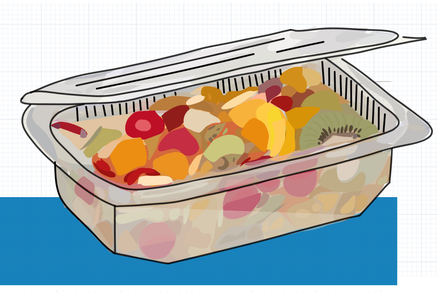
Is it safe to use recycled PET for food contact without a decontamination step ? Case of ABA trays

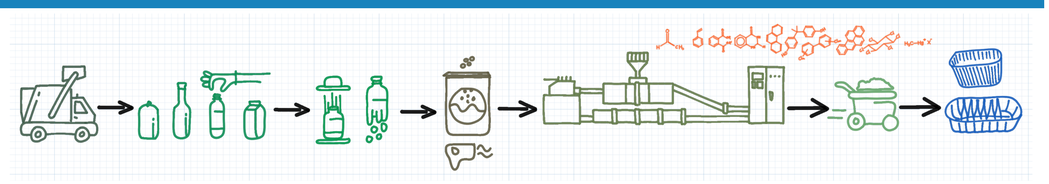


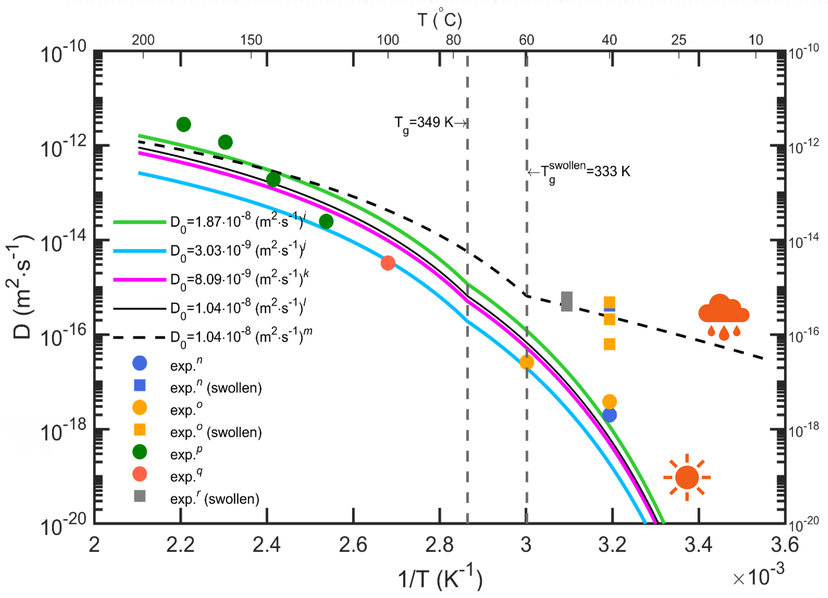
Summary

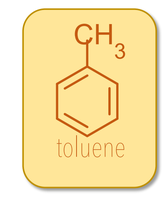
Currently, PET is primarily recycled for beverages. There is an urgent need to extend the use of recycled plastics to other food contact applications. Due to lack of supply, the project ABA (between LNE, CITEO, CTCPA, IPC, INRAE) is exploring the possibility to use non-decontaminated PET in the B-layer sandwiched between two A-layers of recycled and decontaminated PET.

The projects evaluates the contamination levels of streams available on the French market and estimate by modeling the required thickness of layers A to meet EFSA standards for carcinogenetic and genotoxic chemicals originating from post-consumer recycled PET. Experimental validation are carried out on formulated ABA system trays in contact with standard food simulants.

According to Zhu et al. (2019), two extreme scenarios are required to represent "☀" ($T_g \rightarrow 76°C$) and "🌧" (plasticized, $T_g \rightarrow 60°C$) states of PET.







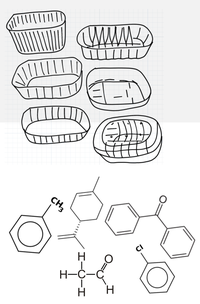
Arrhenius plot of diffusivities of toluene for different "dry" PET (continuous curves) and "wet" PET plasticized in boiling water (dashed curve),

Symbols represent experimental data,

Tested tray scenarios – TTC (genotoxic) 0.15 ppb for adults

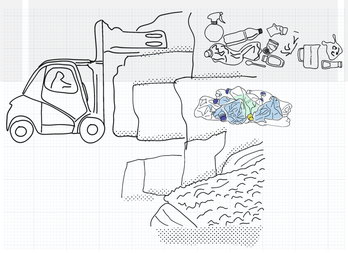
Scenarios

- 80 cases (geometry x food x use)
- 10 surrogates (worst-case=toluene)



Concentrations

- Concentration range reviewed in typical food-grade and non-food grade streams



Diffusivities

- Hole Free-Volume theory

$$D(\xi, T, T_g) = D_0 \exp\left(-\frac{E^*}{RT}\right) \times \exp\left(-\tilde{V}_1^* \frac{\alpha_{lin}(T,T_g) + 1}{0.24}\right)$$

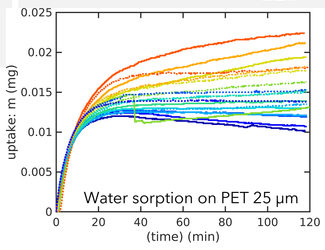
with $\alpha_{lin}(T,T_g) = 1 + \frac{K_\alpha}{r(T-T_g)+K_\beta}$

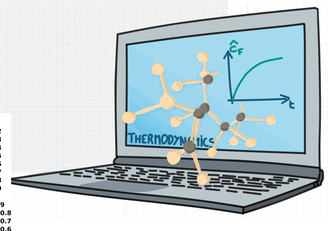
$$with\ r = \begin{cases} 1\ when\ T \geq T_g \\ \frac{\alpha_g}{\alpha_c} \quad T < T_g \end{cases}$$

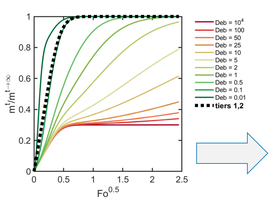
D_0 (m²·s⁻¹)	1.87·10⁻⁸
E^* (kJ·mol⁻¹)	0
$\tilde{V}_1^*$ (cm³·g⁻¹)	84.48

Plasticizing

- Microbalance measurements: water, toluene
- Non-Fickian parameters
- Polymer relaxation





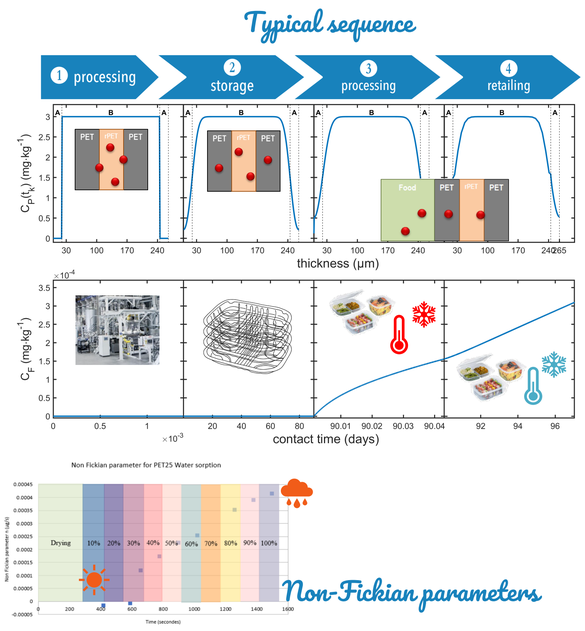


Non-Fickian kinetics

Simulations

- Multiple steps mass transfer including coextrusion

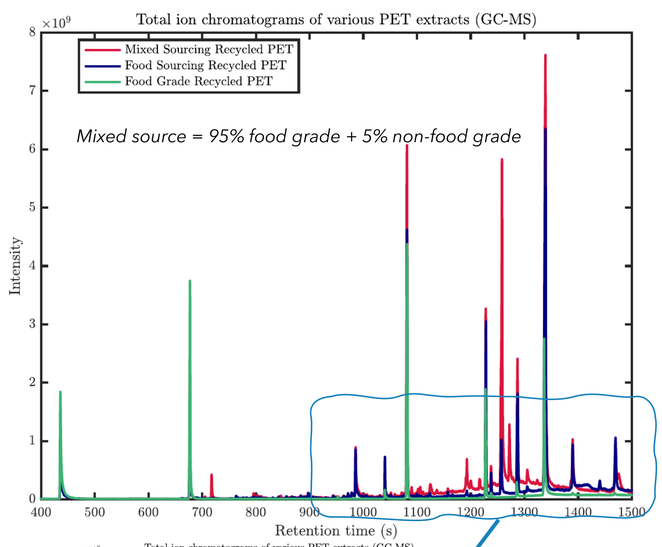
Typical sequence



Non-Fickian parameters

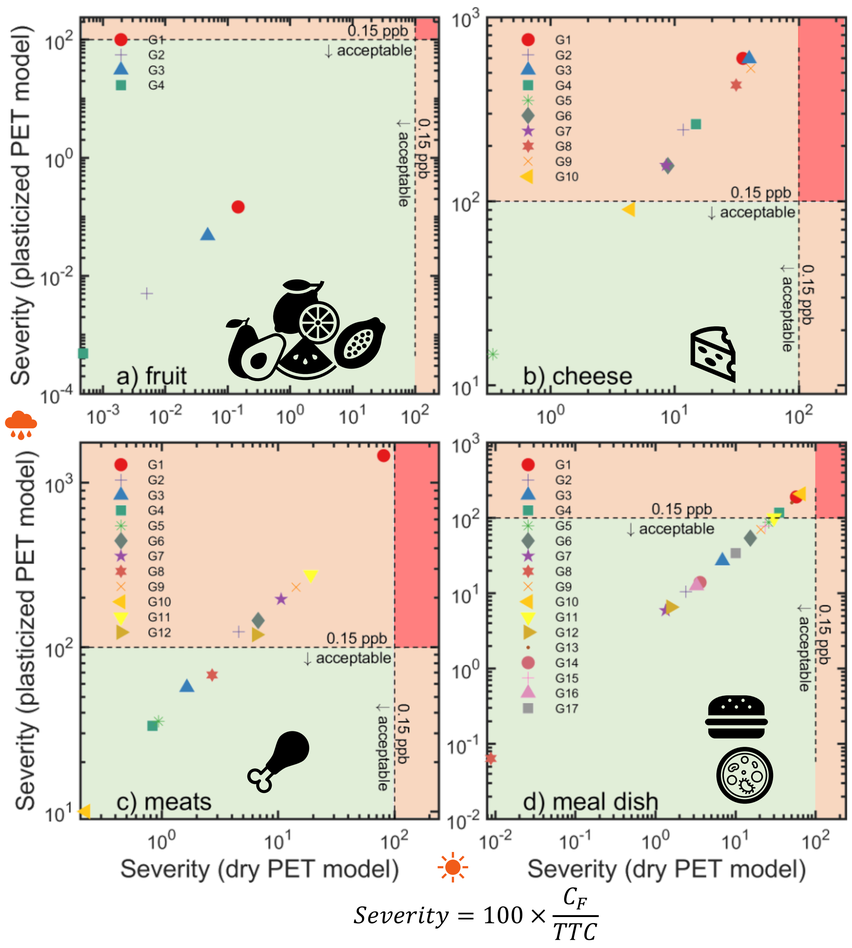
Only simulations can explore the consequences of "real" concentration ranges in streams. Experimental validations are possible only to check key parameters or by considering concentrations several hundred times higher.

Comparison of streams



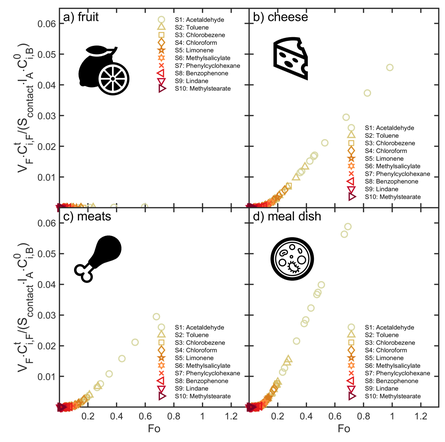
Silylated compounds, aromatics, oils, fatty compounds, detergent traces detected in recycled pellets. Decontamination during the recycling process is necessary if no functional barrier is added to the system.

Risk ranking



$$Severity = 100 \times \frac{C_F}{TTC}$$

Comparison of the severity of toluene with regard to the acceptable migration threshold for adults of 0.15 µg /kg-1 considering the plasticized or dry state of the PET for all the geometries studied.



Migration level of all studied substances as a function of geometry factors, process and use conditions and food applications.

There are acceptable and robust conditions in the presence of uncertainty.

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The project is part of the French Food Grade Recycled Material Consortium

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