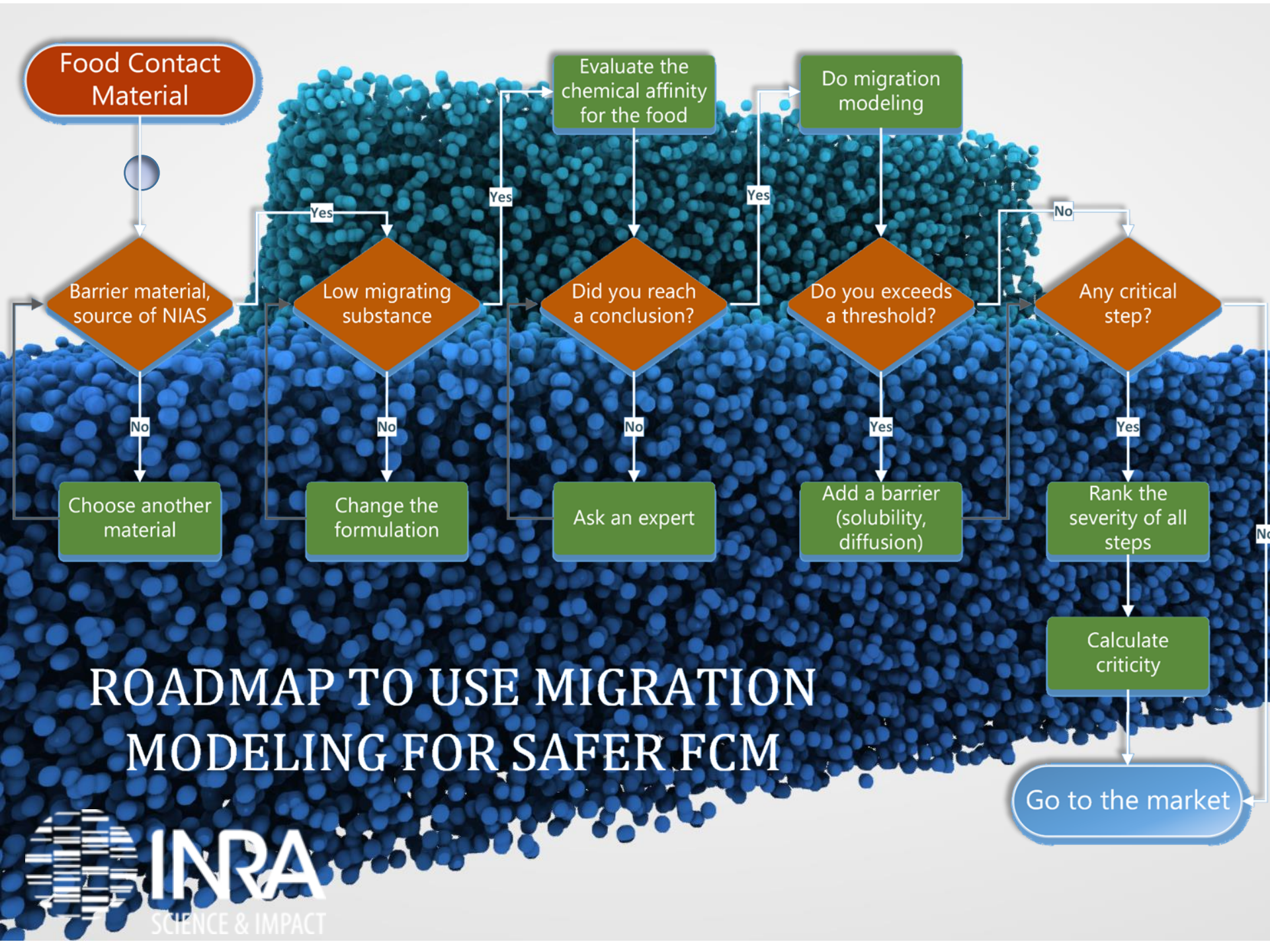



```
>> FMECAKairP ethylbenzene
LOAD_CHEMSPIDER          extraction of ChemSpiderID=7219 ('ethylbenzene') completed in 11.9 s
LOAD_CHEMISPIDER: updated cache
             7219.mat      21-sept.-2015 21:42:34      107.1 kBytes   C:\Data\Olivier\INRA\Codes\MS\cache.ChemSpider
CHEMSPIDER reuses cached data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




Food Contact Material
Barrier material, source of NIAS
Yes
No
Choose another material
Low migrating substance
Yes
No
Change the formulation
Evaluate the chemical affinity for the food
Yes
Did you reach a conclusion?
No
Ask an expert
Do migration modeling
Yes
Do you exceeds a threshold?
Yes
Add a barrier (solubility, diffusion)
No
Any critical step?
Yes
Rank the severity of all steps
Calculate criticity
Go to the market
ROADMAP TO USE MIGRATION MODELING FOR SAFER FCM
INRA
SCIENCE & IMPACT