CARREFOURS DE L'INNOVATION AGRONOMIQUE

La conception d'emballages sûrs est à portée de main

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UMR 1145 Ingénierie Procédés Aliments
Equipe Interactions Matériaux et Milieux au Contact
UMT SafeMat « Matériaux Sûrs »
AgroParisTech site de Massy

UMT SAFEMAT MATÉRIAUX AU CONTACT DES ALIMENTS

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Anatomie d'une crise

Les solutions (1..7)

Conclusions

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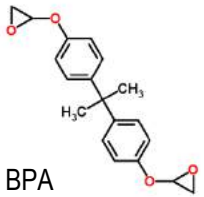
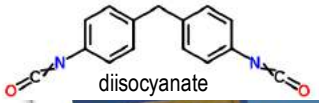
SAFEMAT


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


BPA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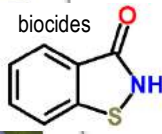
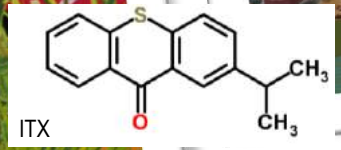
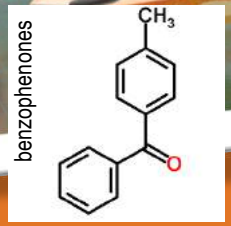
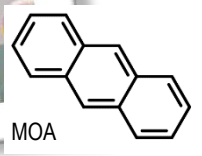

biocides


ITX


benzophenones


MOA


Is it safe?
How to assess it?
How to grant it?
OPEN
INRA

L'ART DE CONSERVER.

PENDANT PLUSI

TOUTES LES SUBSTANCES AN

OUVRAGE soumis au Bureau
Manufactures, revêtu de s
sur l'invitation de S. Exc.

PAR API

Propriétaire à Massy, Depar
ancien Confiseur et Distillat
la Maison ducale de Christi

» un témoign
» du Gouver

A PA

CHEZ PATRIS ET Cie IMPR
NAPOLÉON, AU COIN DE LA RU

18

8me ANNÉE. — N° 49 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

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

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

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 réglements qui ré-

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 fraîches qui est soumise à un groupe de savants et de vétérinaires de valeur.

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

« Le règlement en date de 1908 qui régit l'inspection des conserves alimentaires nous dit : *Aucune substance alimentaire ne doit contenir de produit nuisible, produits chimiques, colorants ou antiseptiques*, et plus loin on nous dit : *Il sera fourni aux Inspecteurs par les soins du Ministère de l'Agriculture les noms des antiseptiques et colorants inoffensifs dont l'emploi est permis. L'addition de tout autre empêchera le produit de recevoir l'étiquette constatant l'inspection.*

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

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

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

« Que si quelques antiseptiques sont considérés comme inoffensifs par le Ministère de l'Agriculture, pourquoi ne pas faire connaître

ement 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-

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.

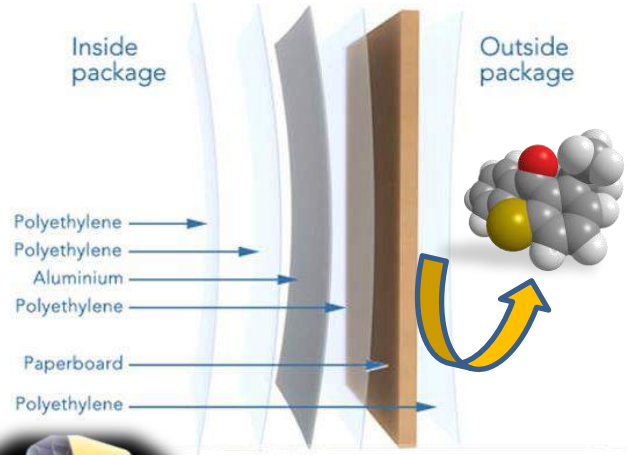
Nestle said the chemical substance was not harmful, but announced it was recalling the infant food in four European countries, including Italy, because of the problem, which related to Tetra Pak cartons.

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

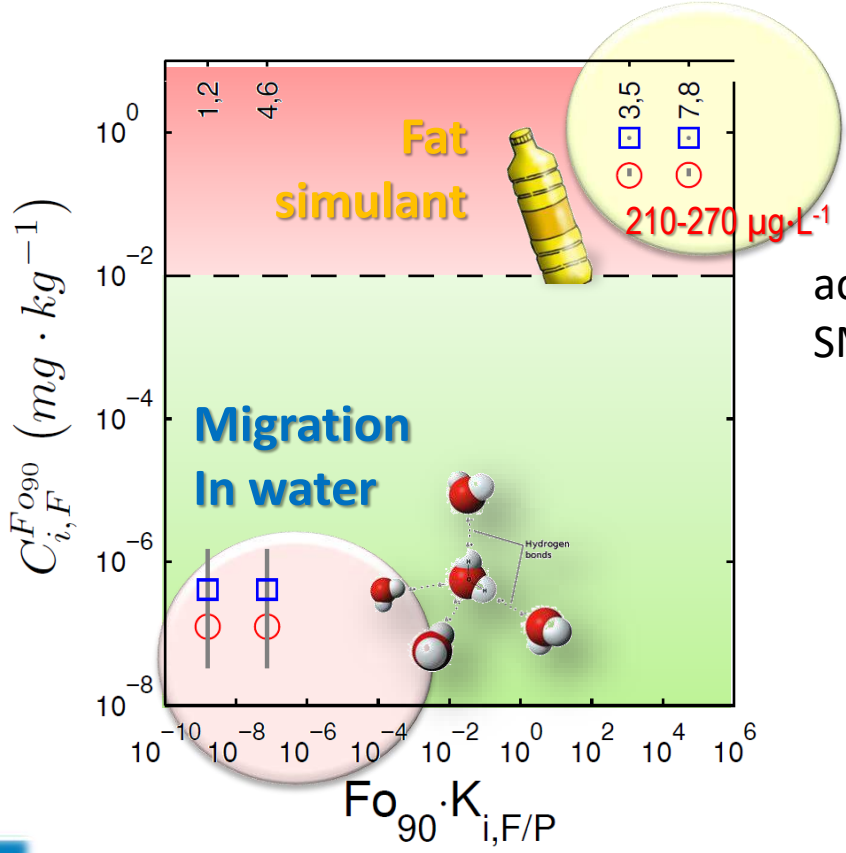
"It is incredible that such defenseless beings as babies should face such serious risks in a product as widely used as milk"



REUTERS AlertNet FOUNDATION

	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

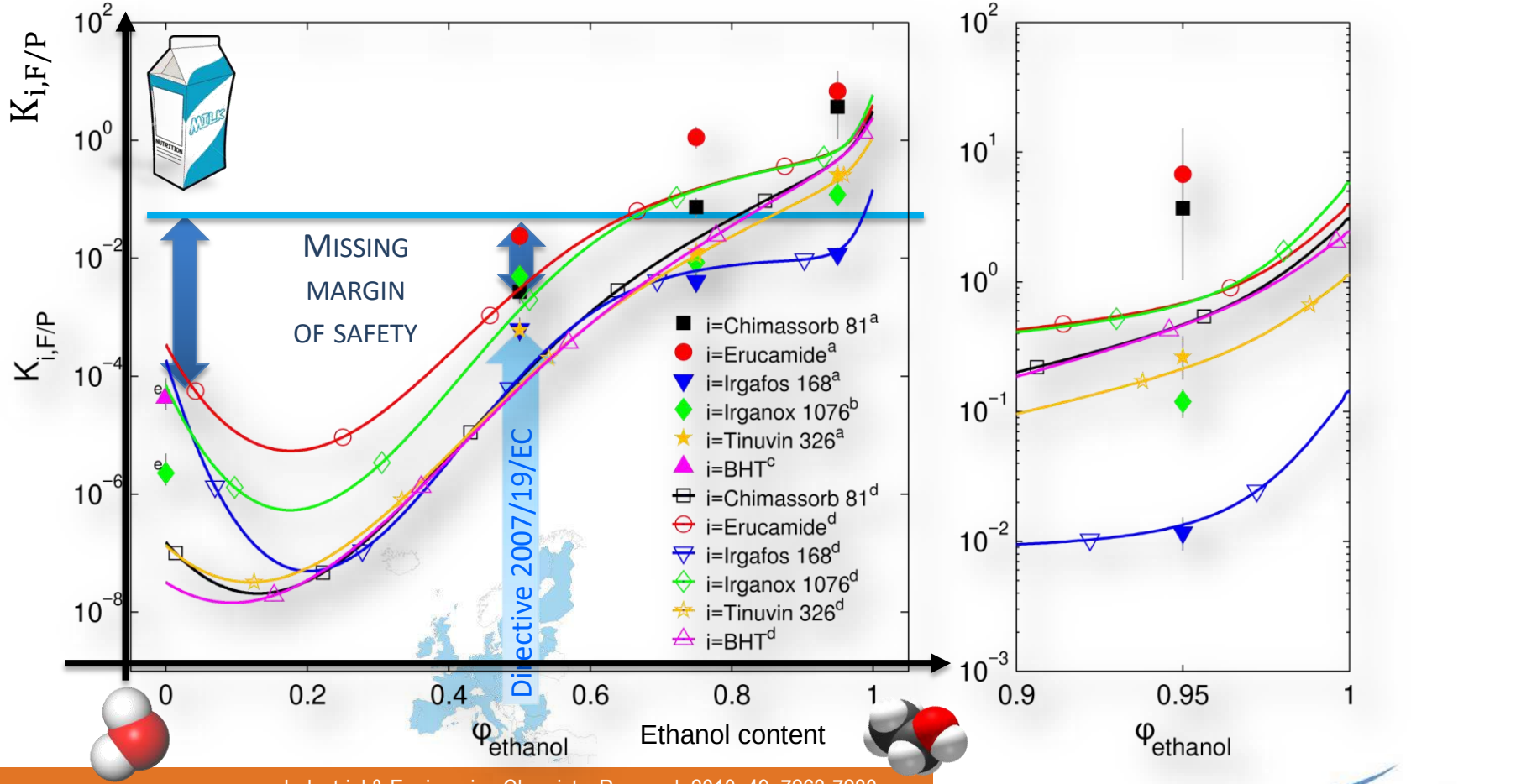
Food Additives and Contaminants, 2009, 26(12), 1556-1573.



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



Industrial & Engineering Chemistry Research 2010, 49, 7263-7280.

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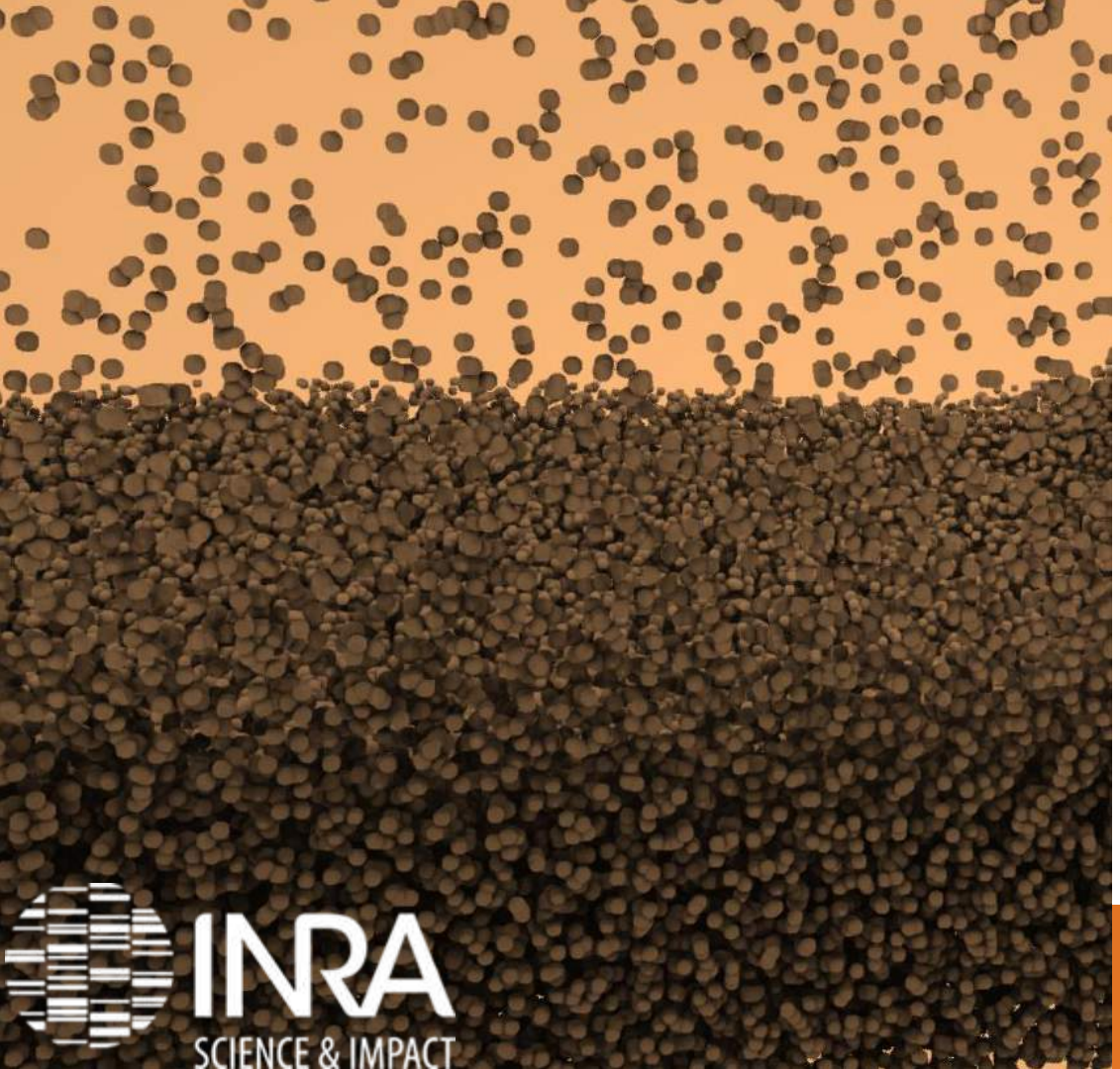

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SOLUTION 1

Modeling

solution 3

solution 4

solution 5

solution 6

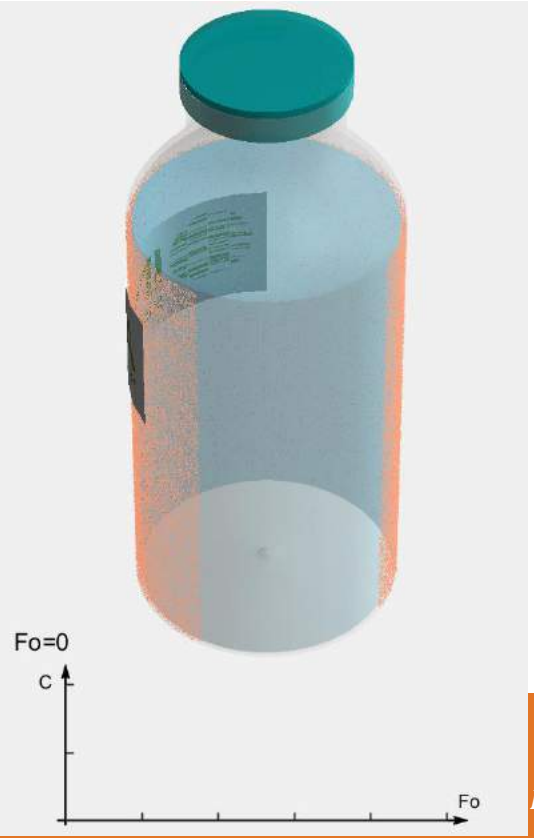
solution 7

Conclusions

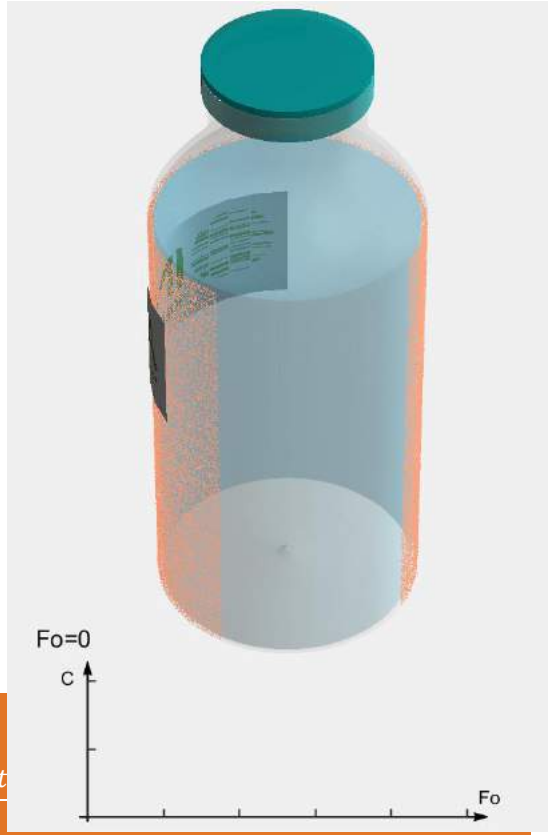
CARREFOURS
DE L'INNOVATION AGRONOMIQUE

MIGRATION: SOME TYPICAL CASES

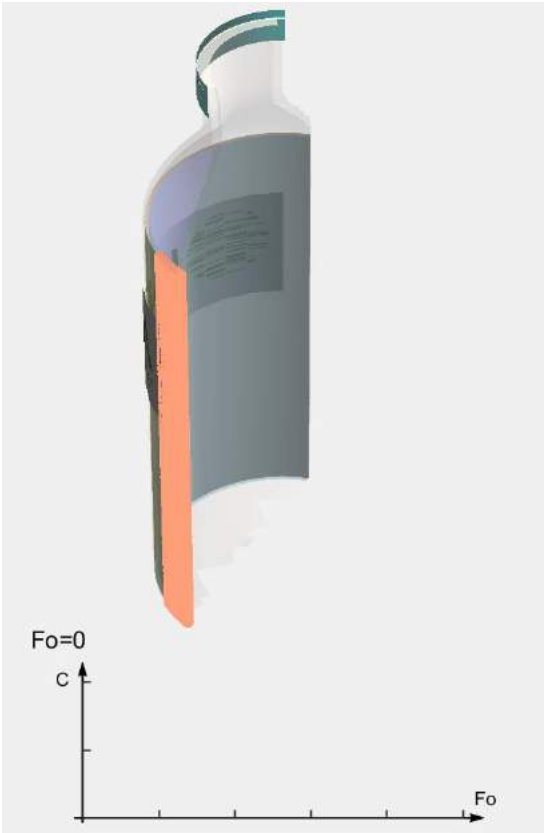
monolayer



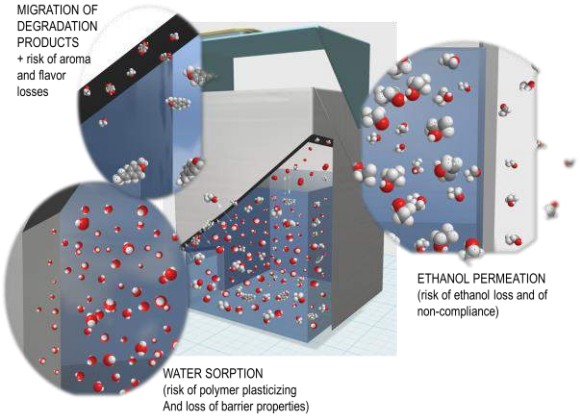
with barrier to diffusion

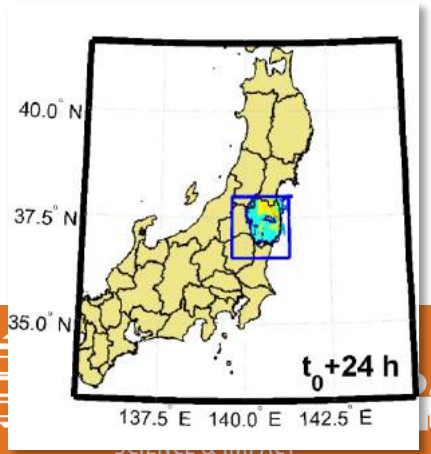


multilayer

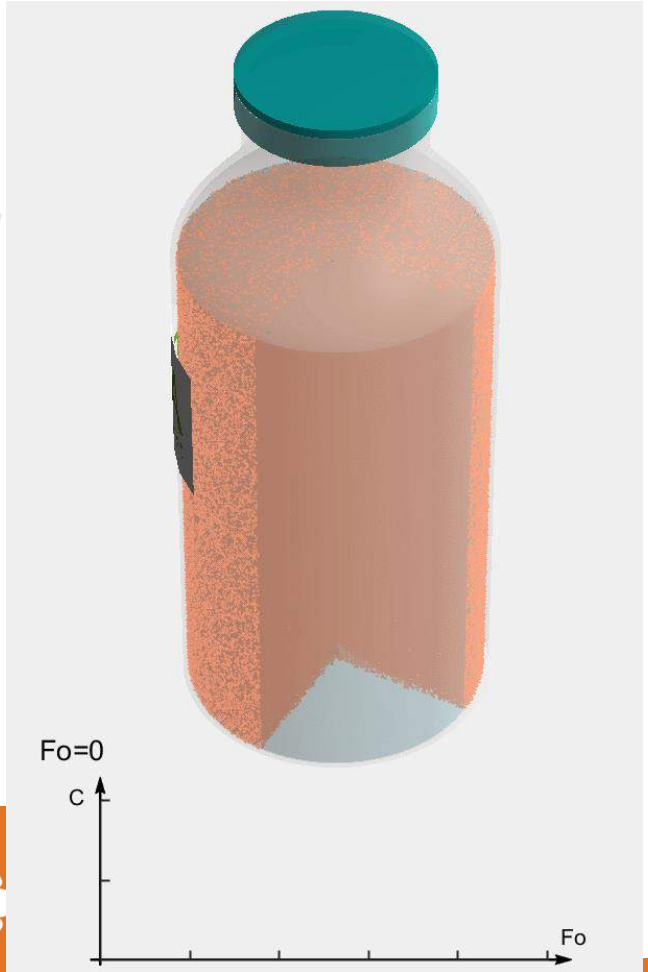


$$Fo = \frac{D_P t}{l_P^2}$$





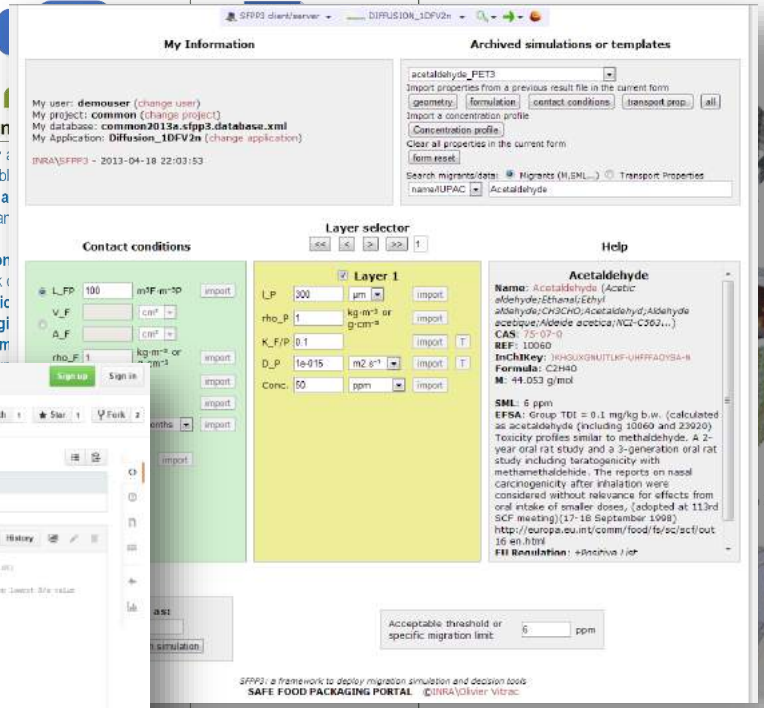
alcoholic beverages

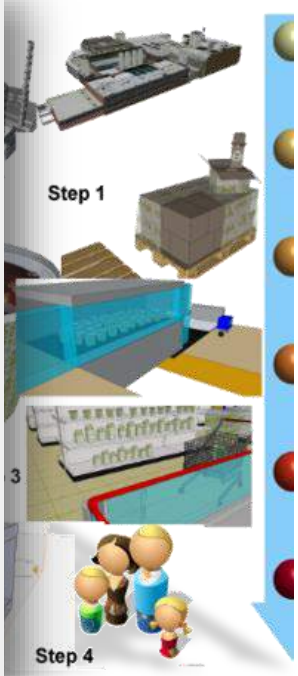


radionuclides

FMECA « milk for infants stored in a brick »

Phase	Formulation	Design	Process	Informations	Mechanisms
	Formulation	**design**	**Process**	**In**	
Inventaire	• monomers (plastics, adhesives) • catalysts • antioxidants • lubricants • biocides (cardboard, ink) • mineral oil (cardboard) • solvents • photoinitiators • other residus (NIAS)	**two components**: • brick body (4 materials, 5 layers) • cap (two materials incl. the sealing system) **six materials** • LDPE, PP (cap) • aluminum foil • cardboard (origin) • « ink » •	• production, storage, assembly of materials • assembly and storage of components • printing (printing technology, curing/drying….) • storage of empty packaging • aseptic packaging filling (temperature, pretreatment…) • storage and retailing of the bricks filled with milk	• identity assembl • **formula** (substar or not) • **test cor** the risk • **conditic packagi consum**	
Hiérarchisation	**Highly concentrated** • antioxidants, lubricants, biocides • mineral oils, photoinitiators • monomers, catalysts, solvents • other residues	**Barr** • **Mat rese weig** • • **Mat rese mol cont** • •			





Collaborative research project SAFEFOODPACK DESIGN

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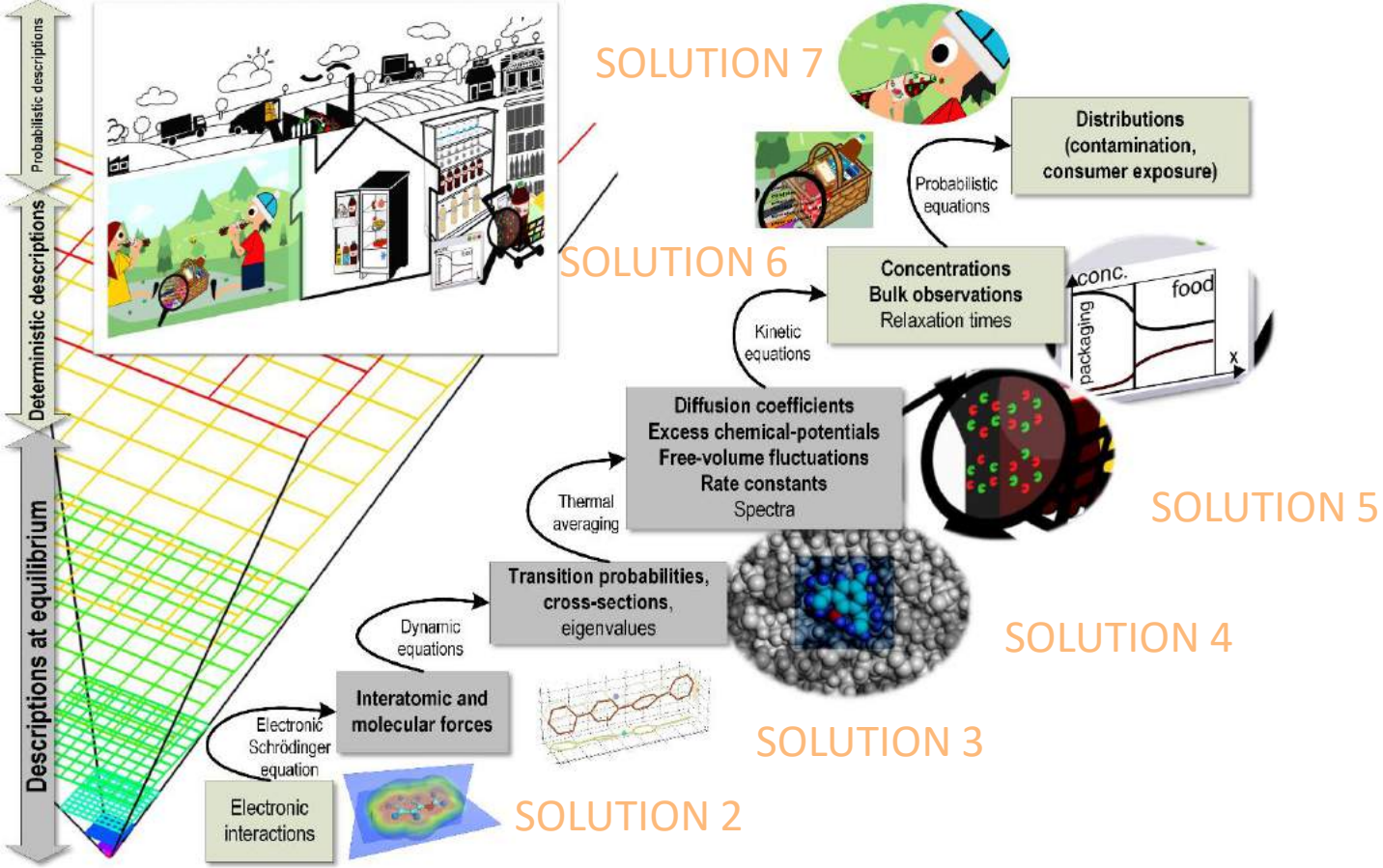
CARREFOURS DE L'INNOVATION AGRONOMIQUE



Food Research International **2017, 88, Part A, 91-104.**

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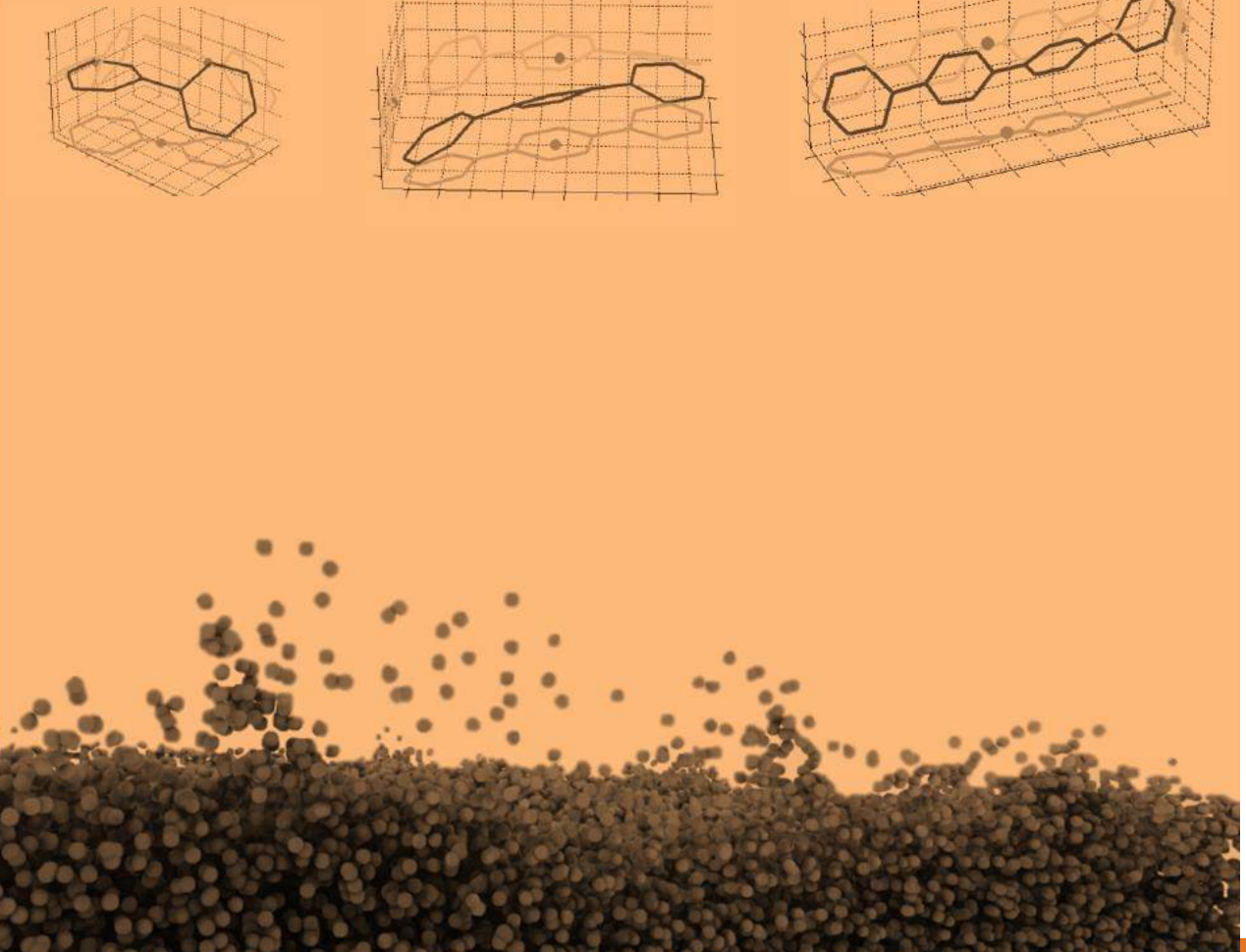
CARREFOURS DE L'INNOVATION AGRONOMIQUE



SOLUTION 2

additives with low diffusion coefficients

solution 3

solution 4

solution 5

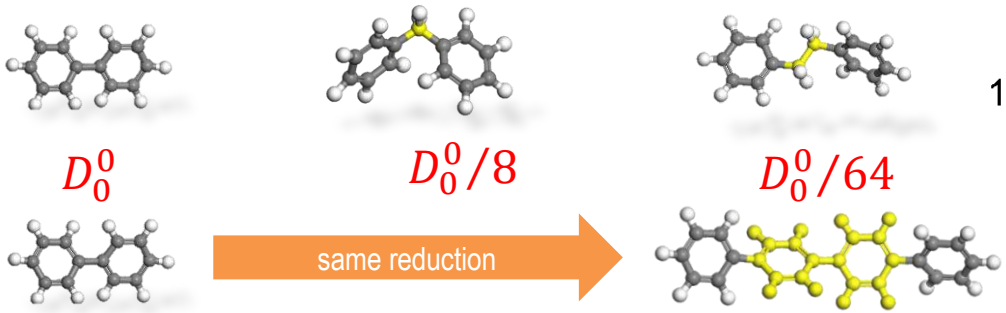
solution 6

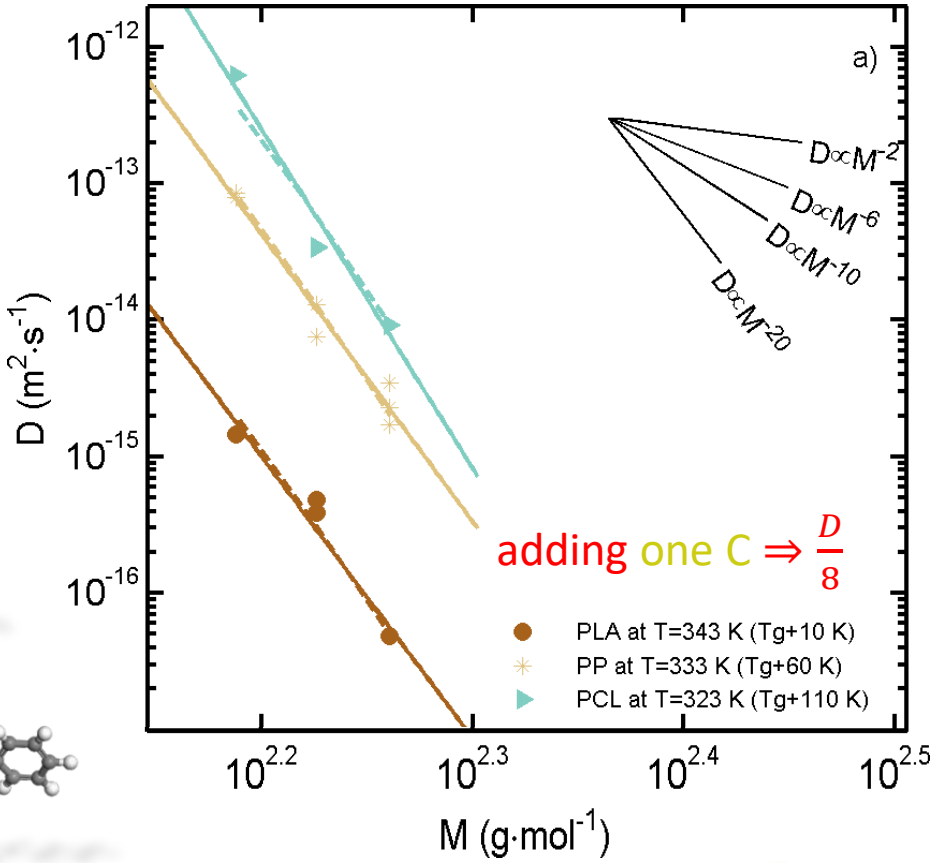
solution 7

Conclusions

CARREFOURS
DE L'INNOVATION AGRONOMIQUE

$$D(M,T,T_g) = D_0 \exp\left(-\frac{E_a{}^{blob}}{RT}\right) \times \exp\left(-\frac{E^{*(M)} - E^*_{blob}}{RT}\right)\left(\frac{M}{M_{blob}}\right)^{-\alpha(T,T_g)}$$





Macromolecules 2013, **46**(3), 874-888

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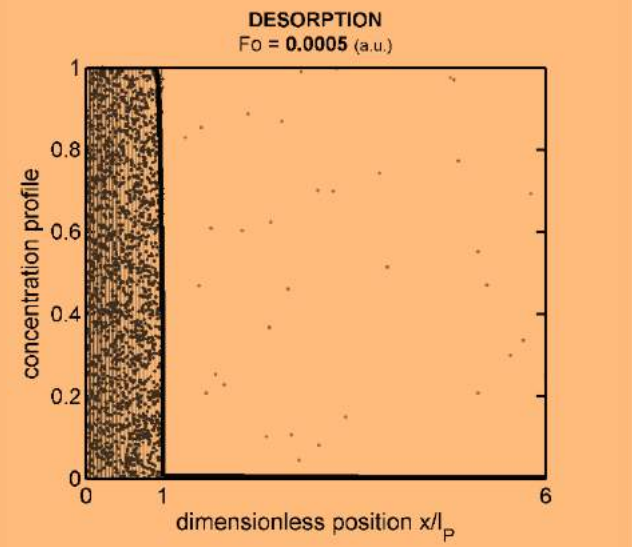
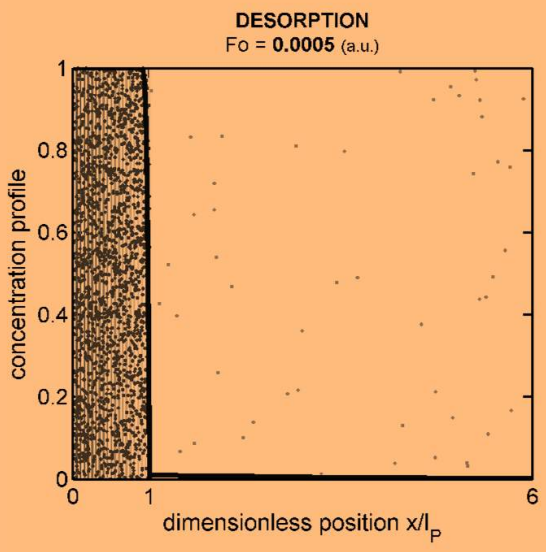
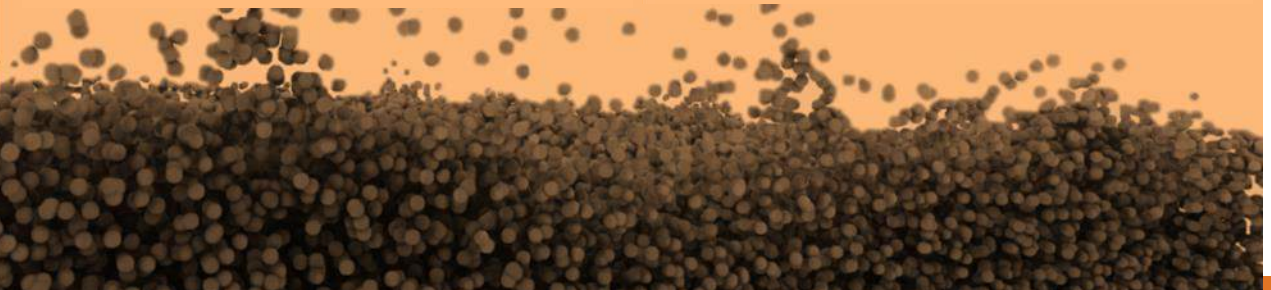
$K_{i,P/F=}$ | 50 | 1/50

50 times for chemical affinity for P

50 times for chemical affinity for F







SOLUTION 3

Solubility barrier for apolar or low polar substances

solution 4

solution 5

solution 6

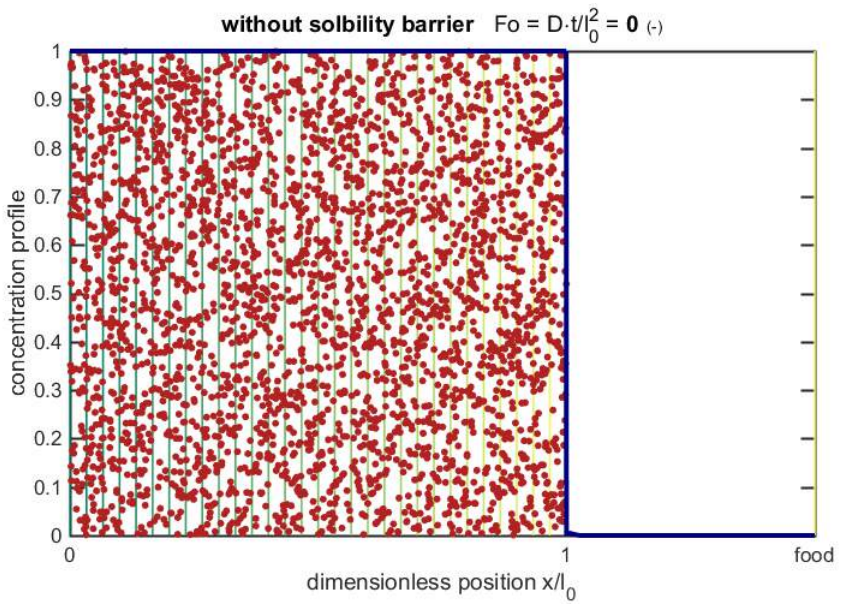
solution 7

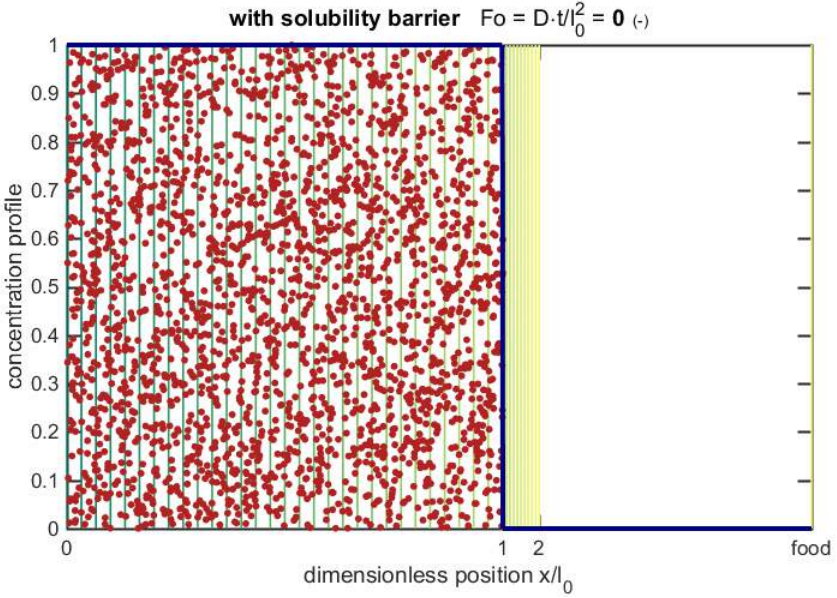
Conclusions

CARREFOURS DE L'INNOVATION AGRONOMIQUE

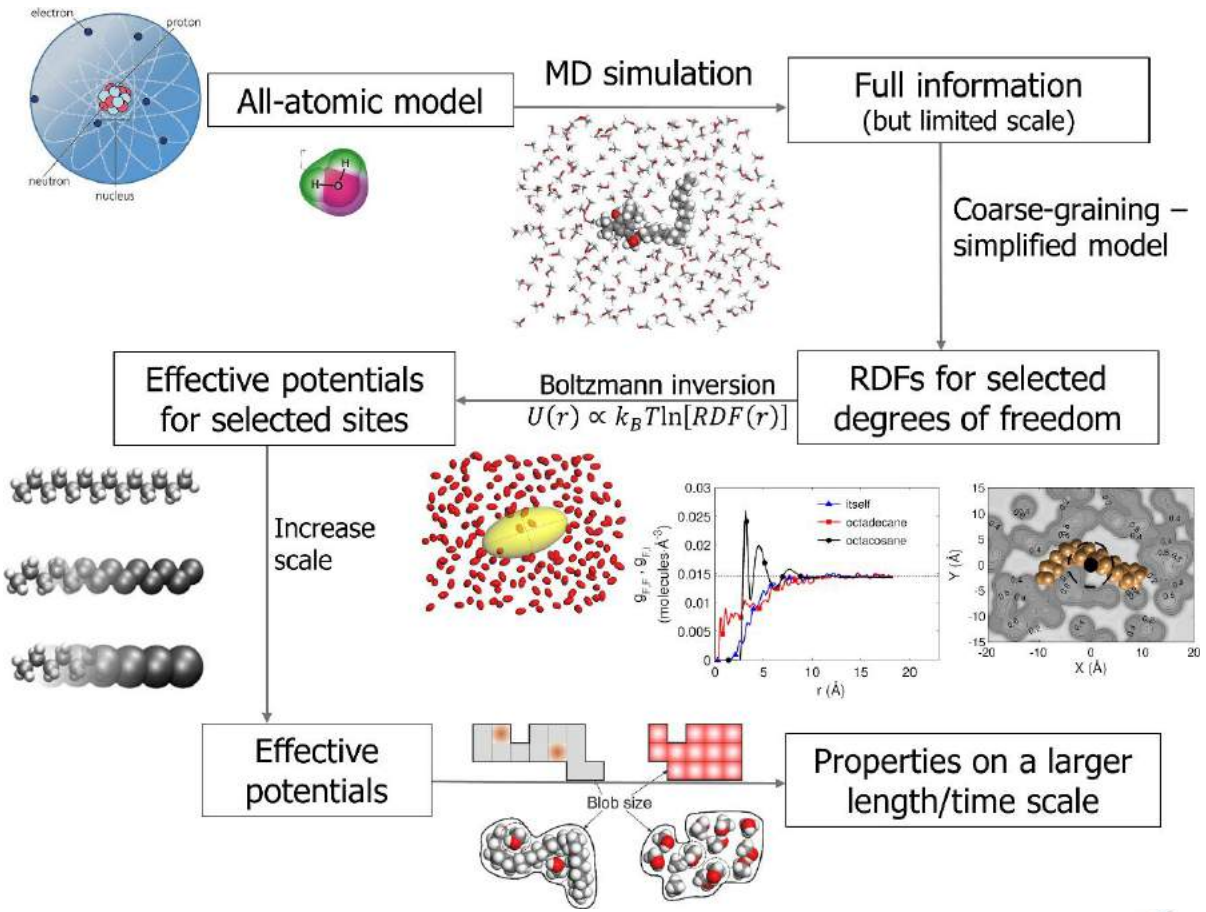
THE CONCEPT OF SOLUBILITY BARRIER

CHANGING THE CHEMICAL AFFINITY CLOSE TO THE SURFACE





Excess mixing enthalpy: atomistic scale



Excess mixing Entropy: coarse grained repre-sentations

Food Research International ***2017, 88, 91-104.***
Journal of Polymer Science Part B: Polymer Physics ***2014, 52, 1252-1258.***
Journal of Chemical Reactor Engineering ***2010, 8.***
Industrial & Engineering Chemistry Research ***2010, 49, 7263-7280 ; 2009, 48, 5285-5301.***

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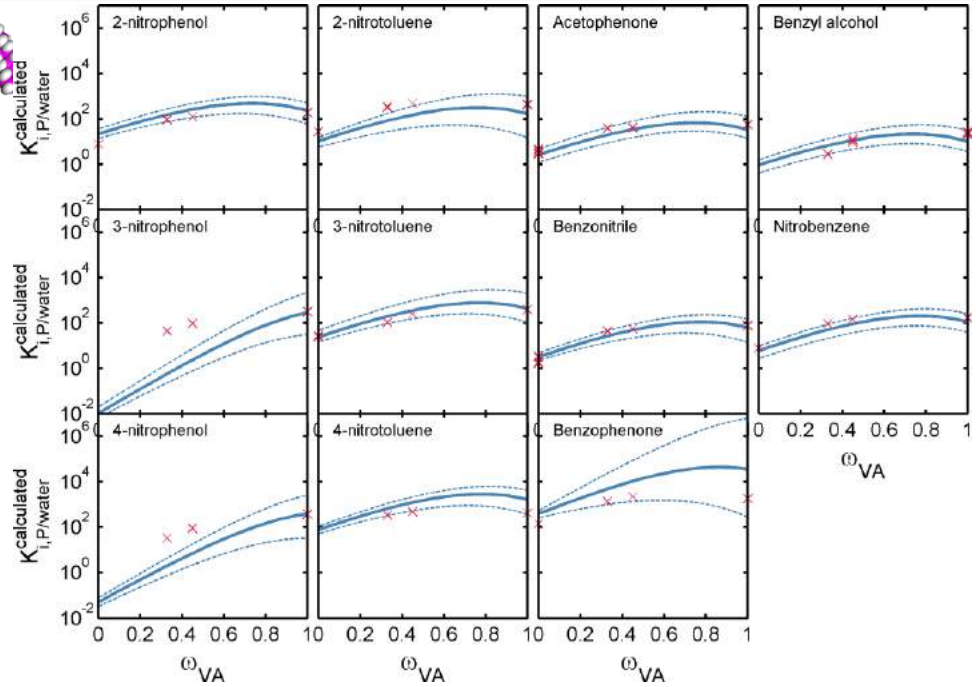
DE L'INNOVATION AGRONOMIQUE

PE EVA33 EVA45 PVAc

ACETYLATION RATE FROM 0 TO 100%

APOLAR

POLARITY++



Industrial & Engineering Chemistry Research ***2017, 56, 774–787.***

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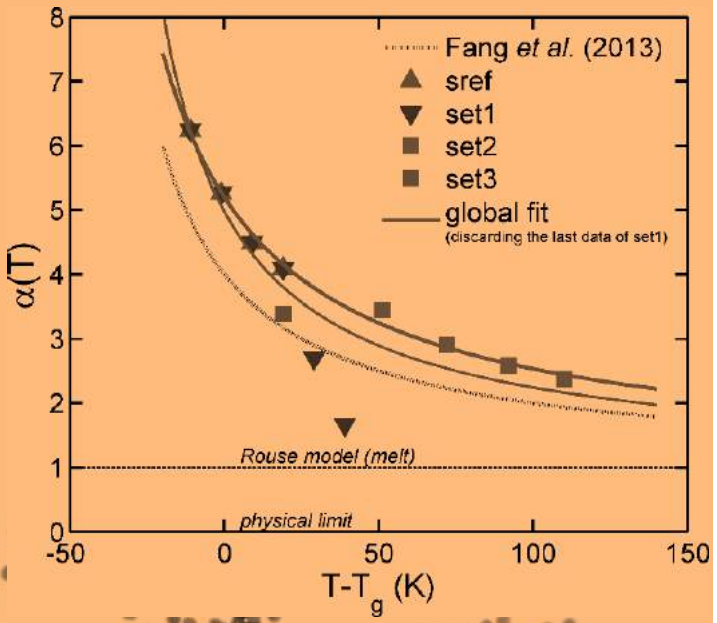
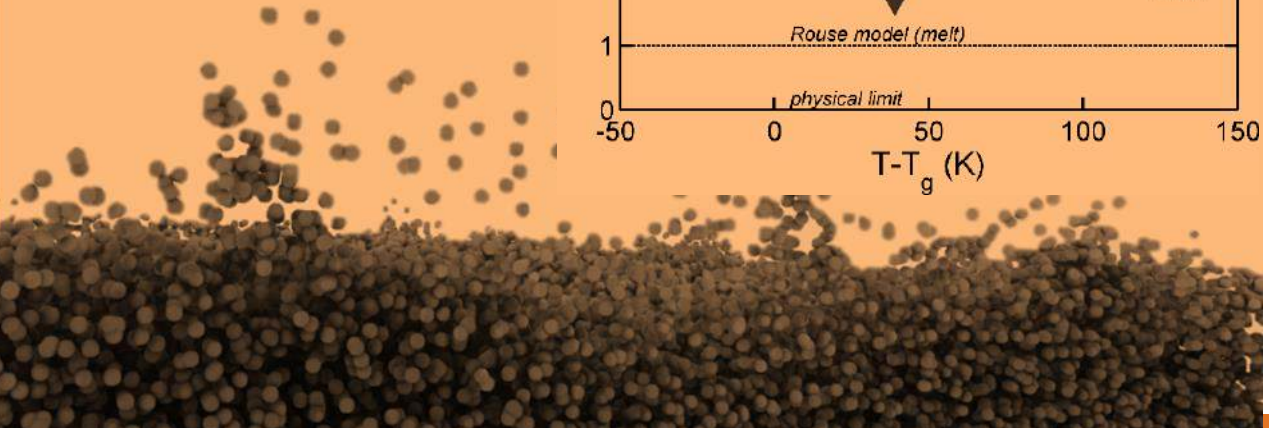
CARREFOURS DE L'INNOVATION AGRONOMIQUE

$$D_1 = \bar{D}_0 \exp\left(-\frac{E^*}{RT}\right) \exp\left(-\frac{\xi}{0.24}\alpha_{probe}^{(T,T_g)}\right)$$

$$\alpha(T,T_g) = \begin{cases} 1 + \frac{K_\alpha}{T - T_g + K_\beta} & \text{for } T \geq T_g \\ 1 + \frac{K_\alpha}{\frac{\alpha_2^g}{\alpha_{c2}}(T - T_g) + K_\beta} & \text{for } T < T_g \end{cases}$$

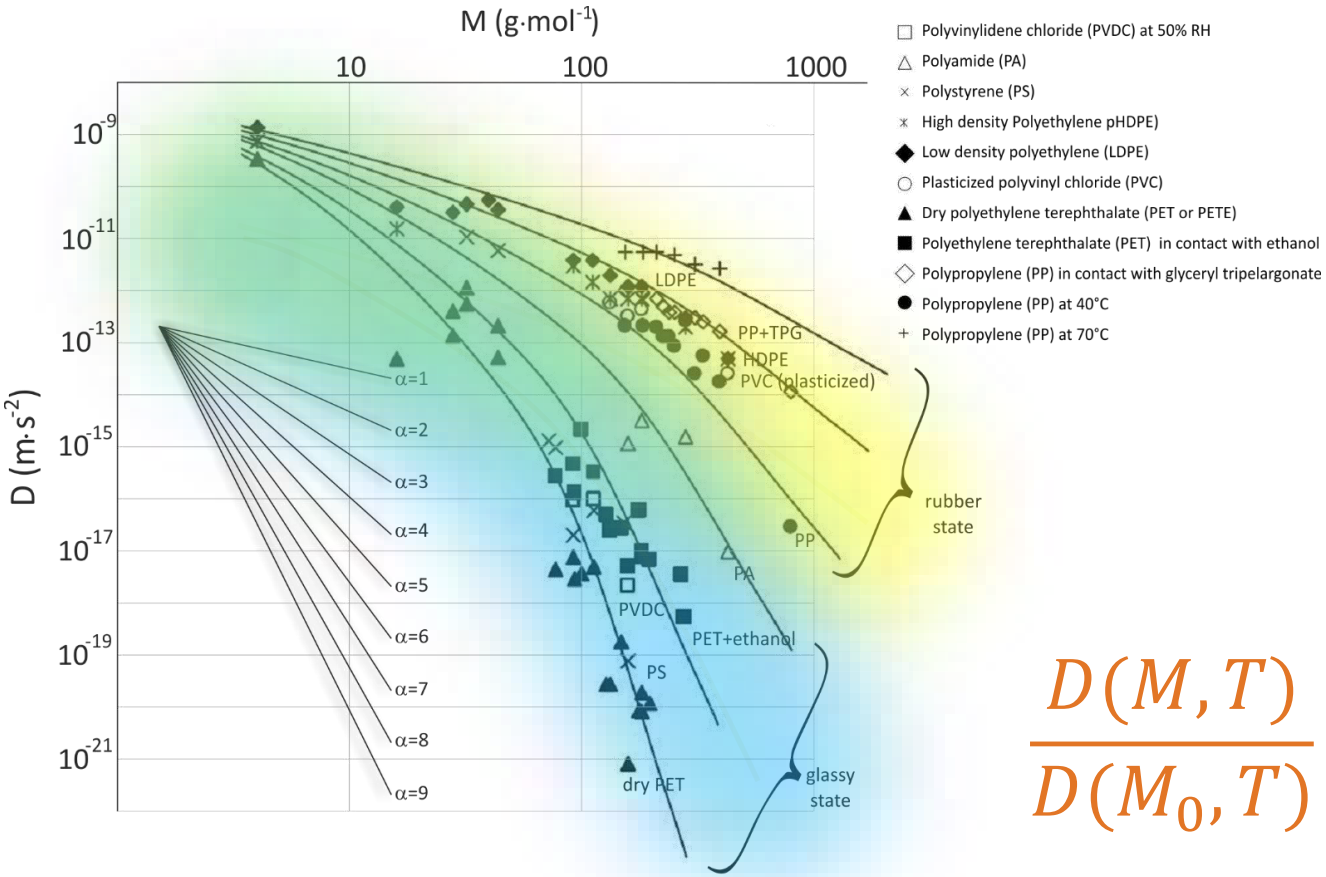




SOLUTION 4

Diffusion barrier with materials with high T_g polar substances

CARREFOURS
DE L'INNOVATION AGRONOMIQUE

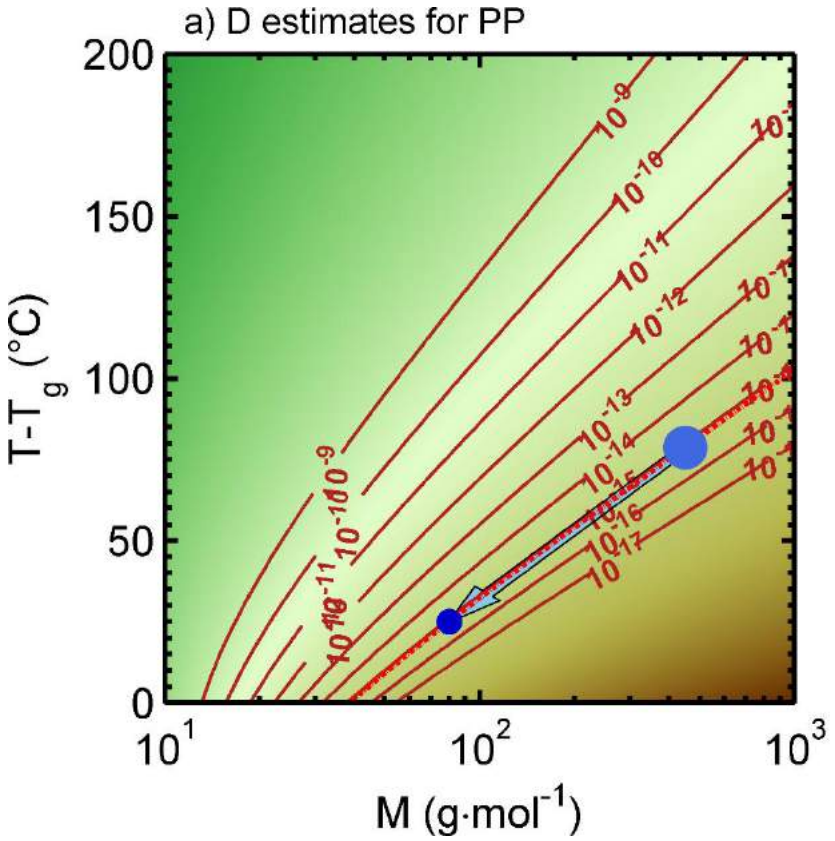


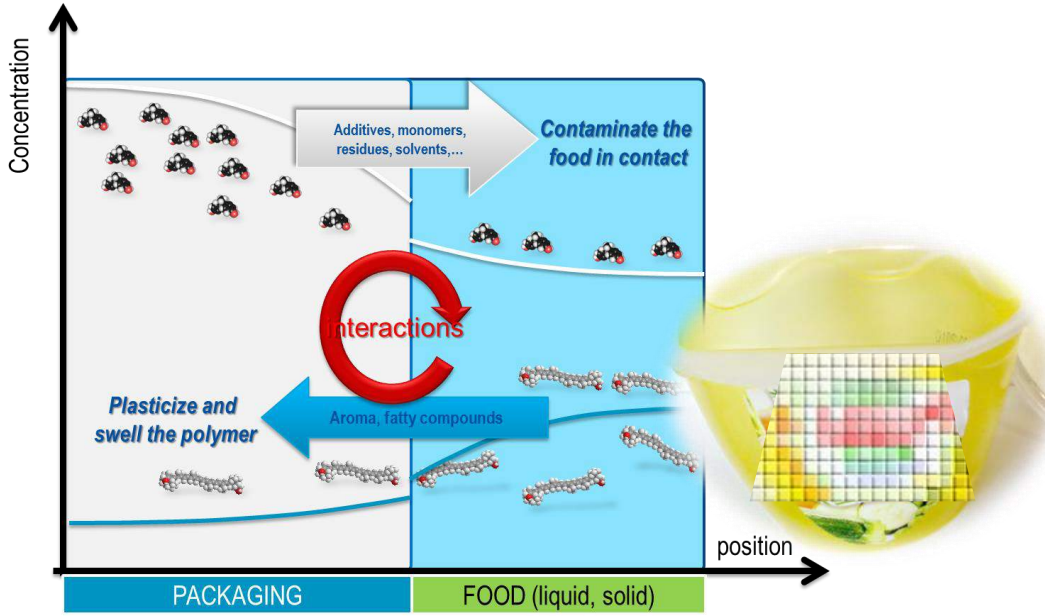
$$\frac{D(M,T)}{D(M_0,T)} \propto \left(\frac{M}{M_0}\right)^{-\alpha(T,T_g)}$$

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

INRA SCIENCE & IMPACT

CARREFOURS DE L'INNOVATION AGRONOMIQUE


a) D estimates for PP
200
150
100
50
0
T-T$_g$ (°C)
10^1
10^2
10^3
M (g·mol^{-1})
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
10^{-15}
10^{-16}
10^{-17}


Concentration
Additives, monomers, residues, solvents,...
Contaminate the food in contact
Interactions
Plasticize and swell the polymer
Aroma, fatty compounds
position
PACKAGING
FOOD (liquid, solid)

SOLUTION 5

Adding a gas phase to slowdown migration

CARREFOURS
DE L'INNOVATION AGRONOMIQUE

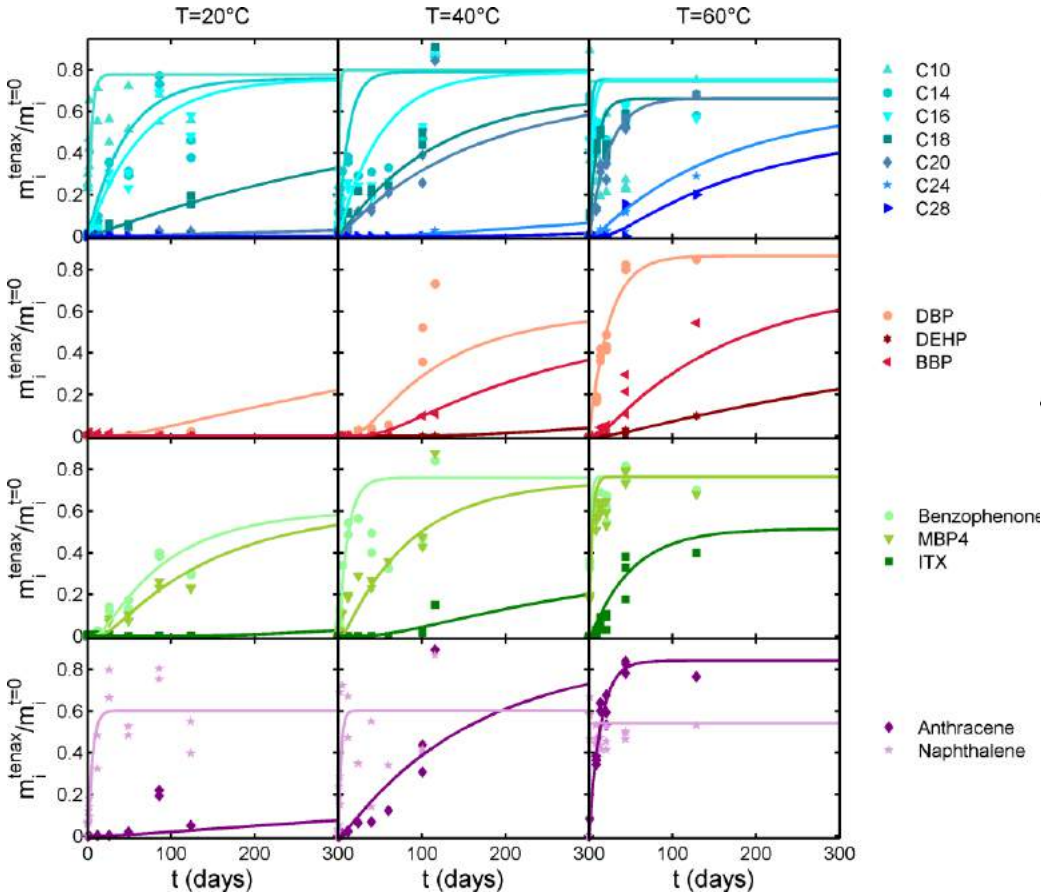
SURROGATES (I)

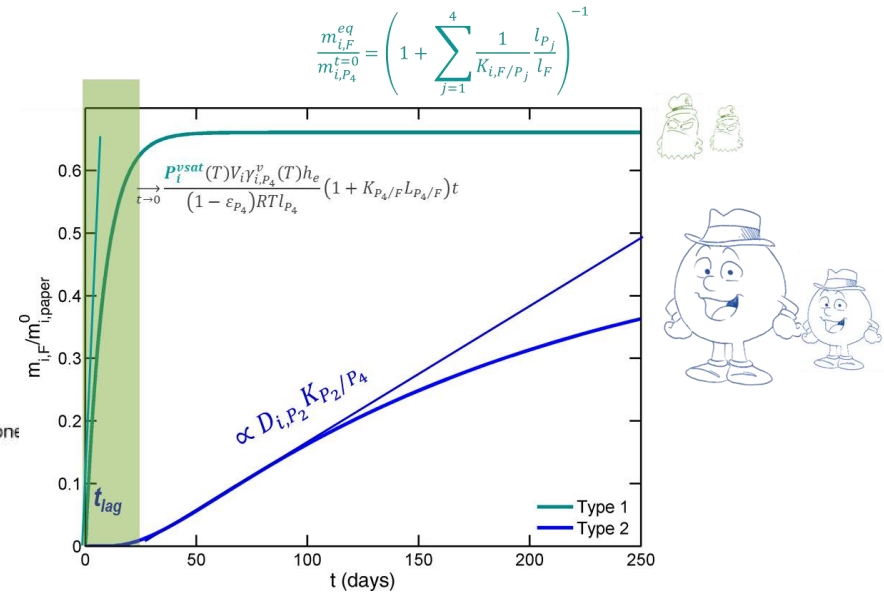
- Decane (C10)
- Tetradecane (C14)
- Hexadecane (C16)
- Octadecane (C18)
- Eicosane (C20)
- Tetracosane (C24)
- Octacosane (C28)
- Dibutyl phthalate (DBP)
- Bis(2-ethylhexyl) phthalate (DEHP)
- Benzylbutyl phthalate (BBP)
- Benzophenone
- 4-methyl benzophenone (MBP4)
- Isopropyl-9H-thioxanthen-9-one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

INRA SCIENCE & IMPACT

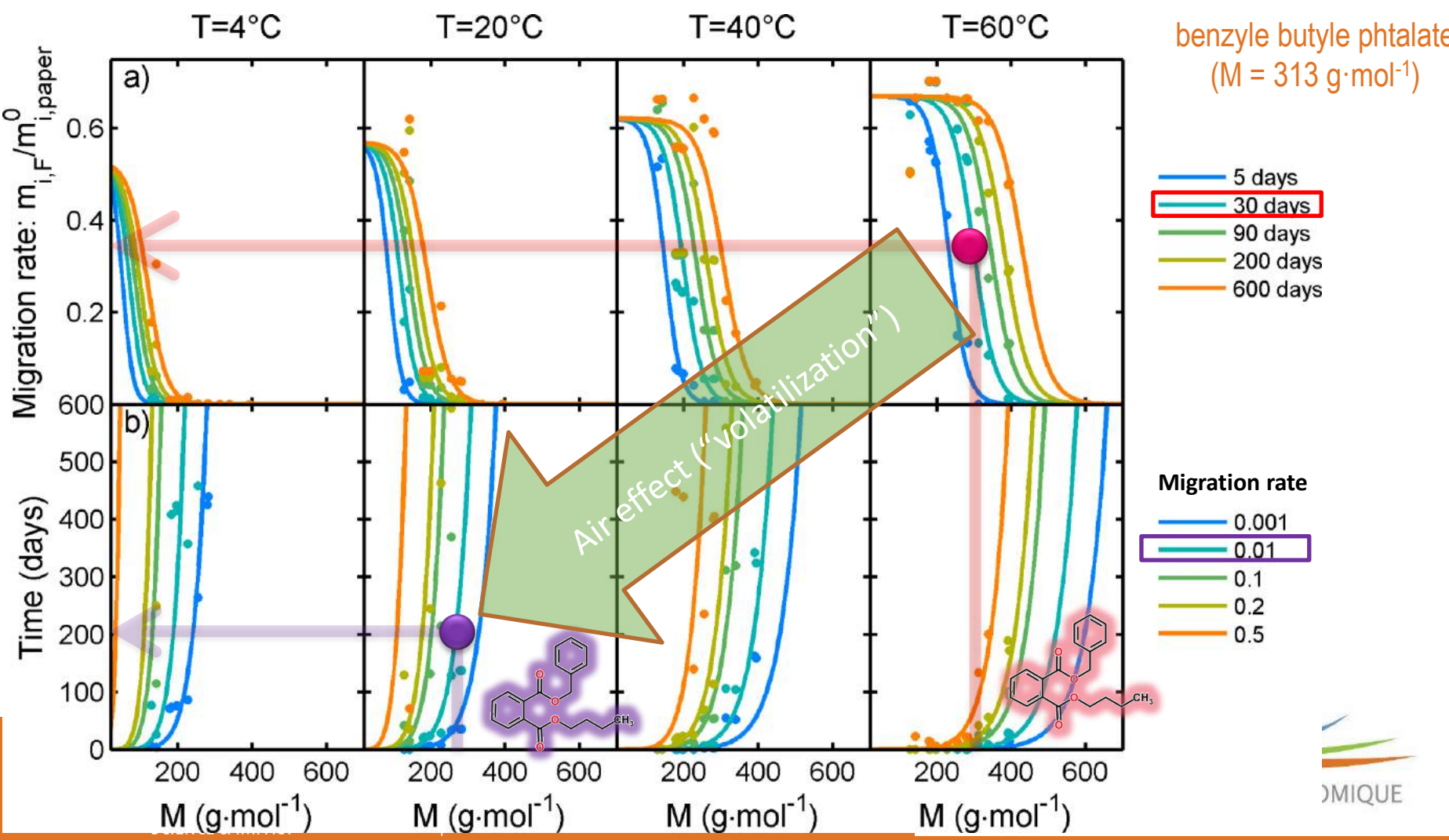
Food Additives and Contaminants
2017, Doi:
10.1080/19440049.2017.1315777.

CARREFOURS DE L'INNOVATION AGRONOMIQUE

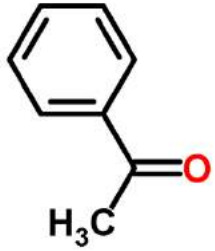




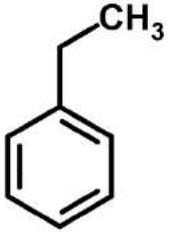
$$\frac{m_{i,F}^{(t)}}{m_{i,P}^{0}} = \frac{V_F}{m_{i,P}^{0}} \int_0^t C_{i,F}^{(t)} \, d\tau$$


T=4°C
T=20°C
T=40°C
T=60°C
a)
b)
Migration rate: $m_{i,F}/m^0_{i,paper}$
Time (days)
M (g·mol^{-1})
Air effect ("volatilization")
benzyle butyle phtalate
(M = 313 g·mol^{-1})
5 days
30 days
90 days
200 days
600 days
Migration rate
0.001
0.01
0.1
0.2
0.5

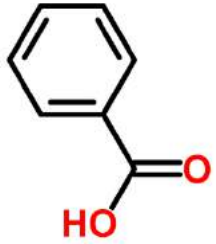
```
>> FMECAKairP acetophenone
LOAD_CHEMSPIDER          extraction of ChemSpiderID=7132 ('acetophenone') completed in 10.26 s
LOAD_CHEMISPIDER: updated cache
             7132.mat      21-sept.-2015 21:37:19      77.6 kBytes    C:\Data\Olivier\INRA\Codes\MS\cache.ChemSpider
CHEMSPIDER reuses cached data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

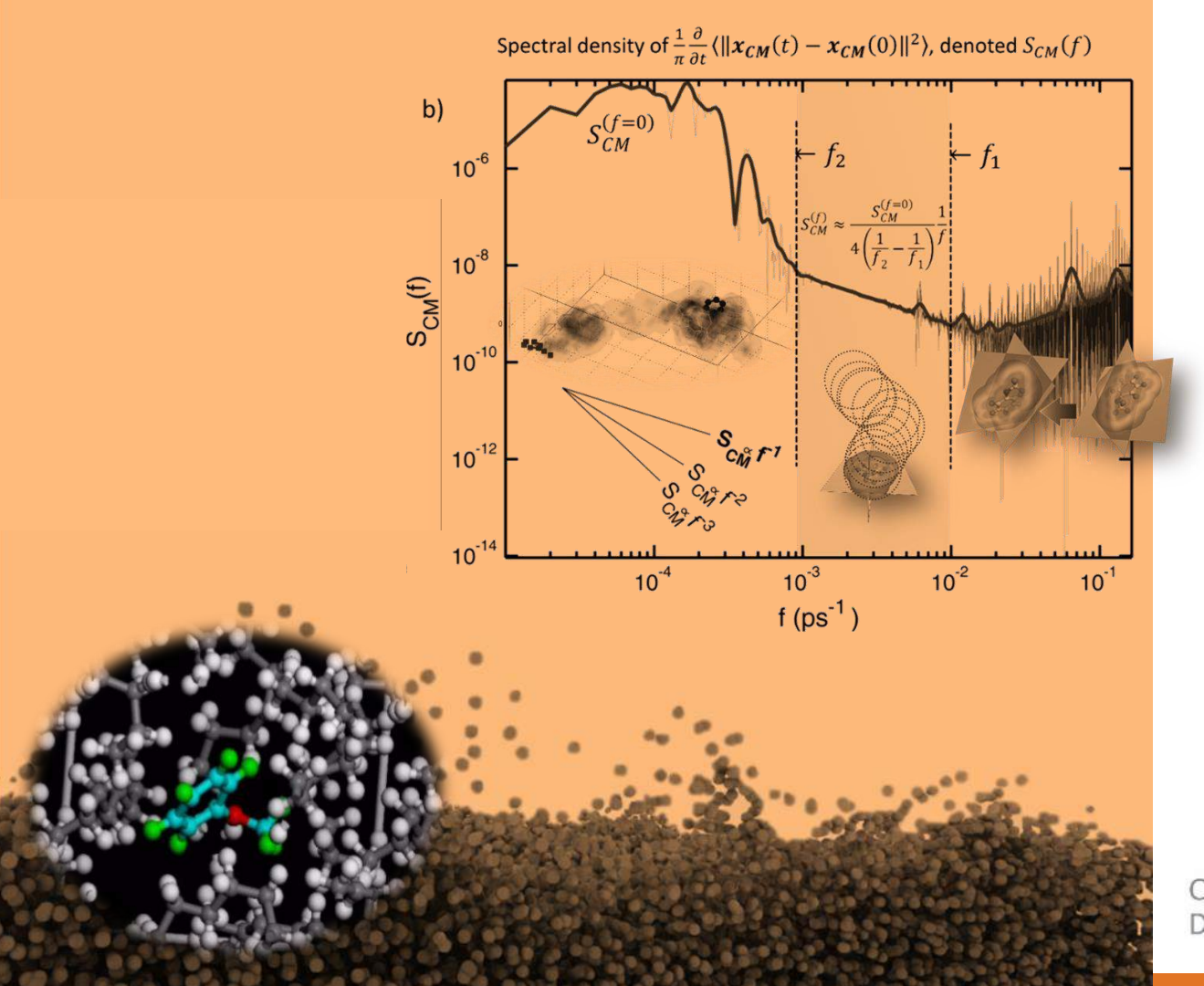


SOLUTION 6

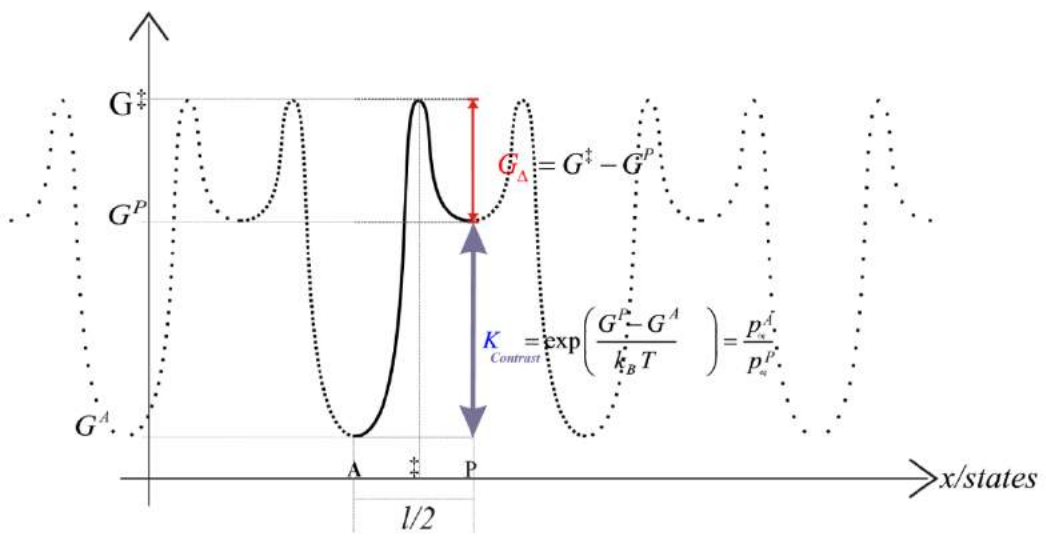
Trapping migrants

solution 7

Conclusions

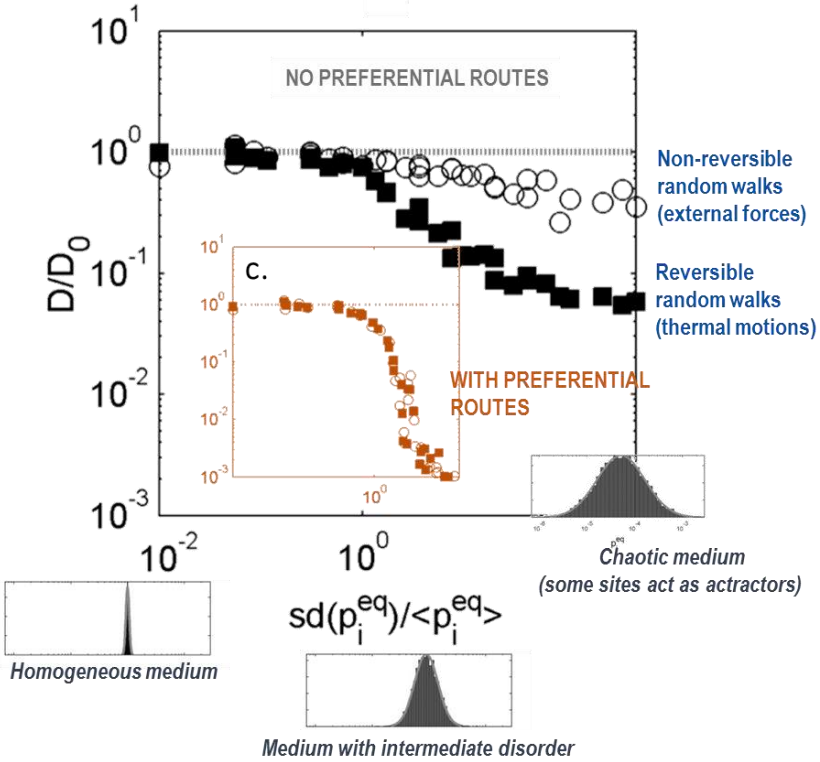


CARREFOURS
DE L'INNOVATION AGRONOMIQUE



$$2D = l^2 k_{A\to P\to A} = \frac{k_0 l^2}{\frac{K}{\exp\left(-\frac{G_\Delta}{RT}\right)} + \frac{1}{\exp\left(-\frac{G_\Delta}{RT}\right)}}$$

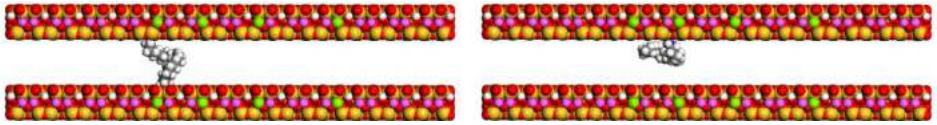
$$= \frac{k_0 l^2}{1 + K_{contrast}} \exp\left(-\frac{G_\Delta}{RT}\right) = \frac{D_0}{1 + K_{contrast}} \exp\left(-\frac{G_\Delta}{RT}\right)$$



Chemical Engineering Science **2007, 62, 2503-2521.**

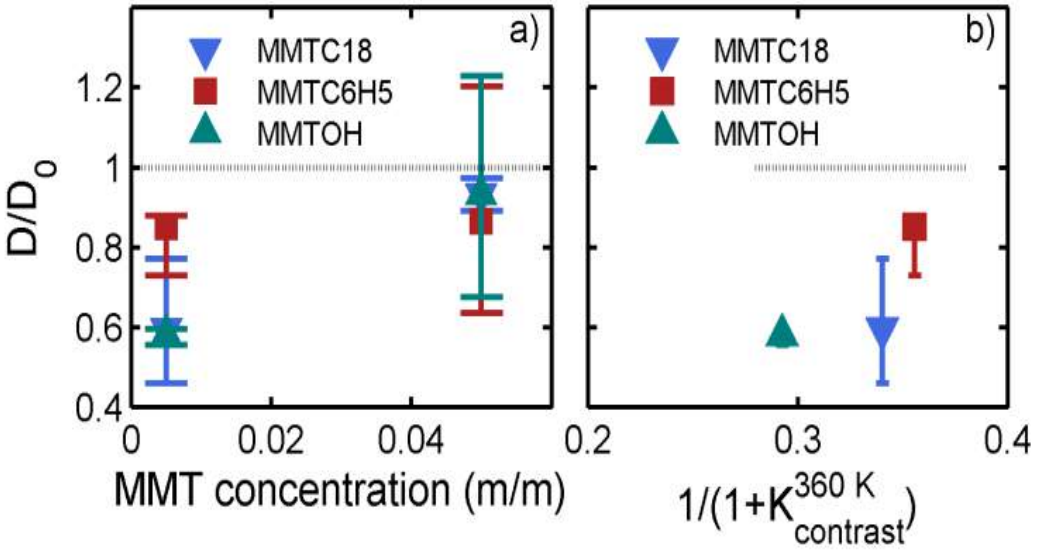
INRA SCIENCE & IMPACT

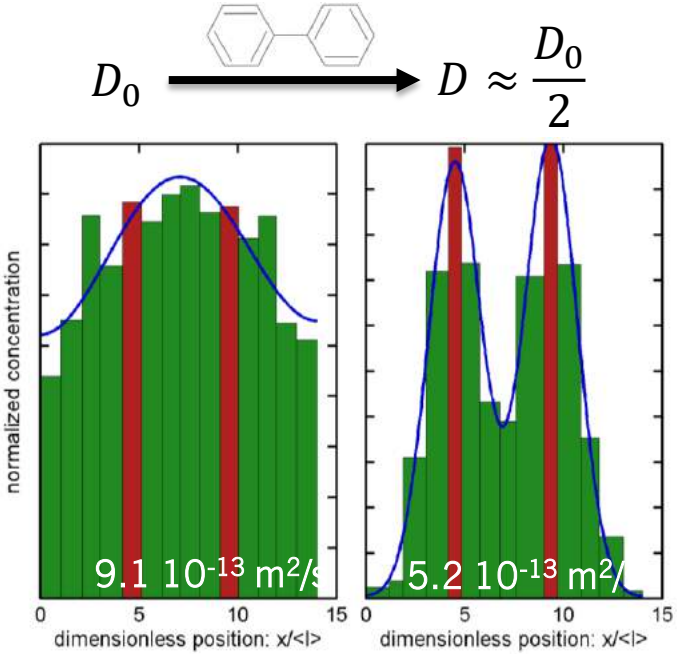
CARREFOURS DE L'INNOVATION AGRONOMIQUE



stack of 14 films assembled as
[0 0 0 0 1 0 0 0 0 1 0 0 0 0]

- 1 = source, 0 = virgin
- film thickness: 40 μm
- contact time: 20 min



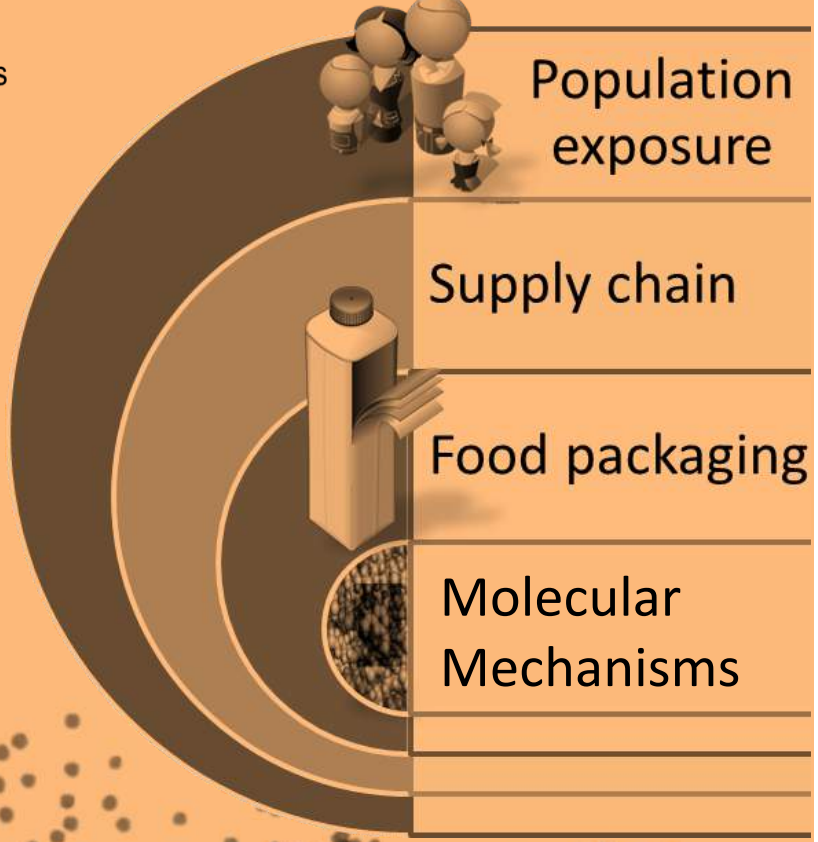


Defect and Diffusion Forum 2011, Diffusion in Materials - DIMAT 2011, 269-274.

INRA SCIENCE & IMPACT

CARREFOURS DE L'INNOVATION AGRONOMIQUE

- List of components and functions
- Failure = migration mode tree
- **Severity** = $f(C_F)$
  - Dimensionless scale
  - Normalized by toxicological data
  - Substance and material independent
  - Linear to C_F for acceptable C_F values and non-linear beyond
- **Criticality ranking**
  - by component
  - by substance
  - by process or storage step
  - Comparative designs
- Ensuring **detectability** via calculations and simulation



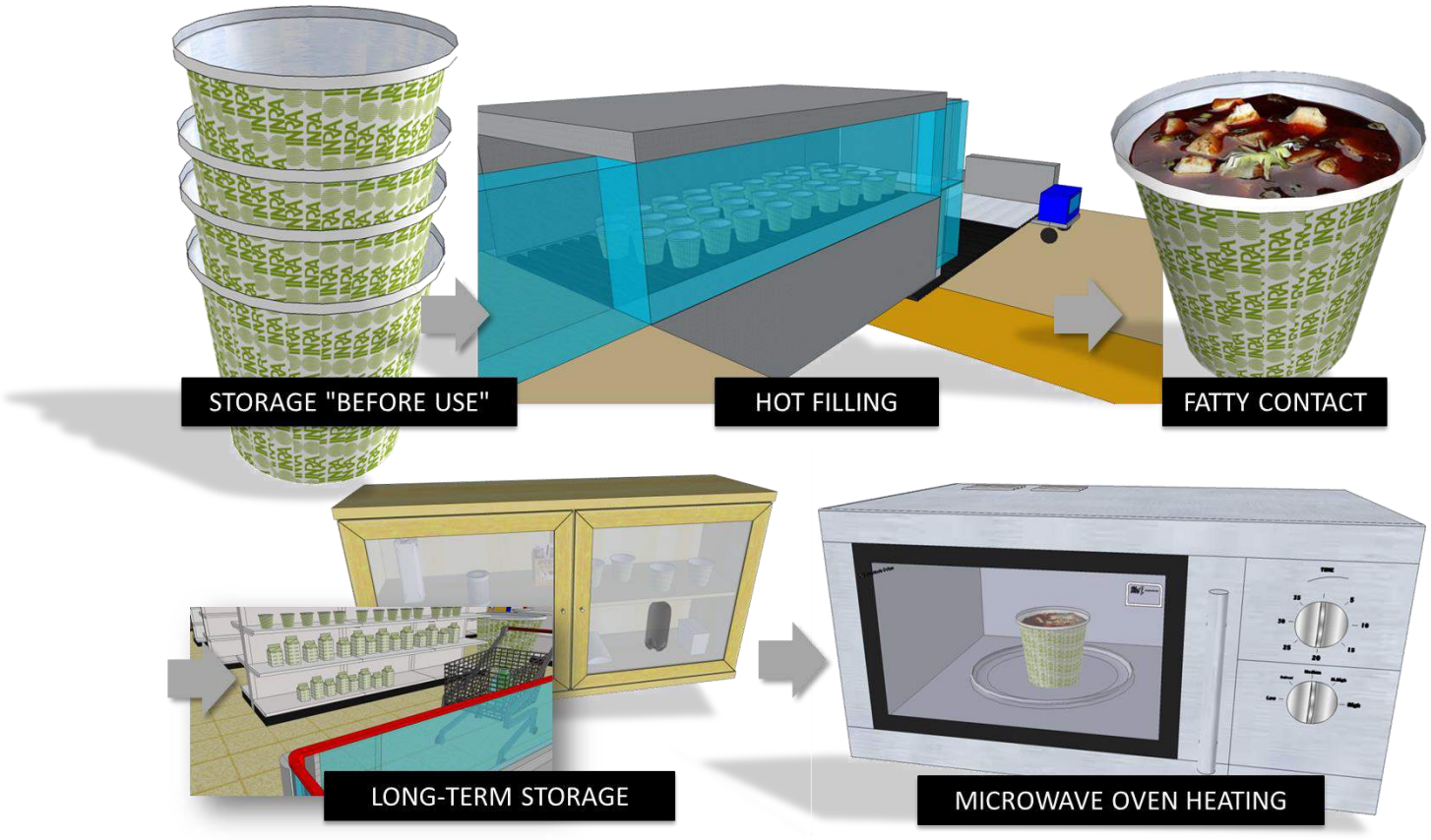
SOLUTION 7

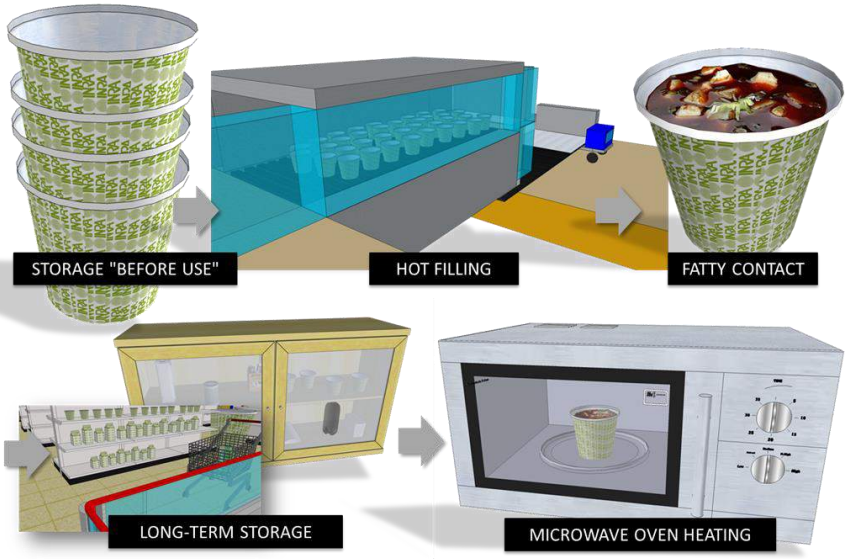
Identification, avoidance, correction of critical steps components, subtances, etc.

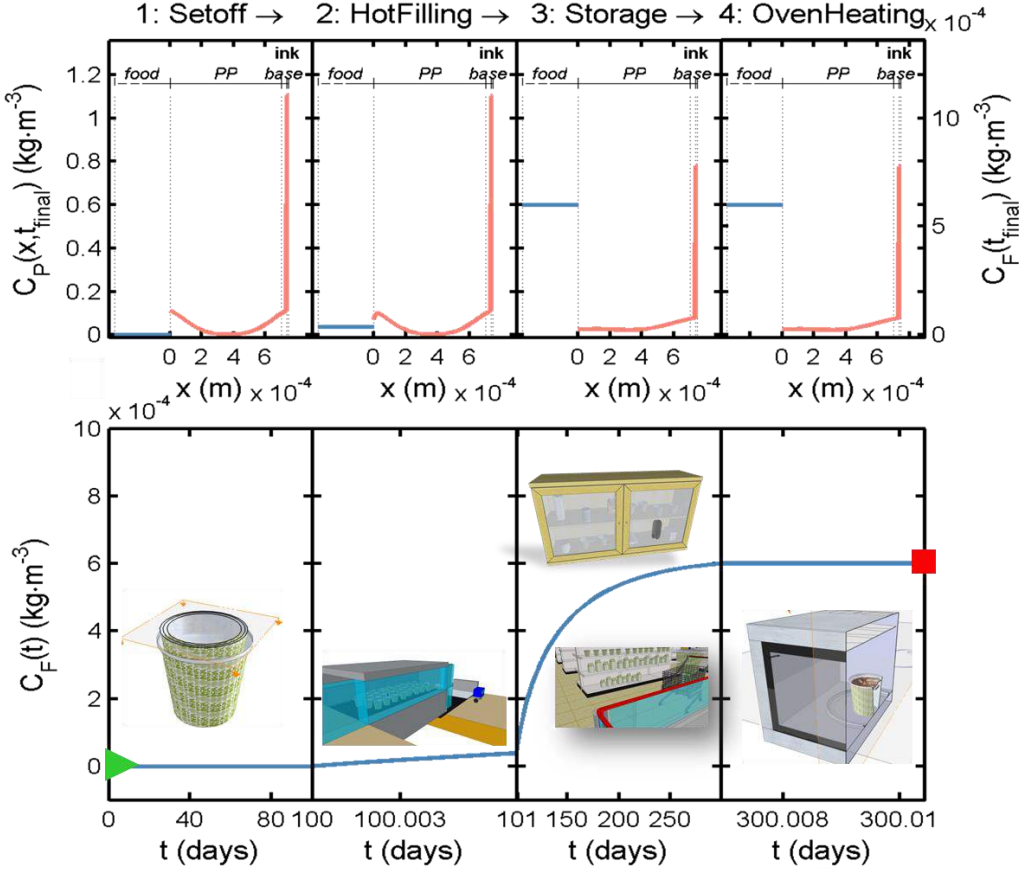
Conclusions

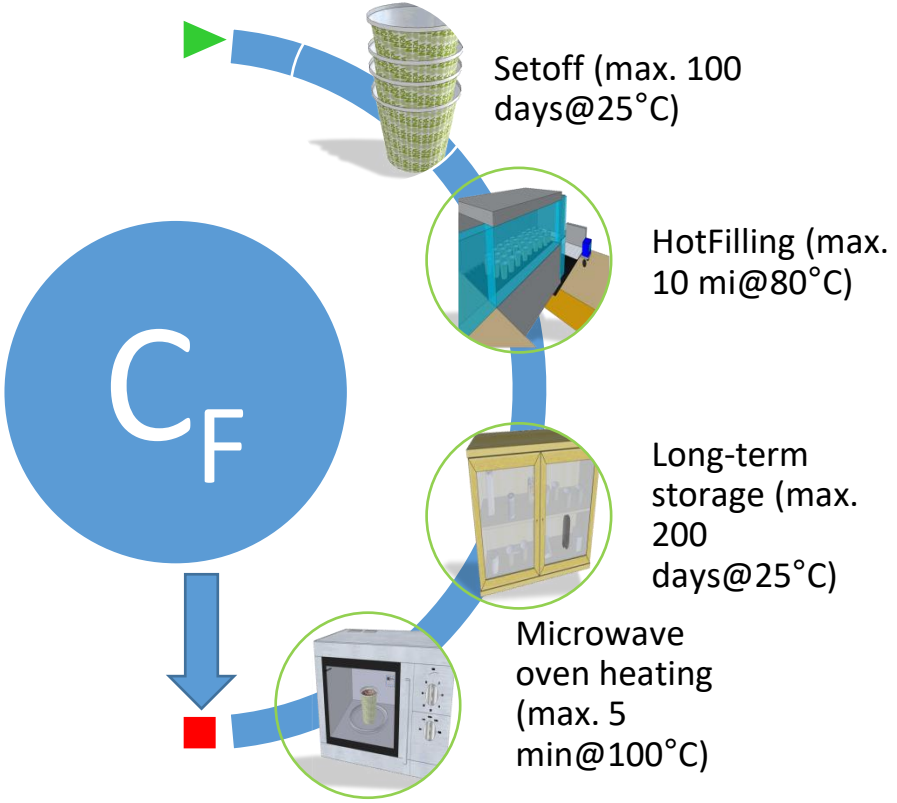
CARREFOURS DE L'INNOVATION AGRONOMIQUE

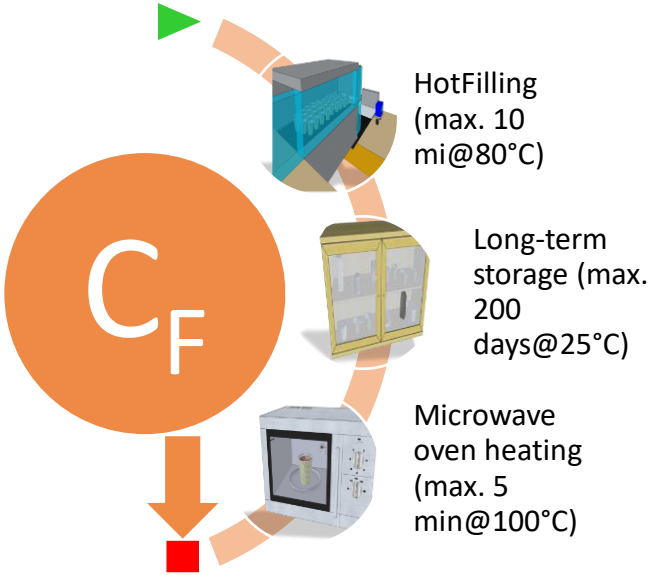
Risk of contamination by a photoiniator in UV-curing printing ink

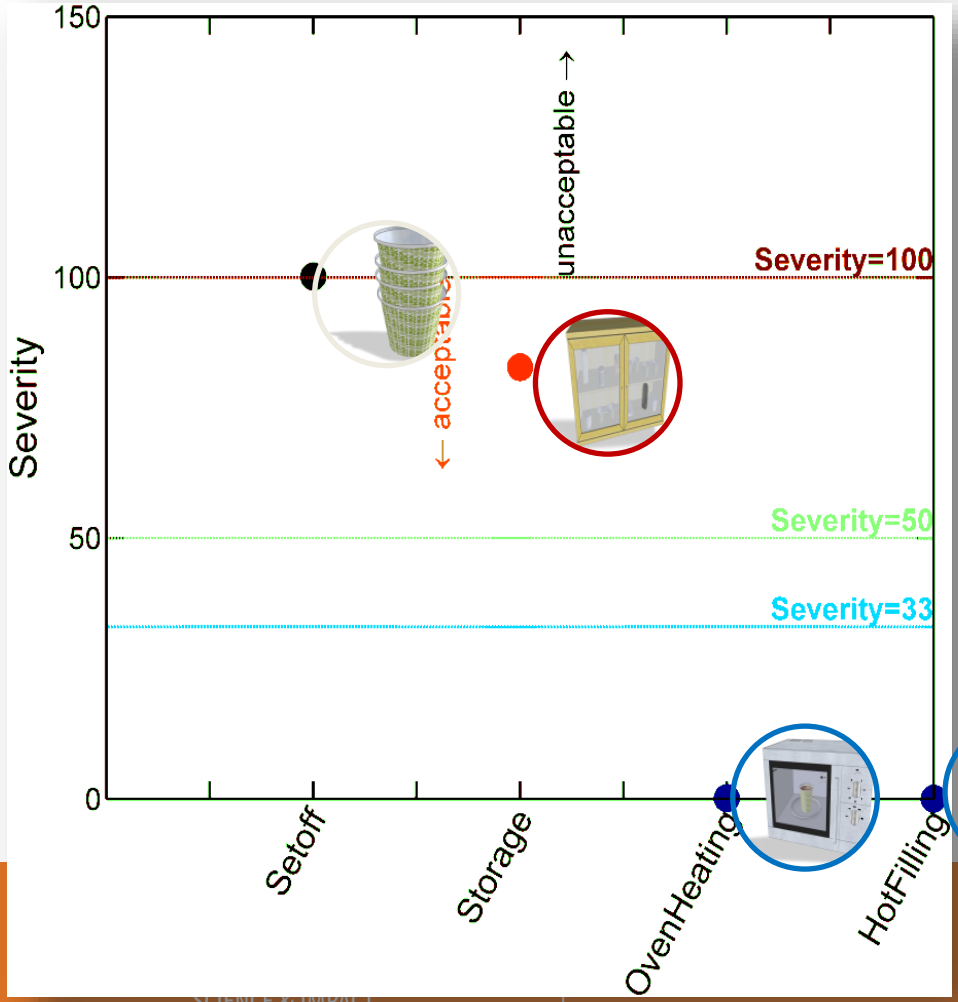


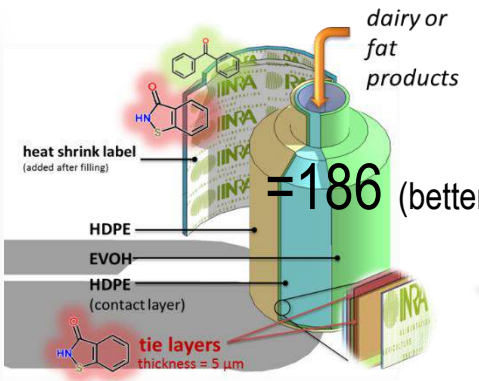

STORAGE "BEFORE USE"
HOT FILLING
FATTY CONTACT
LONG-TERM STORAGE
MICROWAVE OVEN HEATING


1: Setoff →
2: HotFilling →
3: Storage →
4: OvenHeating
ink
food
PP
base
$C_P(x,t_{final})$ (kg·m^{-3})
$C_F(t_{final})$ (kg·m^{-3})
x (m) x 10^{-4}
$C_F(t)$ (kg·m^{-3})
t (days)


Setoff (max. 100 days@25°C)
HotFilling (max. 10 mi@80°C)
Long-term storage (max. 200 days@25°C)
Microwave oven heating (max. 5 min@100°C)
CF

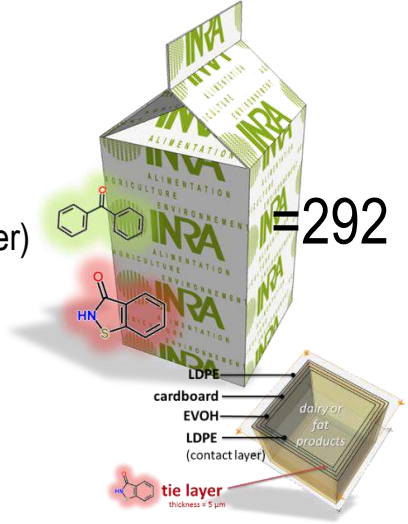

HotFilling (max. 10 mi@80°C)
Long-term storage (max. 200 days@25°C)
Microwave oven heating (max. 5 min@100°C)
CF



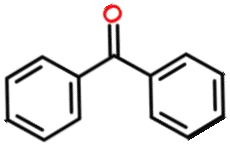


=186 (better)

tie layer = EVA



=292

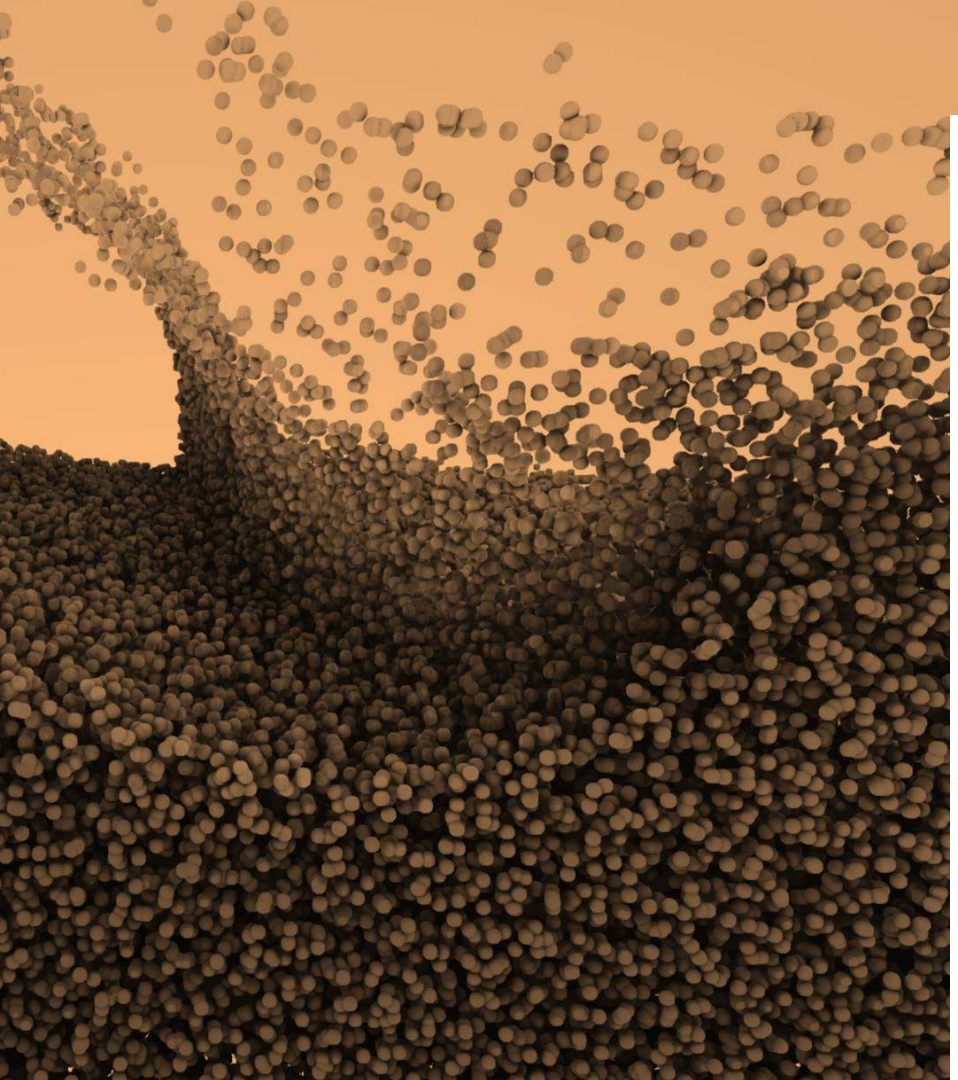


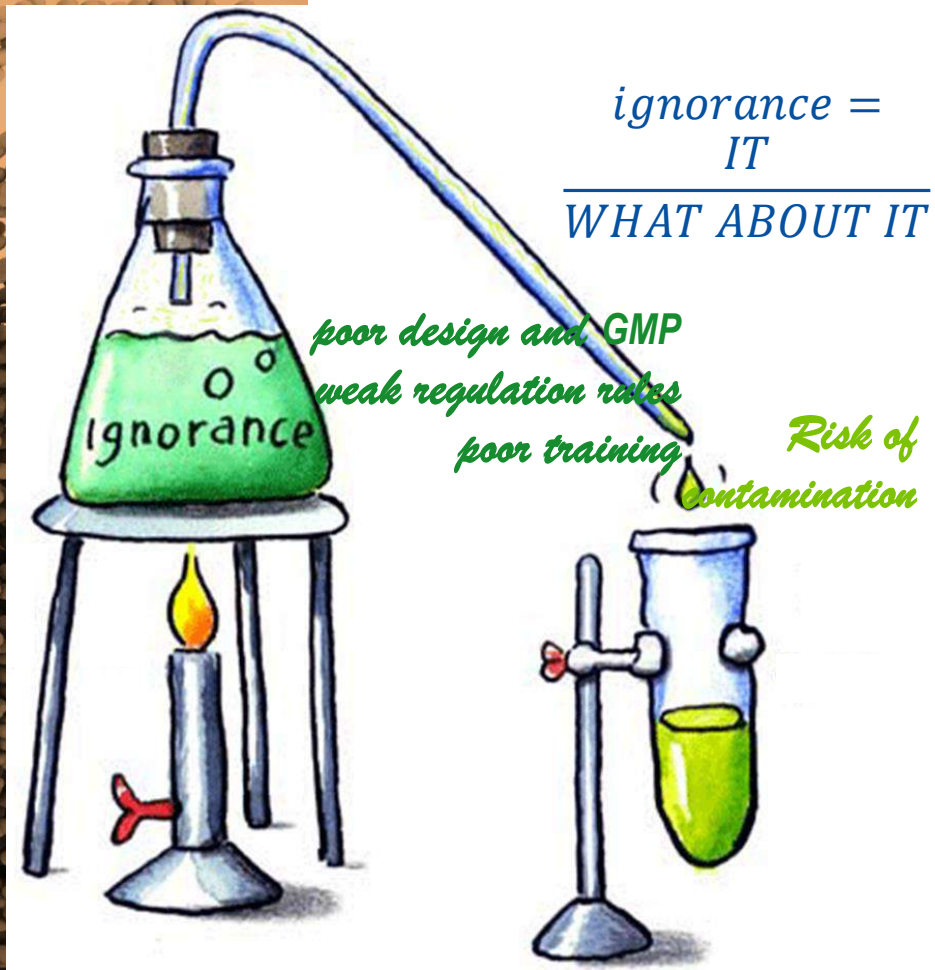
=115
(almost acceptable)

=124

CARREFOURS
DE L'INNOVATION AGRONOMIQUE

CONCLUSIONS

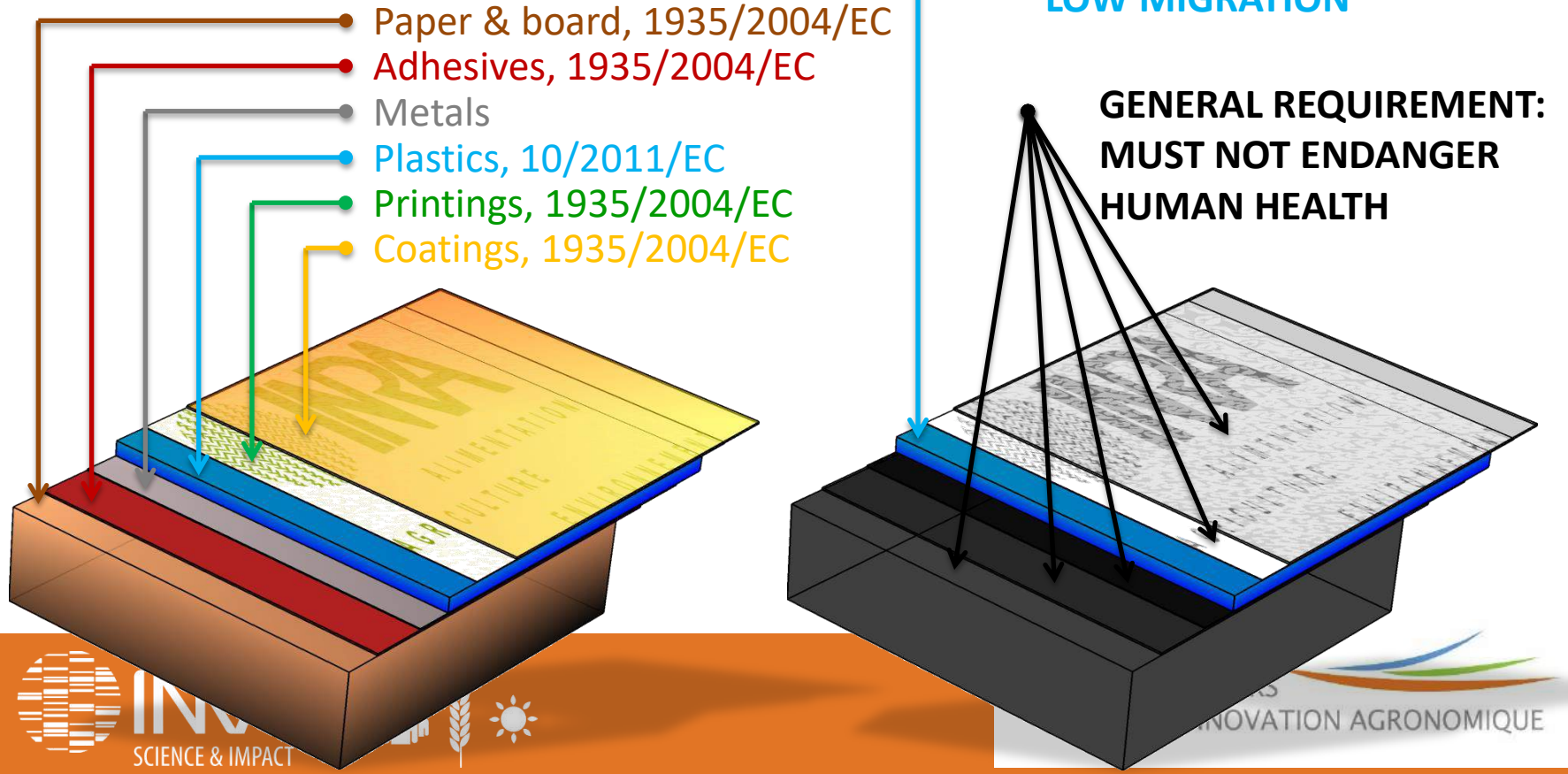


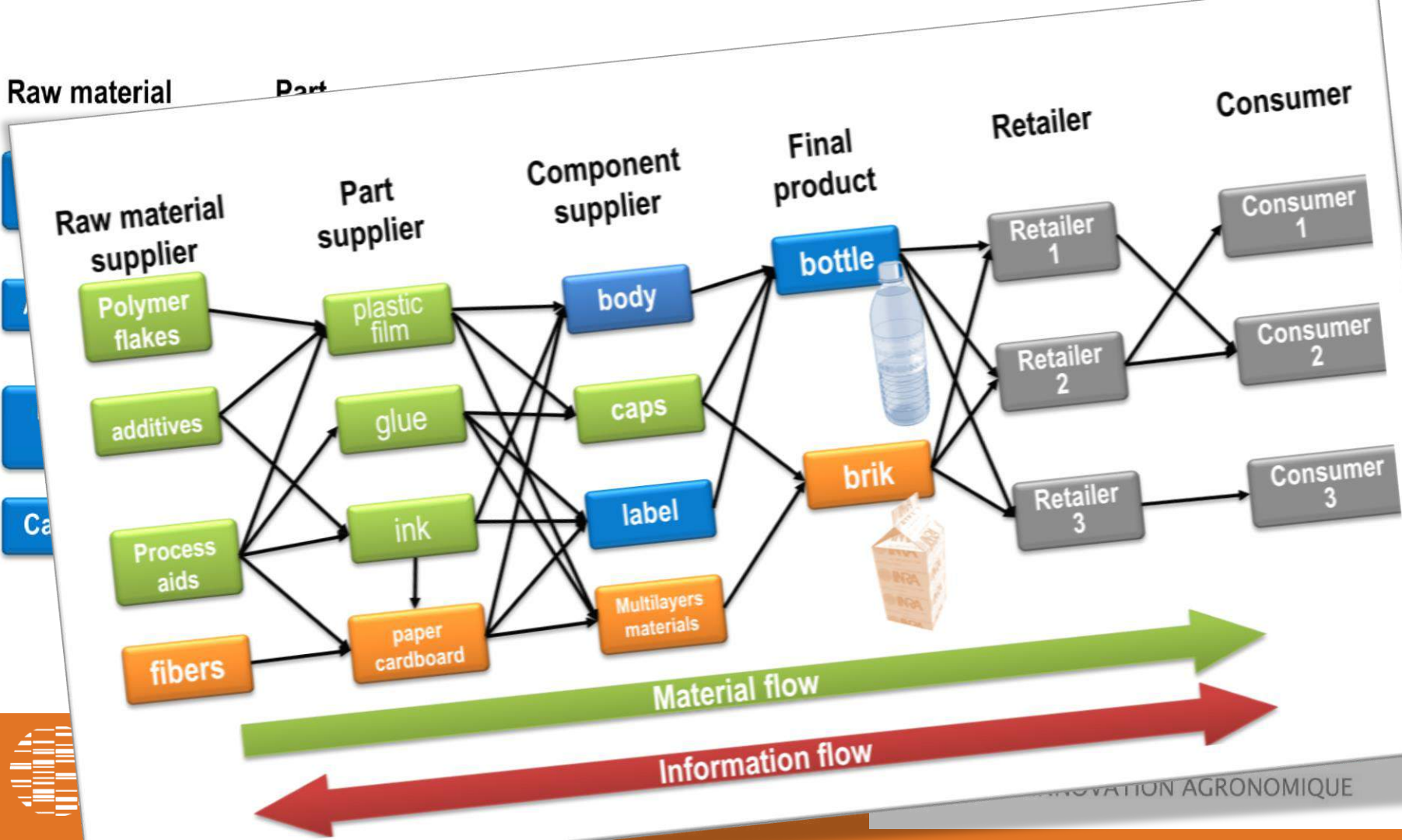


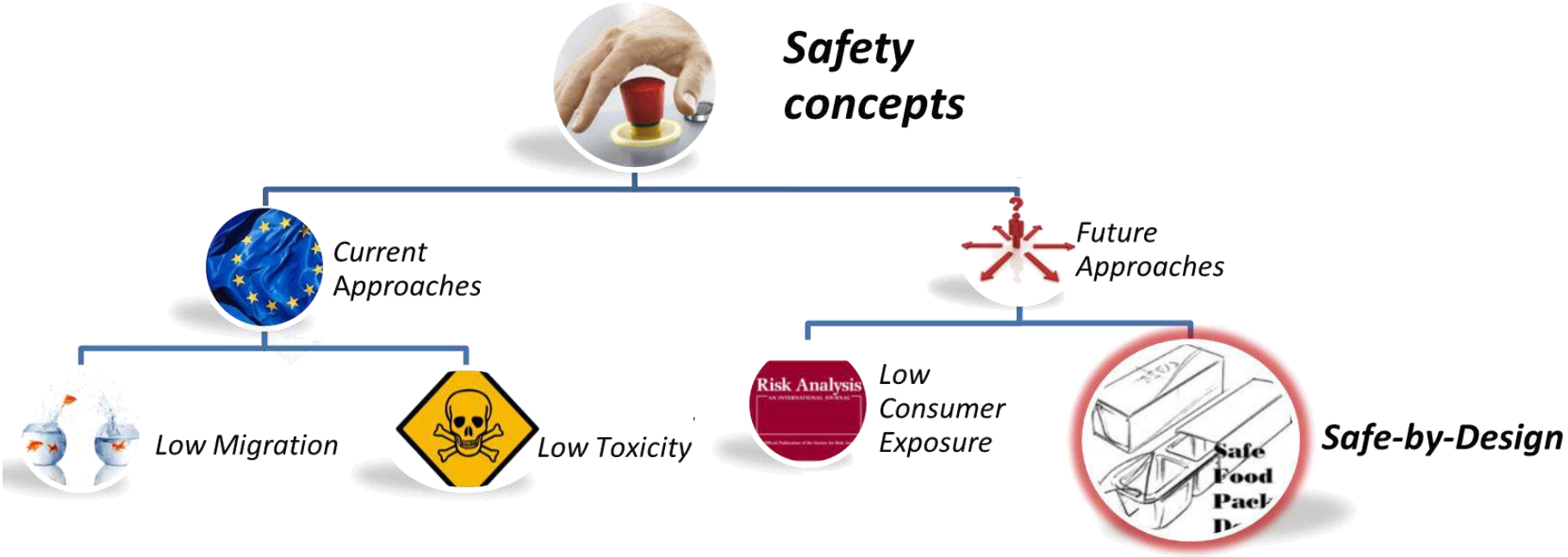
$$ignorance = \frac{IT}{WHAT\ ABOUT\ IT}$$

poor design and GMP
weak regulation rules
poor training

Risk of contamination


Paper & board, 1935/2004/EC
Adhesives, 1935/2004/EC
Metals
Plastics, 10/2011/EC
Printings, 1935/2004/EC
Coatings, 1935/2004/EC
POSITIVE LIST (LOW TOXICITY: monomers, additives)
LOW MIGRATION
GENERAL REQUIREMENT:
MUST NOT ENDANGER
HUMAN HEALTH


Raw material
Part
Raw material supplier
Part supplier
Component supplier
Final product
Retailer
Consumer
Polymer flakes
additives
Process aids
fibers
plastic film
glue
ink
paper cardboard
body
caps
label
Multilayers materials
bottle
brik
Retailer 1
Retailer 2
Retailer 3
Consumer 1
Consumer 2
Consumer 3
Material flow
Information flow

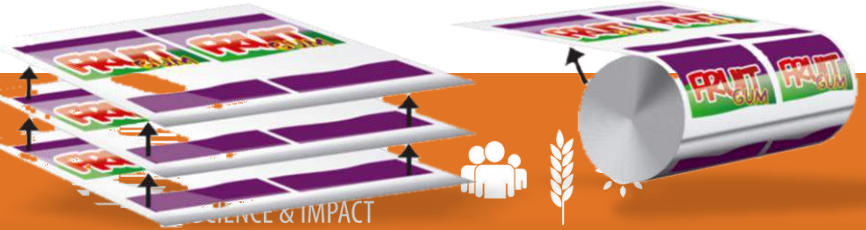


+VOLUNTARY APPROACHES & LOCAL ORDINANCES

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

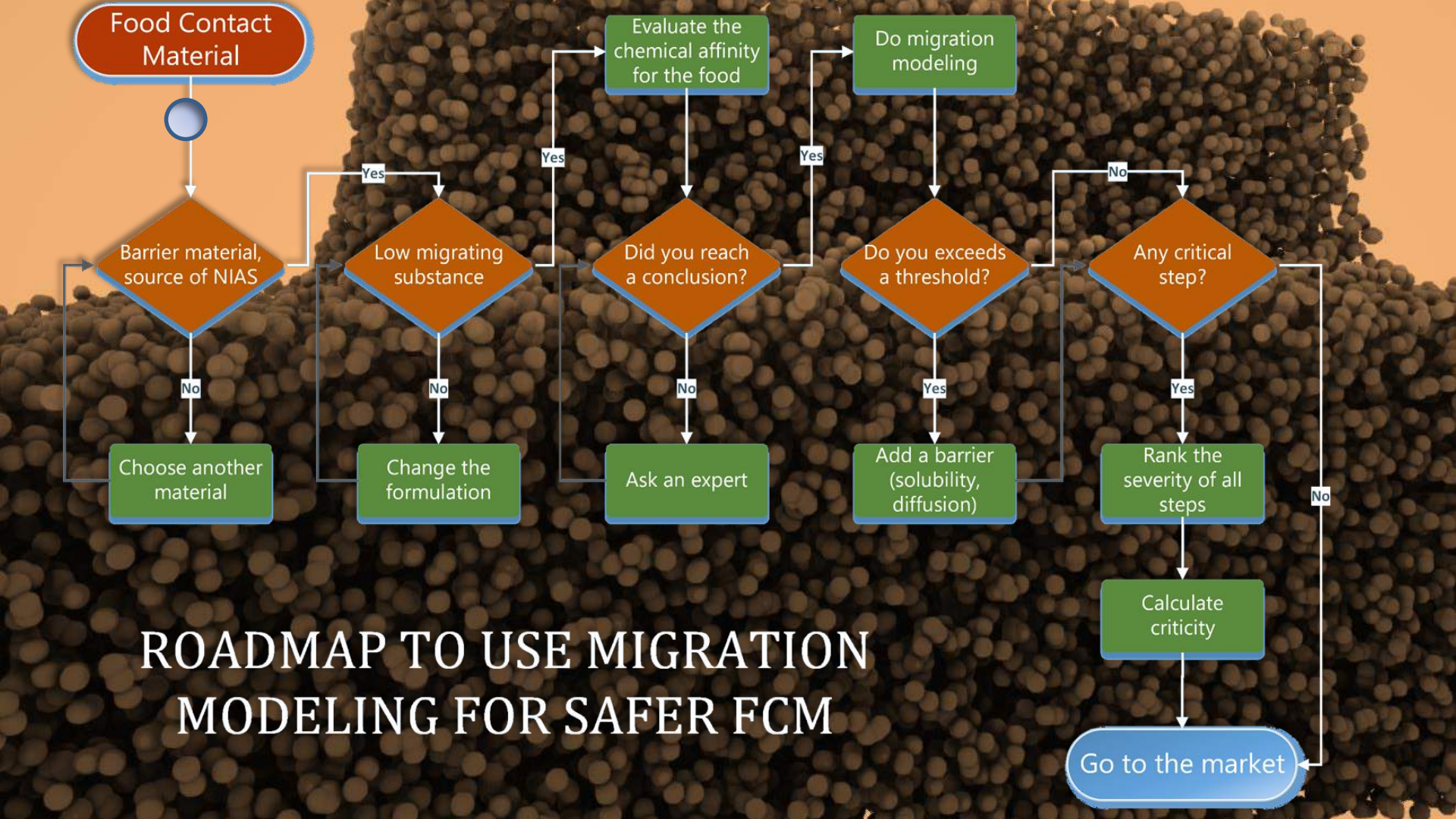
PRINTING INKS
(EUPIA guidelines to be revised)

- Exclusion/Negative lists
- Recommended substances
- Purity/traceability requireme
- 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


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
No
Go to the market
ROADMAP TO USE MIGRATION MODELING FOR SAFER FCM