R3PACK – REDUCE, REUSE, RETHINK PACKAGING TOWARDS NOVEL FIBRE-BASED PACKAGING AND REUSE SCHEMES

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EXECUTIVE SUMMARY

The objective of this task is to assess the food safety of reusable packaging by defining a comprehensive food safety protocol (performance and chemical tests on packaging) and auditing protocol applicable to washing practices for industrial reuse.

The task will address the 3 main areas to work on to ensure the packaging's food safety:

1. **Performance on packaging material regarding the repeated uses**
2. **Migration of the material into the product (food contact tests)**
3. Audit grid to control washing efficiency depending on the material

It will foresee the performance of a comprehensive set of chemical and mechanical tests and simulated rotations, allowing for up to 20 cycles of reuse, in all possible reuse conditions.

It will moreover allow the mapping of washing centers and different systems and protocols used in Europe with special focus on the concerned regions for the demonstration activities in WP5. It will lead to the definition of a food safety protocol and auditing protocol for washing centers for the different identified and analyzed reusable packaging options.

This report will concern performance on packaging material regarding the repeated uses and migration of the material into the product (food contact tests).

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INTRODUCTION

The task 3.2 - normalisation of food safety protocol is the next step of task 3.1 - selection of standardized packaging and recyclability assessment. The report of task 3.2 describes the process of choices on packaging.

SGS has selected packaging, already on the market, depending on materials, type of food products and performance tests to perform.

After having gone through the rationalization process for the packaging selection list (WP3.1), two groups of packaging were chosen to be tested.

The first group has the objective to validate or not the material resistance throughout the reuse scheme. It encompasses six packaging of all formats and all types of plastic resins (PET, PEHD, PP, PBT and Tritan). These packages will be subjected to the entire protocol including migration and performance tests on 0, 5, 10 and 20 cycles. If at any time, one packaging is too deteriorated to pursue the test, then it will be excluded from the protocol, and we will have an approximate idea of its life span in a reuse loop.

For reasons of time and resources, it was not possible to test more packaging with the whole protocol. However, it was important to verify the closing system of the references.

The second group comprises the equivalent references of the first group but in larger sizes. In fact, larger containers are more likely to deform due to heat, shocks, etc, and thus to deteriorate the closing system and the hermeticity of the container. The five packaging of the second group will be exposed only to performance tests*.

**except for bottle and PET packaging, that will not endure microwave tests because bottles won't be put in microwave and PET materials is too sensitive to heat.*

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In the first part, SGS will explain the reuse protocol process. On the second part, SGS will expose testing results. Then, SGS will share choices and constraints on this part of the project.

1. PROTOCOL

1.1. TESTING PROTOCOL

On the basis of reusable food packaging already on the market, we had to create a reuse protocol over a maximum of twenty cycles in order to validate or not their suitability for food contact after repeated use.

We took into account the most stringent conditions with regard to food contact regulations and the physical use of the packaging.

To validate the packaging step by step and to see the behaviour of the materials, we carried out abrasion, dishwasher and microwave cycles and then, after a visual check, we carried out chemical tests, food contact tests, organoleptic tests and NIAS tests. These physical, mechanical, and chemical test cycles were carried out at cycles 5, 10 and 20.

In order to have a reference and to start comparing, we carried out the chemical tests before any physical use.

1.1.1. Summary of Food contact regulation:

In Europe, Food contact packaging must comply to the European Regulation 1935/2004/EC.

Materials and articles, including active and intelligent materials and articles, shall be manufactured in compliance with good manufacturing practice so that, under normal or foreseeable conditions of use, they do not transfer their constituents to food in quantities which could:

- endanger human health;
- bring about an unacceptable change in the composition of the food
- bring about a deterioration in the organoleptic characteristics thereof.

To verify these 3 general rules, we can check different points like migration tests, composition tests and sensory tests.

Migration tests allow to evaluate the transfer of chemical substances from packaging material to food. The food can be replaced by simulant (chemical solution close to food aspect). The test is performed according to the real use of the packaging (Temperature of use and duration of contact with food).

In the plastic regulation 10/2011/EC, specific table give these testing conditions:

- Choice of simulant –
    - regulation 10/2011/EC- Annex III- Table 2- food category specific assignment of food simulants + Table 3- Food simulant assignment for demonstrating compliance with the overall migration limit
    - choice of testing conditions Regulation 10/2011/EC- Annex V- Chapter 2 - Testing for specific migration of materials and articles not yet in contact with food – table 1- Selection of test time + table 2- Selection of test temperature Regulation 10/2011/EC- Annex V- Chapter 3- Testing for overall migration – table 3- Standardized conditions for testing the overall migration.

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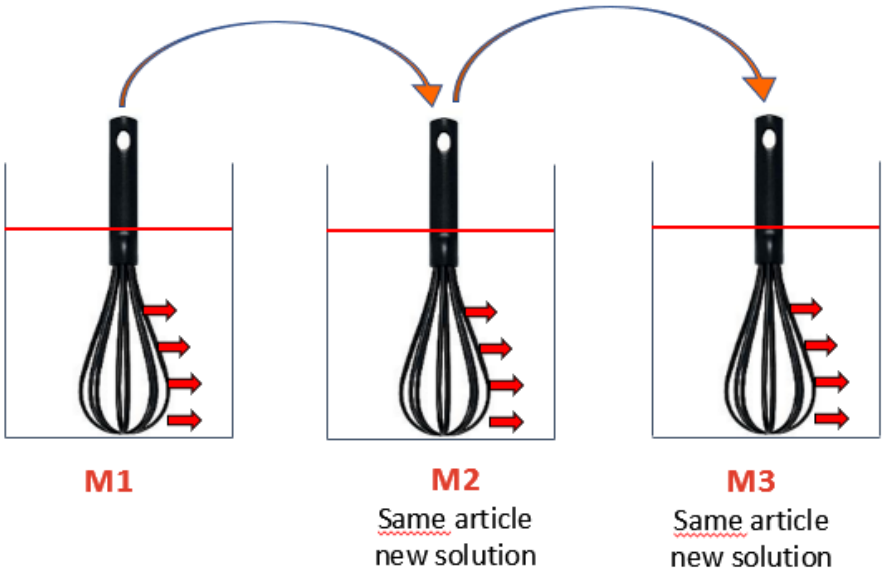
Single use & repeated use article

In plastic regulation 10/2011/EC, 2 types of products are concerned: single use product and repeated use product. The validation of compliance is different for these 2 categories.

Single use article: 1 migration is performed by simulant and the result is compared to regulatory limit to get the compliance.

- Repeated use article: 3 successive migrations are performed on the same article with 3 new fractions of simulant. We get 3 values of migration M1, M2, M3. The compliance is given with 2 conclusions:M3 ≤ regulatory limit
- Stability Evaluation– Migration must decrease = M3 < M2 < M1



Actually, the regulation does not take in account the product wear over time like abrasion, deformation and the chemical risk that it can cause.

1.1.2. Food contact Testing conditions for Protocol

For R3PACK project, we decided to limit the choice of testing conditions to be able to mutualize the packaging for the maximum types of use.

We selected a contact with all types of food + dairy product so we took 3 simulants D1 (50% ethanol), B (3% acetic acid), D2 (fatty simulant)

The simulant D1 covers the simulant A (10% ethanol) used for all types of food.

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Foods covered	Food simulants in which testing shall be performed
all types of food	1. distilled water or water of equivalent quality or food simulant A; 2. food simulant B; and 3. food simulant D2.
all aqueous and alcoholic foods and milk products with a pH ≥ 4,5	food simulant D1

For D2 simulant (to simulate fatty food), we preferred to use substitutes (95% ethanol and isooctane) instead vegetal oil to facilitate the testing in the laboratory.

For Overall testing conditions, we chose OM5 to consider the largest use of selected packaging (storage at T° < 100°C, hot filling, microwave function).

OM5	2 h at 100 °C or at reflux or alternatively 1 h at 121 °C	High temperature applications up to 121 °C.

For one plastic Material (PET), we preferred to take a less restrictive conditions excluding microwave function.

OM2	10 d at 40 °C	Any long-term storage at room temperature or below, including when packaged under hot-fill conditions, and/or heating up to a temperature T where 70 °C ≤ T ≤ 100 °C for a maximum of t = 120/2^((T-70)/10) minutes.

To get the Food contact compliance according to regulation 10/2011/CE, we must perform all the required tests according to the use of the product. This step is called T0. The tests are listed below:

- Overall migration in different simulant (aqueous, acid, alcoholic, fat,..)
- Specific migration of 19 heavy metals
- Specific Migration of Primary Aromatic Amines for colored plastic
- Sensory test (transfer Odor and taste)
- Other specific migration according the composition of plastic (monomers, additives,..)

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For this study SGS did not perform specific migration of 19 heavy metals and other specific migrations to limit the number of needed samples. We focus only on major tests (overall migration and sensory tests).

We added the Migration of NIAS (Non-Intentionally Added Substances) for this study. The NIAS screening allows to evaluate the degradation of plastic material.

For next steps (called Tx, x being the number of cycles the product can make), we decided to select the most relevant tests and not all the regulatory tests to confirm with the given timeframe. We make a focus on:

- Overall migration in 3% acetic acid
- Overall migration in 50% ethanol
- Overall migration in 95% ethanol
- Overall migration in Isooctane
- Migration of Primary Aromatic Amines for colored plastic
- Migration of NIAS in fat simulant
- Sensory test (transfer Odor and taste)

For sensory test, we took the worst test conditions corresponding of all types of uses: Water during 2 h at 100°C.

1.1.3. NIAS (Non-Intentionally Added Substances) Testing

For NIAS screening, we performed the test in fat simulant 95% ethanol (worst case) during 2h at 60°C follow by 24h at 40°C

The migration was analyzed after tenfold concentration by GC-MS and GC-FID using Phenol-d6, Naphthaline-d8 and Bis(2-ethylhexyl)phthalate-3,4,5,6-d4 as internal standards (IS). Unless otherwise indicated, quantification was performed semi-quantitatively via response in GC-FID, using Bis(2-ethylhexyl)phthalate-3,4,5,6-d4 as reference. Identification of the detected substances was carried out by comparison of obtained spectra with commercial spectra libraries (NIST14, NIST05, Wiley7). We want to point out that a clear identification, without ambiguity, is not possible in all cases, especially if the search on the mass spectra data base does not lead to a non-ambiguous classification or the mass spectrum shows a non-significant fragmentation.

When Several organic substances were detected above the reporting limit of 0.01 mg/L in the simulant by GC-MS/FID, these substances were in part identified by comparison to commercially available spectra libraries

We have 4 categories of substances:

- Identified substances (listed in Regulation (EU) No. 10/2011)
  - We compare the measuring value of migration to Specific Limit of migration SML given by the regulation 10/2011
  - When The migration of the substances listed in Regulation (EU) No. 10/2011 is below the legally applicable SML. The sample meets the requirements of Regulation (EU) No. 10/2011.

- Identified substances – NIAS (not listed in Regulation (EU) No. 10/2011)
  - Several of the identified substances are classified as "non-intentionally added substances", NIAS for short. NIAS include impurities, reaction, and degradation products. There is currently no legal limit for many NIAS. As an indicator of

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potential toxicological concerns, these substances were assigned to Cramer classes with a respective threshold of toxicological concern concept (TTC) based on their structural characteristics.
    - The estimated exposition for identified NIAS is above the applicable TTC threshold (see TTC-Concept and TTC-limits). In course of this risk assessment, there is reason to assume that the identified NIAS pose a significant risk to human health. The sample does not meet the requirements of Regulation (EU) No. 10/2011.

- Alkanes
    - All alkanes are assigned to the Cramer class I with a respective to the TTC concept
    - The estimated exposition for the Alkanes is below the applicable TTC threshold (see Tab. A3). In course of this risk assessment, there is no reason to assume that the identified Alkanes pose a significant risk to human health. The sample meets the requirements of Regulation (EU) No. 10/2011

- Inconclusive substances
    - Some substances could not be identified with the applied analytical technique and commercially available databases. The TTC concept is only applicable to the assessment of substances with a known chemical structure. These substances were assessed as potentially genotoxic with the respective TTC of 0.0025 µg/kg bw/day (or the TTC of 0.00015 mg/adult/day) in accordance with the recommendations European Food Safety Authority (EFSA). However, the legislator has given no requirements to the toxicological assessment of unknown substances.
    - Therefore, the result was rated as inconclusive in these cases.

TTC-Concept and TTC-limits

The evaluation of the potential toxicological concerns for the detected substances not listed in Regulation (EU) No. 10/2011, was performed in accordance to "Guidance on the use of the Threshold of Toxicological Concern approach in food safety assessment" (EFSA, 2019) to all detected substances above the level of interest of 0.01 mg/L. The TTC is calculated based on an adult with a body weight of 60 kg (see Tab. A1). The exposition was estimated by assuming the amount migrating into 1 kg consumed daily.

Tab. A1: TTC-limit of the TTC-concept (EFSA, 2019) for an adult with a body weight of 60 kg.

Substance class	TTC-limit [µg/kg bw/day]	TTC-limit [mg/adult/day]	TTC-limit [µg/adult/day]
Substances of Cramer class I	30	1.8	1800
Substances of Cramer class II	9	0.54	540
Substances of Cramer class III	1.5	0.09	90
Organophosphates and carbamates	0.3	0.018	18
Substances with structural alerts of genotoxicity	0.0025	0.00015	0.15

1.1.4. Choice of performance tests

In order to determine the test protocol, the whole life cycle of packaging is analyzed according to the type of food contained and the possible use.

We have selected 3 performance tests: abrasion, microwave, and industrial washing.

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Constraints studied:

- Abrasion/scratches due to its use with knives/forks
- Hot filling
- Reheating in microwave
- Cleaning (dishwasher, industrial washer)

The protocol must be standardized and reproducible in the laboratory. It is therefore intended to simulate these aggressions by getting as close as possible to them.

As mentioned previously, all the constraints related to the use of the packaging in its final environment are listed. Given the mutualization of the packaging, an identical protocol is applied to all the selected packaging.

Abrasion/Scratches

The packaging may be subject to the use of knives and forks. The reuse of packaging implies the multiplication of these aggressions which can have an impact on the aptitude for food contact and the capacity of the selected packaging to resist the number of rotations to come.

In order to set limits for the test parameters, it is assumed that one use represents an average of 10 round trips of a knife.

Concerning the force to be applied, pre-tests have established a maximum value of 10N. Considering the diversity of the food contained and thus the variability of the type of consumption as well as the customer panel, an average value of 5N was retained.

Using a scratch and rubbing automatic machine 3 axis. This device allows automatic and repeatable scratching with appropriate force on a surface. It is equipped with a 0.75 mm diameter tip to simulate the blade of a medium sharp knife. With this technique, we can ensure the reproducibility of the test.

As the position of the generated scratches is random, the scratch test is conducted in such a way as to produce a checkerboard. This allows to cover a larger surface while creating overlaps on some areas.

The tests are performed to simulate 5 uses on some samples, 10 uses on another group of samples and finally 20 uses on a last group of samples. This corresponds to 50 round trips for the 5 cycles of use, 100 round trips for the 10 cycles of use and 200 round trips for the 20 cycles of use.

Each simulation of a cycle (10 round trips) is performed on the same line. Below is an example of scratches made for 5, 10 and 20 cycles.

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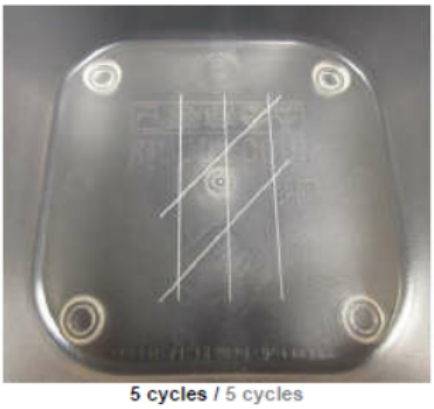
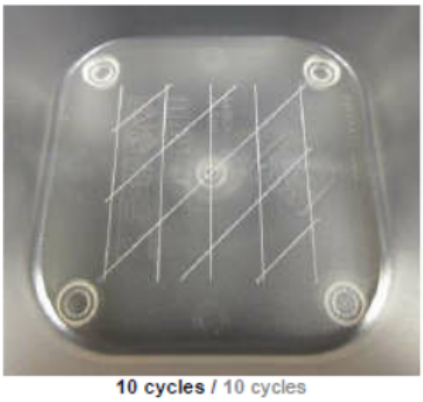
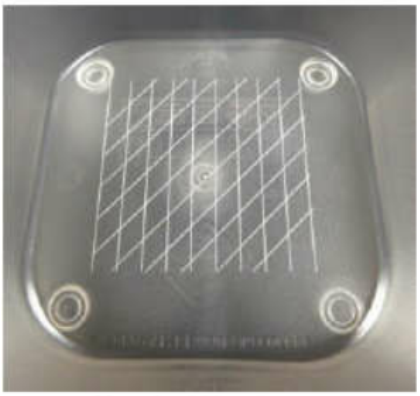


5 cycles / 5 cycles



10 cycles / 10 cycles



20 cycles / 20 cycles

Reheating in microwave

The use of these packages may involve reheating or defrosting with a microwave. The test protocol therefore includes heating cycles of the packages in order to put the product in the context of its final use.

As far as the microwave is concerned, we have used a classic power level, which is used most of the time, and therefore in severe conditions. Many recommendations ask you to lower the power of the microwave to heat up the dishes. The reality is quite different. 600W at 3'30'' against 2'' at 1000W, we assume the consumer tends to choose the easiest and quickest option. We therefore decided to use the 2 minutes at 1000W. The packages are filled with tap water at room temperature before each heating cycle. One heating cycle corresponds to one use.

Cleaning

Regarding the dishwasher, this test is not simple because it does not reflect all the types of washing that we have seen during our research, particularly on the audit grid, but also with our customers. There are many different washing methods, ranging from a few seconds to more than 2 hours, from industrial to domestic to canteen washing.

In order to propose a protocol that is feasible in the laboratory, we were inspired by existing standards and programs. The test is carried out in such a way as to simulate an industrial washing for plastic materials.

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Description of the cycle:

1. Cold pre-wash(1) : 3 minutes at 60 ± 5°C.
2. Washing(1,2): 3 minutes at 75 ± 5°C.
3. Neutralizing rinse(3) : 3 minutes.
4. Rinse with running water: 1 minute.
5. Cold demi rinse: 1 minute.
6. Hot demi rinse(1): 1 minute at 75 ± 5°C.
7. Drying: 30 minutes with door open.

(1) Approximately 8 minutes to be added to the time to reach a temperature higher than 50°C.

(2) Use of detergent for laboratory glassware. Amount used: approximately 5 mL/L per cycle according to the manufacturer's instructions.

(3) At room temperature with the use of a rinse aid for laboratory glassware such as acetic acid (neutral). Amount used: approximately 3 mL/L per cycle according to the manufacturer's instructions.

For the temperature, we set a temperature that is bearable for the majority of plastics i.e. 75°C. The detergent has a basic pH, we based ourselves on the most common washing methods, then finally the drying part.

Finally, for some packaging, after these performance cycles, we checked the compatibility of the lids. Without a lid, the packaging cannot be reused.

As in the previous test, one wash cycle corresponds to one use.

For each package, we carried out a visual check after these cycles before sending the samples for chemical testing.

Thermal shock

The life cycle of a bottle is different from that of a tray. They are not intended to be reheated but can be filled while hot and put in the refrigerator. To take into account this type of constraints, a thermal shock test has been set up. The aim is to simulate the instantaneous temperature difference that the bottles can undergo.

The bottles are filled before the test with water at room temperature.

To carry out the thermal shock, we use a specific climatic chamber allowing to switch in less than 3 seconds the samples from a hot compartment to a cold compartment.

The cold temperature used is 0°C for the most unfavorable case of a refrigerator.

The hot temperature retained is 100°C to be placed in a temperature close to that used for the pasteurization.

The temperature steps are of 10 minutes.

A cycle of use thus corresponds to 10 minutes at 100°C then 10 minutes at 0°C.

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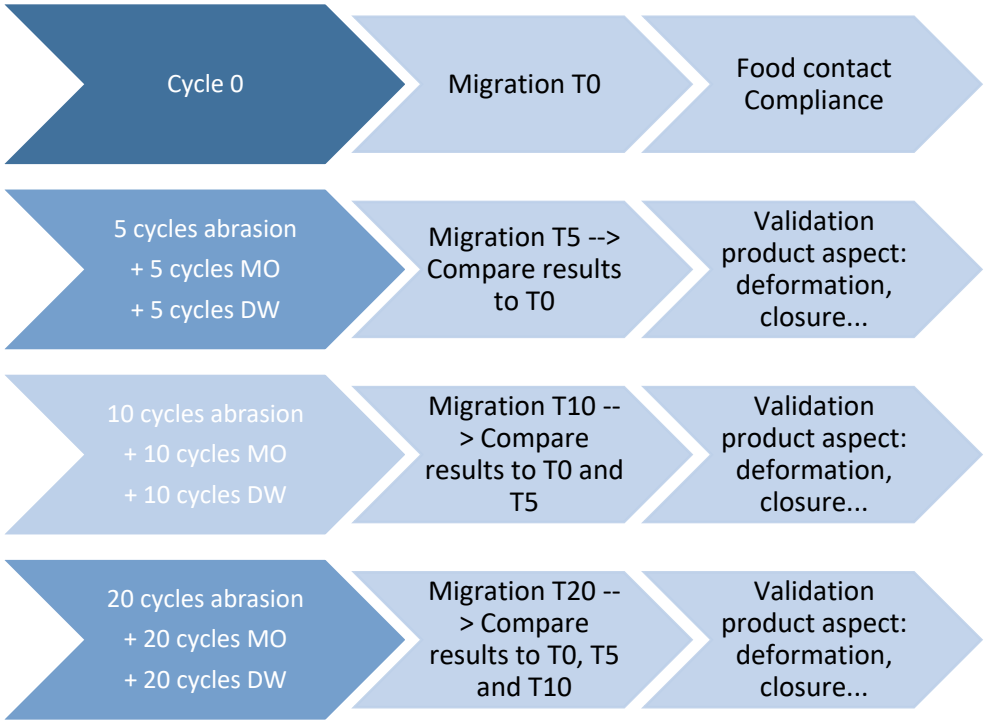
1.2. COMPLETE PROTOCOL

The aim of this protocol is to combine food contact analyses and performance tests to see the impact of the product wear on product aspect and on migration of chemical substances. This protocol has been based on closed loop and includes a wide range of plastics packaging.

The protocol we applied for R3PACK project is:



**MO: microwave test*

**DW: dishwashing test*

We performed food contact test in the beginning to get the compliance according to the regulation (step T0).

In parallel, we performed different cycles of performance tests combining Abrasion, Micro-wave and washing.

After 5,10 and 20 cycles (steps T5, T10 and T20), we performed selected Food contact tests, and we compared the results with step T0 to see if the migration of chemical substances has changed after different uses.

We also check the product aspect after these cycles to observe any deformation, discoloration, problem of closure, and other visual aspects to report.

The protocol is not fixed. We can adapt it according to the product and the final use, for example for the number of cycles, the selected chemical and performance tests.

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In R3PACK, we tried to be as wide as possible to cover a maximum of use and to have the same packaging for all applications (pack mutualization):

- Packaging in contact with all type of food
- All applications: storage, microwave application, Eating in the product, Industrial Washing

Regarding the setting up of this protocol into a future potential regulation, we insist on adapting those performance and chemical analysis on the number of cycles claimed. This means for a product with a 200 cycles claims, we should conduct 200 cycles of performances tests and validate the ability of the material on food contact, organoleptic and NIAS releases.

2. DATA REUSE AND GENERATION

To avoid targeting the manufacturers of the reusable packaging tested, we have chosen to anonymise samples and renamed them as below:

Pack 1 big black PBT
Pack 2 big TRITAN
Pack 3 big M-ABS
Pack 4 TRITAN
Pack 5 big PP
Pack 6 small PP
Pack 7 small TRITAN
Pack 8 small black PBT
Pack 9 small M-ABS
Pack 10 PET
Pack 11 bottle white PE

Each packaging has its own material composition (type of plastics, additives, colorants…), therefore our analysis and tests cannot be generalized by type of plastics.

2.1 PANEL ANALYSIS

During our R3PACK physical consortium meeting on January 2023, SGS has conducted 2 panels to experiment the use of packaging with random consumers. The panel was not included in the R3PACK project, but SGS used the data to go further on protocol bias.

Panelists were volunteers' members of the consortium.

2 panels have been done:

1. Observe: to collect general impression for all packaging we have selected after W.P3 task 3.1
2. Use: eat in the packaging to collect data on the real-life experience

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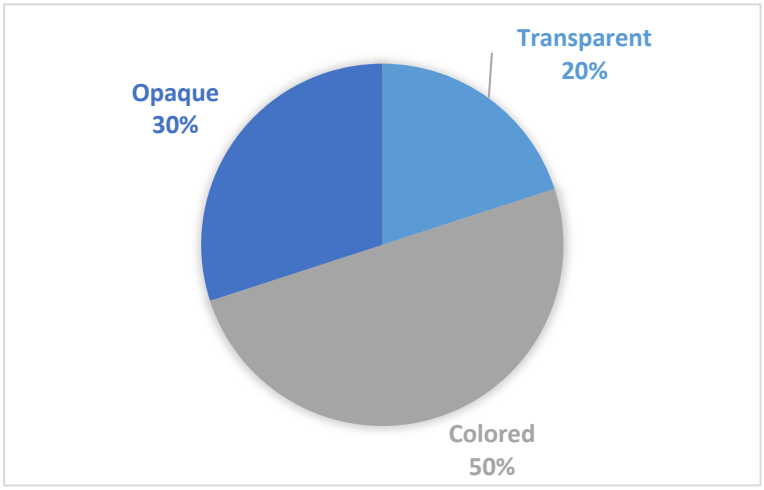
2.1.1 Panel Observe

Chosen packaging, anonymously:

Packaging preference

What is your packaging preference?

This question was a starter to see what kind of packaging will provide the best experiment to consumers.



50% of persons prefer colored packaging.

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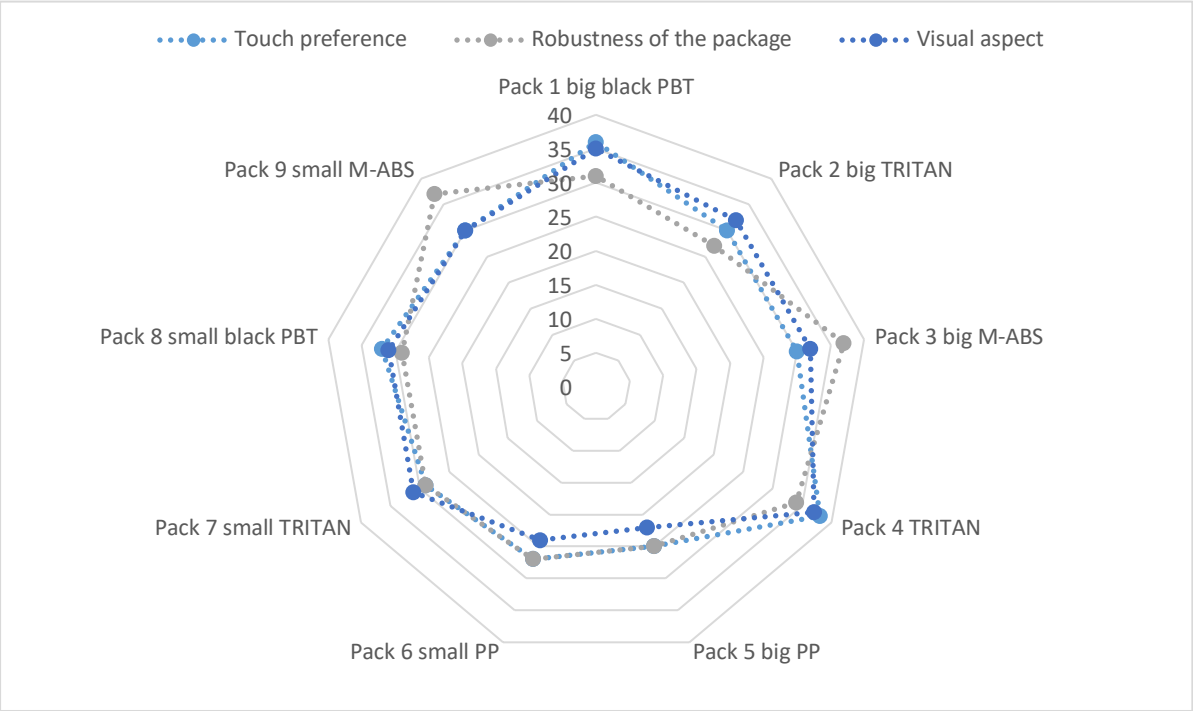
Packaging analysis

Ranking from 1 to 4: 1 – poor quality to 4 - high quality

Score on 120 points

Through 3 parameters such as touch preference, robustness and visual aspect, our panelists have ranked their packaging preferences.



Pack 4 TRITAN is beyond expectation on touch, robustness, and visual preference with 109 points. **Pack 1 big black PBT and pack 3 big M-ABS** are just behind with respectively 102 and 99 points.

In parallel, the bucket pack 5 big PP was not successful, certainly the format is not appropriate for BtoC reuse.

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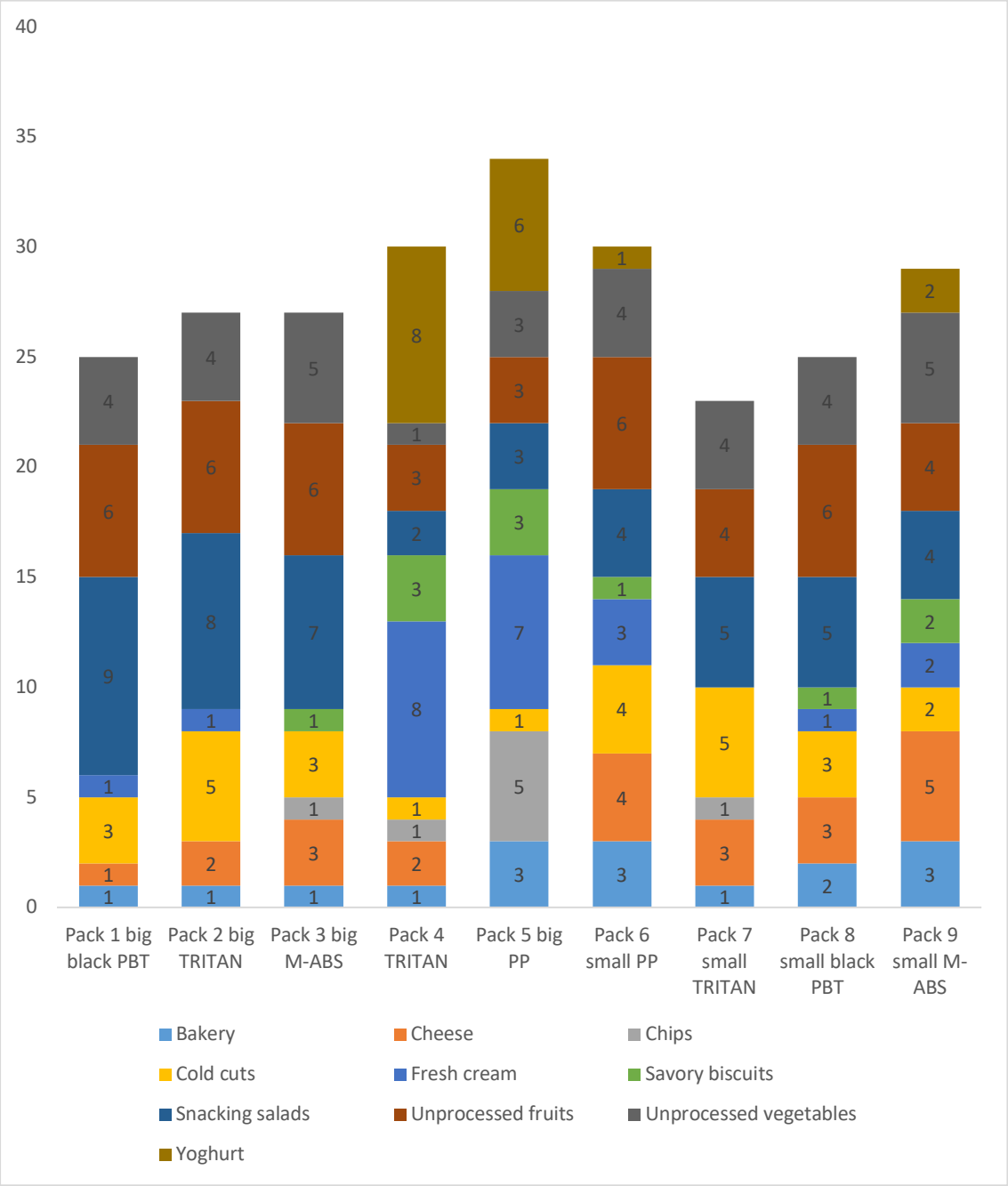
Use per packaging

What kind of food will you put in it?



Even if the bucket **pack 5 big PP** was not successful on visual and touch preference, every panelist agrees on the multitude of use up to 35 votes and all food types.

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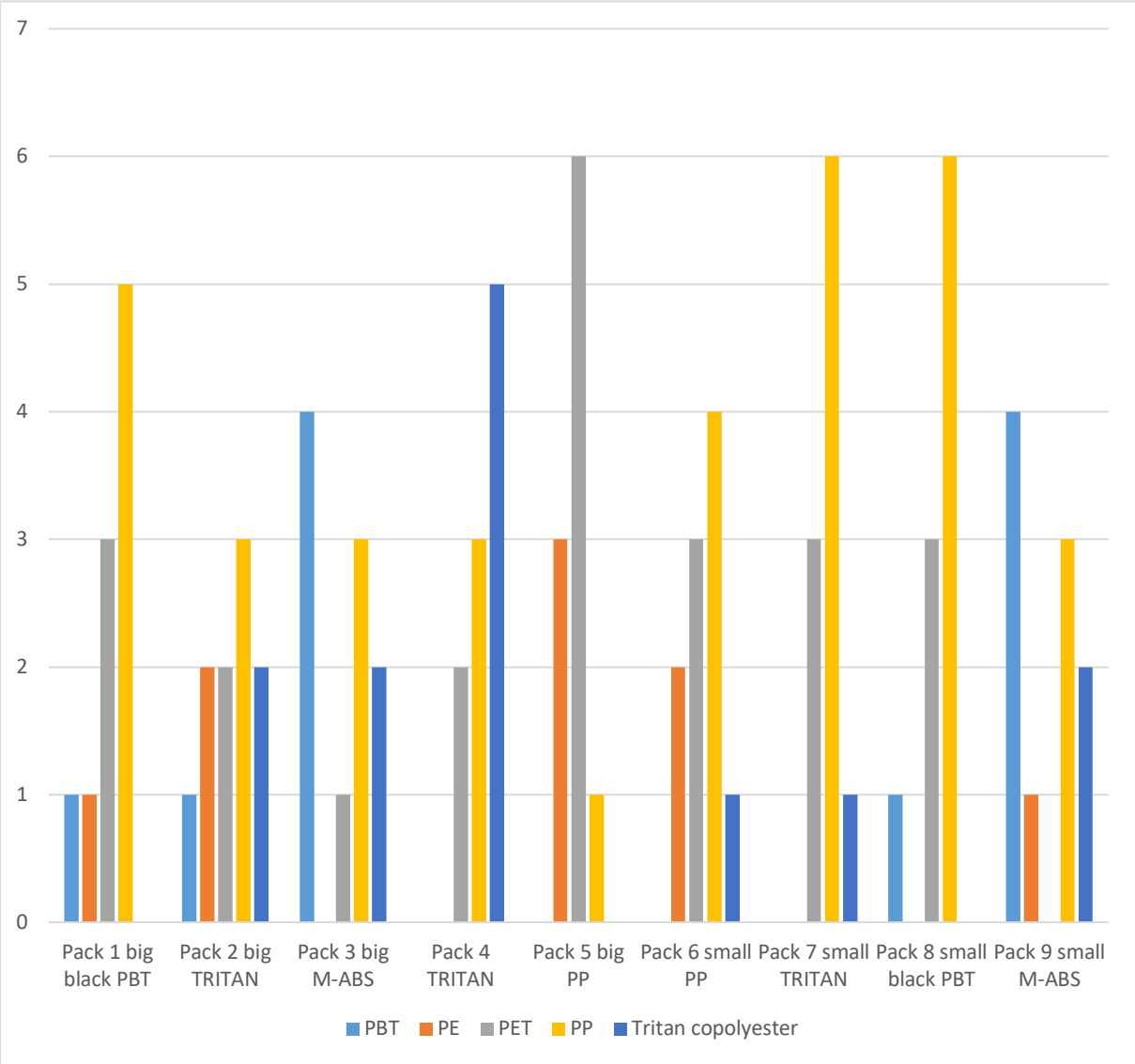
Guess the material

As packaging are made of different type of plastics, this question allows to apprehend our perception of plastics and to know if experts and common consumers can guess which plastics are packaging made.



This question was not easy. Over 9 packaging, only 2 (pack 4 and pack 6) of them got maximum of correct answers. This means material is very difficult to track.

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Ranking

Among all packaging presented, panelists had to rank by their preferences packaging.

In the general ranking, we observe the same first 3 packaging on visual and touch preferences and sensory aspects.

Main adjectives

The idea of this open question was to collect panelists impressions on each packaging.

	Pack 1 big black PBT	Pack 2 big TRITAN	Pack 3 big M-ABS	Pack 4 TRITAN	Pack 5 big PP	Pack 6 small PP	Pack 7 small TRITAN	Pack 8 small black PBT	Pack 9 small M-ABS
+	Smooth (7) Solid (4)	Smooth (4) Solid (3) Flexible (3)	Solid (9)	Solid (6) Smooth (4)	Flexible (4) Smooth (2) Solid (2)	Smooth (4) Solid (3) Flexible (2)	Smooth (4) Solid (4)	Smooth (7) Solid (3)	Solid (7)
-	Fragile (3) Rigid (3)	Rigid (3) Fragile (2)	Rough (6) Rigid (3)	Rigid (2)	Fragile (3) Cheap (2) Rough (2)	Rigid (3) Fragile (3) Rough (2)	Rigid (3) Fragile (2)	Rigid (5) Fragile (2)	Rough (4) Rigid (3)

One more time, the best packaging are Pack 4 TRITAN, pack 3 big M-ABS and pack 1 big black PBT.

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2.1.2 Panel use: Eat in the pack

13 panelists have tested on packaging between pack 1, 2 and 3 to eat.

The goal of this use panel was to collect impression and meal experience and then to analyze scratches on packaging at the laboratory.

	Pack 1 big black PBT	Pack 2 big TRITAN	Pack 3 big M-ABS
Number of persons	5	3	5
Lunch type	100% meat	67% meat, 33% fish	60% meat, 20% fish, 20% vegetarian
Use of fork	80%	100%	100%
Use of knif	60%	100%	40%
No inconvenient	100%	100%	100%
Rate the ease of opening	95% easy	83% easy	80% easy
Rate the ease of closing	90% easy	67% easy	80% easy
Sharp edges	100% no	100% no	80% no, 20% yes
Adjectives	hard, resistant	nice, with scratched	no problem, rough pack so interesting
Scratches after eating	100% no	67% no, 33% yes	60% no, 40% yes (with knives)
Suitable to be reused in a BtoC scheme	100% yes	100% yes	100% yes
Very positive feedbacks	very positive	positive	positive
Score	Score ++	Score +	Score -
Comments		use of knives superior than n°3 with less scratching	lots of scratching for the use of only 20% knives
Place in the ranking panel "observe"	3	4	2
Conclusion	**Pack 3 big M-ABS is the highest in the ranking for observe but it gets the worst experiment compared to pack 1 big black PBT**		

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2.2 FOOD CONTACT RESULTS ON T0 CYCLE

This part includes tests results of T0 cycle on chemical tests.

In the below table, we can see a resume of the results of Migration tests and sensory test

TEST	Test conditions	OM Acide	OM aqueux	OM gras	MS PAA	SENSORY TEST
Pack 6 small PP	OM5	PASS	PASS	**FAIL**	NA*	**FAIL**
Pack 9 small M-ABS	OM5	PASS	PASS	PASS	PASS	**FAIL**
Pack 7 small TRITAN	OM5	PASS	PASS	PASS	PASS	PASS
Pack 8 small black PBT	OM5	PASS	PASS	PASS	PASS	PASS
Pack 10 PET	OM2	PASS	PASS	PASS	NA*	PASS
Pack 4 TRITAN	OM5	PASS	PASS	PASS	NA*	PASS
Pack 11 bottle white PE	OM5	PASS	PASS	PASS	PASS	Problem with hot T° retest at lower T° PASS at low T°

** NA : Non applicable*

We observe that sensory tests are failed for 2 samples (Pack 6 small PP and Pack 9 small M-ABS) with the conditions 2 hours at 100°C in water.

The Pack 6 small PP is failed for overall migration in fat simulant. We can use this material for contact with other types of food like fruit, vegetables, dairy products.

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In below table, we resume the NIAS screening after migration in 95% ethanol:

	NIAS		
TEST	**Identified substances (listed in Regulation (EU) No. 10/2011)**	**Identified substances – NIAS (not listed in Regulation (EU) No. 10/2011)**	**Inconclusive substances**
Pack 6 small PP	1 substance	1 substance + 12 Alkans	39 Unidentified substances
Pack 9 small M-ABS	8 substances (1 inconclusive)	13 substances (3 FAIL) + 2 Alkanes	155 Unidentified substances
Pack 7 small TRITAN	1 substance	2 substances + 1 Alkane	17 Unidentified substances
Pack 8 small black PBT	1 substance	/	24 Unidentified substances
Pack 10 PET	1 substance	/	6 Unidentified substances
Pack 4 TRITAN	/	/	9 Unidentified substances
Pack 11 bottle white PE	/	3 substances + 35 Alkanes (5 FAIL)	60 Unidentified substances

We can find in annex 1 the details of all results.

2 samples presented failed results for NIAS migrations at T0: Pack 9 small M-ABS and Pack 11 Bottle white PE.

The article Pack 9 small M-ABS presents a high number of migrated substances. 1 identified substance is close to SML (Specific Migration limit) so we cannot put a conclusion but there is a FAILED result for 1 NIAS identified substance. We can also see 155 non-identified substances which shows that the matter is not stable under these testing conditions. There is a high degradation of material.

For Pack 9 small M-ABS sample, Benzaldehyde substance is identified in NIAS screening. There is a risk that the migration of this substance deteriorates the organoleptic characteristics of the food in contact and then, that the final product does not comply with Article 3(1) c of the Framework Regulation (EC) No 1935/2004. Sensory test for this sample is failed for odor and taste.

For Pack 11 bottle white PE, 5 Alkanes substances have been measured over the regulatory limit and 60 unidentified substances have been detected. The testing conditions is too high for this matter and the polymer degrades during migration tests.

For sensory test at high temperature (2h at 100°C), we also observe a degradation of polymer making it impossible to perform the test. We choose a lower testing condition (10 days at 40°C) and the result is passed

For other samples (Pack 4 Tritan, Pack 7 small Tritan, Pack 8 small Black PBT & pack 10 PET), Only few substances are identified. The value of NIAS substances which migrated into simulant are under

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regulatory limit or TTC limit. And the number of non-identified substances are small showing a little degradation of plastic material

In conclusion, after the T0 tests which determined the compliance of material with the testing conditions OM5, 3 samples are not good to be used for all applications (hot, storage, micro-wave): Pack 6 small PP (FAIL for sensory test), Pack 9 small M-ABS (FAIL for sensory test and NIAS screening) and Pack 11 bottle white PE (FAIL for NIAS Screening)

These samples cannot be used for packaging mutualization. They should be used for other applications (for example cold contact) but new tests must be performed with other testing conditions to confirm this compliance.

Pack 10 PET sample has been tested with lower testing conditions (OM2) because PET did not resist at High temperature. With these testing conditions, Pack 10 PET sample is compliant to food contact tests.

The two Samples made from Tritan (Pack 4 Tritan, Pack 7 small Tritan) and the PBT sample (Pack 8 small black PBT) seem to be the most stable polymers with the OM5 testing conditions; Overall migration results in 4 simulants are very low and no odor and bad taste have been detected during sensory test; The NIAS screening showed only the migrations of few substances under the regulatory limits.

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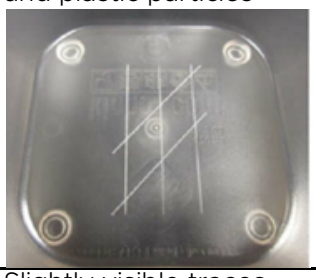
2.3 PERFORMANCE TESTS - ASPECT CHECKING

2.3.1 T5

Below is a summary of the results obtained for 5 cycles of use:

	RESULTS			
Samples	Test 1 Scratch resistance	Test 2 Microwaves	Test 3 Dishwasher	Global results
Pack 9 small M-ABS	Whitening in the scratches Appearance of grooves and plastic particles 	Slight trace of water and calcareous	No visible degradations	PASS
Pack 6 small PP	Slightly visible traces 	Slightly visible traces	No visible degradations	PASS
Pack 10 PET	Appearance of grooves on the smooth area, less visible grooves on the grained area 	Test not performed because not relevant to the use of the product	Irreversible deformation during the 1st cycle 	FAIL
Pack 7 small TRITAN	Whitening in the scratches Appearance of grooves and plastic particles 	No visible degradations	No visible degradations	PASS
Pack 8 small black PBT	Appearance of grooves and plastic particles Whitening or no whitening in the scratches	No visible degradations	No visible degradations	PASS

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Pack 4 TRITAN	Whitening in the scratches Appearance of grooves and plastic particles 	No visible degradations	No visible degradations	PASS

The PET reference is not suitable for reuse because it does not withstand the temperatures required for cleaning.

All the references show slight traces of scratches due to reuse, but the black PBT reference seems more resistant.

	RESULTS		
Samples	**Test 1** Thermal shock	**Test 2** Dishwasher	**Global results**
Pack 11 bottle white PE	No visible degradations	No visible degradations 	PASS

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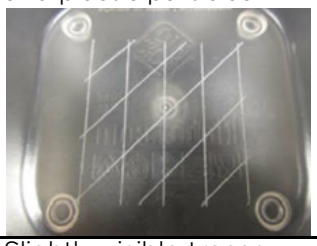
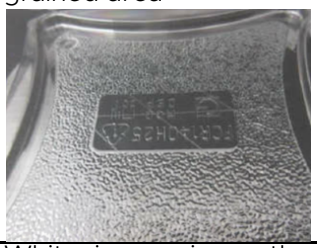
2.3.2 T10

Below is a summary of the results obtained for 10 cycles of use:

	RESULTS			
Samples	Test 1 Scratch resistance	Test 2 Microwaves	Test 3 Dishwasher	Global results
Pack 9 small M-ABS	Whitening in the scratches Appearance of grooves and plastic particles 	Slight trace of water and calcareous	No visible degradations	PASS
Pack 6 small PP	Slightly visible traces 	Slightly visible traces	No visible degradations	PASS
Pack 10 PET	Appearance of grooves on the smooth area, less visible grooves on the grained area 	Test not performed because not relevant to the use of the product	Not tested	FAIL
Pack 7 small TRITAN	Whitening in the scratches Appearance of grooves and plastic particles 	No visible degradations	No visible degradations	PASS
Pack 8 small black PBT	Appearance of grooves and plastic particles Whitening in the scratches 	No visible degradations	No visible degradations	PASS

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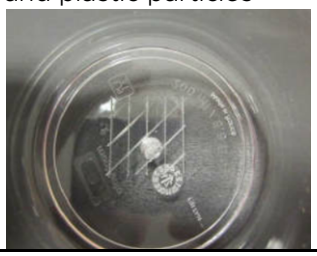
Pack 4 TRITAN	Whitening in the scratches Appearance of grooves and plastic particles 	No visible degradations	No visible degradations	PASS

All the references show slight traces of scratches due to reuse.

	RESULTS		
Samples	Test 1 Thermal shock	Test 2 Dishwasher	Global results
Pack 11 bottle white PE	No visible degradations	No visible degradations 	PASS

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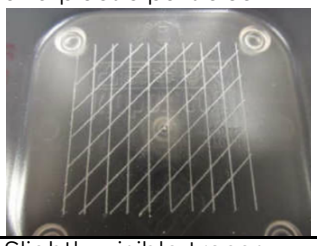
2.3.3 T20

Below is a summary of the results obtained for 20 cycles of use:

	RESULTS			
Samples	Test 1 Scratch resistance	Test 2 Microwaves	Test 3 Dishwasher	Global results
Pack 9 small M-ABS	Whitening in the scratches Appearance of grooves and plastic particles 	Slight trace of water and calcareous	No visible degradations	PASS
Pack 6 small PP	Slightly visible traces 	Slightly visible traces	No visible degradations	PASS
Pack 10 PET	Appearance of grooves on the smooth area, less visible grooves on the grained area 	Test not performed because not relevant to the use of the product	Not tested	FAIL
Pack 7 small TRITAN	Whitening in the scratches Appearance of grooves and plastic particles 	No visible degradations	No visible degradations	PASS
Pack 8 small black PBT	Appearance of grooves and plastic particles Whitening in the scratches	No visible degradations	No visible degradations	PASS

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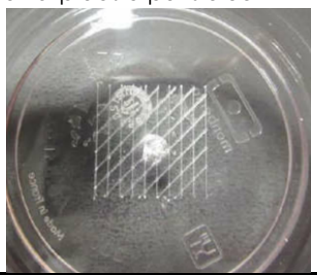
Pack 4 TRITAN	Whitening in the scratches Appearance of grooves and plastic particles 	No visible degradations	No visible degradations	PASS

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2.4 FOOD CONTACT RESULTS ON CYCLE T5/T10/T20

After realizing performance tests (Abrasion + Micro-wave + dishwasher), we performed again food contact tests (overall migration + sensory test + NIAS screening). To reduce the testing plan, we decided to perform only 1 migration test (and not 3 successive migrations) and we compare these values to the T0 results obtained for the 1st migration M1

For this study, we kept 5 packaging (1 PBT, 2 TRITAN , 1 M-ABS and 1 PP)

The unit for Overall migration is mg/dm²

PACK 6 SMALL PP

	Cycle T0	Cycle T5	Cycle T10	Cycle T20
OM 3% acetic acid	1.3	0	0.46	0.16
OM 50% ethanol	3.5	2.16	2.2	1.52
OM 95% ethanol	8.38	0	0.57	0.75
OM isooctane	**17.18**	0.53	1.44	1.16
Sensory test Odor	**3.5**	2.5	**3**	2.
Sensory test Taste	**3.5**	**3**	**3**	2.5
NIAS -Identified substances (listed in Regulation (EU) No. 10/2011)	1 substance	1 substance	1 substance	1 substance
NIAS - Identified substances – NIAS (not listed in Regulation (EU) No. 10/2011)	1 substance	/	/	/
NIAS - Alkanes	12 alkanes	8 alkanes	29 alkanes	6 alkanes
NIAS - Unidentified substances	39 substances	43 substances	31 substances	36 substances

After the performance tests (5/10 and 20 cycles), the values of Overall migration decrease for each simulant. We supposed that during washing cycles, the substances which could migrate have been eliminated.

But the values of sensory test are still very high and not compliant for T0, T5 and T10. The value seems to decrease a little bit for T20 but with a value of 2.5, the taste is very pronounced.

Sensory test has been performed at 100°C during 2 hours in water. This condition (which covers micro-wave use) seems to be too strong for this PP material. It could be interesting to perform again this test with another condition to validate this packaging for other applications without micro-wave function.

Cycles of performance tests have a small influence on the material. Only few NIAS substances and alkanes migrate after 5,10 and 20 cycles and there is no significant increase of NIAs migration with the number of cycles.

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PACK 9 SMALL M-ABS

	Cycle T0	Cycle T5	Cycle T10	Cycle T20
OM 3% acetic acid	0	0.45	1.34	0.82
OM 50% ethanol	7.08	7.28	7.56	8.72
OM 95% ethanol	**73.09**	**34.83**	**105.17**	**38.13**
OM isooctane	2.95	**34.67**	**41.64**	**15.57**
MS PAA	< 0.001	**0.0022**	0.001	0.0008
Sensory test Odor	**3**	**2.5**	**2.75**	2
Sensory test Taste	**3**	**3**	**2.75**	2.5
NIAS -Identified substances (listed in Regulation (EU) No. 10/2011)	8 substances (1 inconclusive)	9 substances (1 FAIL)	8 substances (1 FAIL)	10 substances (2 FAIL)
NIAS - Identified substances – NIAS (not listed in Regulation (EU) No. 10/2011)	13 substances (3 FAIL)	14 substances (8 FAIL)	10 substances (8 FAIL)	8 substances (4 FAIL)
NIAS - Alkanes	2 alkanes	7 alkanes	5 alkanes	11 alkanes
NIAS - Unidentified substances	155 substances with 16 substances > 1 mg/person/day	173 substances with 17 substances > 1 mg/person/day	202 substances with 18 substances > 1 mg/person/day	247 substances with 32 substances > 1 mg/person/day

The overall migration in 50% ethanol increases a little bit with the number of cycles.

But in fat simulant Isooctane, the overall migration increases and are not very stable; In 95% ethanol, the values are still very high for each cycle and the results are not homogeneous and consistent.

We obverse also an increase of migration of PAA (Primary Aromatic Amines) from T0 to T5.

Sensory tests are still strong for each cycle T0/T5/T10 and T20 and this can have a bad effect for the food which entry in contact with this box under these conditions.

Performed tests seem to change this material and degrade it.

After 5,10 and 20 cycles, NIAS migration increases and many substances migrate beyond the regulatory limit, especially different styrene dimers due to the decomposition of ABS matter.

The number of alkanes and of un-identified substances increase with the number of cycles of performance tests which degrade this material.

In Un-identified substances, we can find a not negligible number of substances with an amount greater than 1 mg/person/day. This packaging degrades more and more with the number of performance test cycles.

This product cannot be used as re-usable product under the conditions we defined. It could present a danger for human health.

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PACK 7 SMALL TRITAN

	Cycle T0	Cycle T5	Cycle T10	Cycle T20
OM 3% acetic acid	0.31	0.57	0.75	1.13
OM 50% ethanol	0.53	0.18	0.4	0.3
OM 95% ethanol	0.76	0.58	0.71	1.01
OM isooctane	0.2	0.48	0	0.22
MS PAA	< 0.001	< 0.001	< 0.001	< 0.001
Sensory test Odor	0	0	1.5	0.
Sensory test Taste	0	1.5	2	1.5
NIAS -Identified substances (listed in Regulation (EU) No. 10/2011)	1 substance	1 substance	2 substances	/
NIAS - Identified substances – NIAS (not listed in Regulation (EU) No. 10/2011)	2 substances	/	1 substance	/
NIAS - Alkanes	1 alkane	2 alkanes	1 alkane	2 alkanes
NIAS - Unidentified substances	17 substances	51 substances	26 substances	12 substances

There is no influence of performance tests on the results of Overall migration.

But we can see an increase of sensory test from T0 to T5/T10/T20, especially for taste.

This parameter should be monitored to validate the product for more cycle beyond 20.

NIAS migrations are stable with the number of performance tests cycles. The material doesn't degrade after 20 cycles.

This packaging can be used as re-usable product under the conditions we defined up to 20 cycles.

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PACK 8 SMALL BLACK PBT

	Cycle T0	Cycle T5	Cycle T10	Cycle T20
OM 3% acetic acid	1.12	1.83	1.53	1.7
OM 50% ethanol	2.27	1.65	2.04	2.04
OM 95% ethanol	0.76	0.84	0.67	1.14
OM isooctane	0.16	0	0.05	0
MS PAA	<0 .001	<0 .001	<0 .001	<0 .001
Sensory test Odor	1.5	1	1	1.5
Sensory test Taste	2.5	2	2	2
NIAS -Identified substances (listed in Regulation (EU) No. 10/2011)	1 substance	1 substance	1 substance	1 substance
NIAS - Identified substances – NIAS (not listed in Regulation (EU) No. 10/2011)	/	/	/	/
NIAS - Alkanes	/	1 alkane	3 alkanes	2 alkanes
NIAS - Unidentified substances	24 substances	15 substances	10 substances	48 substances

The overall migration and sensory tests are quite stable for all simulants for each cycle T5, T10 and T20.

NIAS migrations are stable with the number of performance tests cycles. The material doesn't degrade after 20 cycles.

This matter doesn't evolute with the influence of performance tests.

This packaging can be used as re-usable product under the conditions we defined up to 20 cycles.

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PACK 4 TRITAN

	Cycle T0	Cycle T5	Cycle T10	Cycle T20
OM 3% acetic acid	0.43	0.76	0.56	0.75
OM 50% ethanol	0.58	0.93	1.15	0.95
OM 95% ethanol	4.83	1.55	0.82	0.75
OM isooctane	0.53	0.44	0.17	0.56
Sensory test Odor	0	0	0	0
Sensory test Taste	1	1.5	1	1
NIAS -Identified substances (listed in Regulation (EU) No. 10/2011)	/	1 substance	1 substance	1 substance
NIAS - Identified substances – NIAS (not listed in Regulation (EU) No. 10/2011)	/	/	/	/
NIAS - Alkanes	/	/	1 alkane	/
NIAS - Unidentified substances	9 substances	8 substances	7 substances	7 substances

The overall migration and sensory tests are quite stable for all simulants for each cycle T5, T10 and T20.

After migration, we found only few NIAS substances up to the regulatory limit and unidentified substances are minimal.

This shows that the matter is stable after 5,10 and 20 cycles of performance tests.

This product is a good candidate to be a re-usable article under the defined conditions up to 20 cycles.

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3. BIASES AND RISKS ANALYSIS OF PACKAGING REUSE LOOP

3.3 LIMITS ON PERFORMANCE AND CHEMICAL TESTS

As in all projects, we had to make choices, in line with the time and budget allocated.

Making choices is the main bias while conducting research & development in agile mode and to be able to move forward step by step.

Choices on selection of tests have been made, therefore it is important to highlight the following points.

Firstly, we had to reduce the number of samples as part of the optimization process. This had an impact on the tests we were able to carry out subsequently. Our R&D phase was reduced to the minimum and results by materials cannot be taken as generalities for all materials.

Conducted/not conducted tests:

- To start, we relied on the existing European regulations on food contact in plastics. Another option was to create a specific simulant, composed of several type of food to be closest to reality. Nevertheless, this option was excluded because we would have not enough data to be able to make a single conclusion.
- Therefore, for the food contact tests, we took the most severe case with known simulant even if it would be possible to obtain better results with lower conditions.
- For the performance tests, we were faced with the crucial choice of which tests to perform. Indeed, we could have added thermal shock tests (hot/cold), chocks or leakage tests in order to be as exhaustive as possible.
- The same goes for washing, with the choice of washing mode and temperature.
- Permeability tests are similar to closure tests. If the packaging can be sealed or closed but leaks, then the packaging is not suitable for reuse.
- Transport tests are important when setting up the reuse loop. Vibrations and shocks can damage the packaging, making it more fragile and potentially shortening its life.
- Thermal shocks simulate the ability of the packaging to pass a temperature to another. This would validate the packaging from dishwashers to ice cream for example.
- Shocks tests have an impact in terms of falls but also on the collect of used packaging (waste collection in restaurant).

From our point of view, it would be interesting to extend the protocol to tests such as closing. Indeed, the sealing of a package proves its ability to be reused. If the package cannot be sealed or the lid does not close, the package is thrown away.

3.1 MISUSE AND MICROBIOLOGICAL RISKS

Misuse

We have deliberately not considered misuse, simply because misuse does not reflect the main use of the product and the protocol cannot take these into account with consistent results.

In fact, if testing conditions are too severe, products would fail to test and no conclusion would emerge as tests would not have been conclusive. However, this is a high risk to be considered, also regarding responsibilities on a reuse loop.

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Washing

Regarding washing, no washer was in the consortium.

Not having a professional washer was not easy to start an audit grid without a washer partner in the consortium, this was a hindrance on several points.

First of all, their approach would have allowed us to adapt the washing protocol as much as possible upstream, without taking too many biases on the temperature, the duration of the cycle or the type of detergent for the food safety protocol.

Then, for the drafting of the audit grid, to be able to adapt to the practices already in place while providing a reassuring framework.

The audit grid imposes obligations of results and not of means, which is to the advantage of the washers. On the other hand, it will be imperative to monitor the results, particularly with regard to microbiological and allergenic tests.

At the same time, neither the audit grid nor the test protocol takes into account the time elapsed between the collection of the dirty packaging and the washing. This time, more or less long, can drastically impact the packaging, its suitability for food contact and also impact the result of the washing and contain harmful substances at the time of its final reuse.

3.2 OTHER TOPICS

Responsibility

The first is the notion of responsibility when setting up the re-use loop, either it is opened or closed one. Today, the marketer is responsible for the safety of the product.

What will happen for reuse where the various players follow one another? How can this responsibility be defined? What happens in the case of open loops, for example when the packaging goes to the consumer who then returns it to the shop (misuse, uncontrolled deterioration)?

There are distributors, transporters, manufacturers, washers, industrials and even consumers. All these responsibilities are not shared today.

Traceability and information to consumers of the packaging

Concerning traceability, the aim here is to understand the life of the packaging, considering misuse but also a means of counting the maximum number of rotations of a package and to be able to count each cycle.

Concerning consumer information, we are aware of the difficulties of setting up bulk sales and providing information on the product, its use, and the risks. For reuse, it is the same thing. The regulations must take these parameters into account in order to guide the consumer as best as possible during use and to enlighten his choice.

In our R&D, we would like to point out that we have not considered baby food. Indeed, additional precautions must be taken. This is important information to note for consumers if not covered.

Packaging end of life

How will reusable packaging be collected at the end of its life; can it be recycled?

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To date, our work has not included the percentage of recycled material in packaging, but this could be a very interesting study and impact results on packaging tested.

CONCLUSION

We have conducted performance tests to make the food contact tests more stringent and to validate or not the suitability of the material for reuse.

Regarding performance tests and most of the packaging withstands the temperatures of microwave and washing tests. But these also show scratches related to abrasion tests, from cycle 1.

On chemical perspective and according to food contact tests realized after different cycles of performance tests, we conclude that some products cannot be used for all applications and for a mutualization of packaging.

Hard plastic like Tritan and PBT are more stable and resist better to high temperature. The migration of chemical substances is minor and doesn't increase significantly after performance tests.

We have mostly to include sensory test. Sensory test is the most sensitive analysis, and this parameter evolves after performance tests.

This analysis must be checked systematically to see if after more than 20 cycles, the result would be over the regulatory limit.

NIAS screening is also an important parameter to follow the degradation of plastic after performance tests.

Once the tests have been carried out, marketers (washers, manufacturers, distributors, etc.) must create their own specifications and set the level of visual non-compliance (deformation of the packaging, visible scratches).

In conclusion, to validate the Re-use of packaging, it is important to define the real use of product and to choose the best testing conditions for food contact tests and for performance tests to be closed to the finish use. In case of mutualization of packaging, the worst conditions should be selected to cover all uses.

The combination of performance tests and food contact tests permit to evaluate that the re-use of packaging does not present a danger for human health and does not change the performance of product (deformation, closing,..) and we could define the maximum of rotations the packaging can make without physical and chemical modifications.

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ANNEXES

Annex 1: Details of Results for T0

Regulatory limit for Overall Migration OM (regulation 10/2011/CE + Standard EN 1186) ≤ 10 mg/dm² + 2 mg/dm² (tolerance for evaporable simulant)

The values of OM under 1 mg/dm² are not significant because they are under the detection limit

Regulatory limit for Sensory test (DIN 10955) ≤ 2.5 for Odor and Taste

PACK 6 SMALL PP

Migration tests by filling – Volume of simulant= 410 ml – surface in contact = 2.33 dm²

Simulant		Testing Conditions	1st migration	2nd migration	3rd migration	Conclusion
3 % Acetic Acid	ech 1	2h -100°C	0,86	0,95	1,04	
	ech 2		1,74	0,86	1,56	
	Average		**1,3**	**0,9**	**1,3**	PASS
50 % ethanol	ech 1	2h -100°C	3,94	1,92	0,07	
	ech 2		3,06	2	0,25	
	Average		**3,5**	**1,96**	**0,16**	PASS
95% Ethanol	ech 1	4h- 60°C	8,97	13,62	16,6	
	ech 2		7,9	11,15	15,38	
	Average		**8,38**	**12,39**	**16**	FAIL
Isooctane	ech 1	2h -60°C	15,64	15,02	18,19	
	ech 2		18,72	13,45	19,16	
	Average		**17,18**	**14,24**	**18,67**	FAIL
SENSORY TEST	odor	water 2h -100°C	**3,5**			FAIL
	taste		**3,5 (chemical, 2x isophorone, PVC adhesive, solvent, sweet)**			

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NIAS migration in 95% ethanol - 2h-60°C follow by 24h-40°C

Substances	CAS n°	retention time	result	limit	Conclusion
		min	mg/kg	mg/kg	
Identified substances (listed in Regulation (EU) No. 10/2011)					
acids, fatty (C8-C22) from animal or vegetable fats and oils, esters with alcohols, linear, aliphatic, monohydric, saturated, primary (C1-C22)		17.67 19.24	0,68	60	PASS
Identified substances – NIAS (not listed in Regulation (EU) No. 10/2011)					
2,4-ditertbutylphenol	96-76-4	13,23	0,01	1,8	PASS
Alkan		8,54	0,019	1,8	PASS
Alkan		10,64	0,021	1,8	PASS
Alkan		11,18	0,073	1,8	PASS
Alkan		11,29	0,046	1,8	PASS
Alkan		13,03	0,022	1,8	PASS
Alkan		13,50	0,096	1,8	PASS
Alkan		13,70	0,053	1,8	PASS
Alkan		13,92	0,01	1,8	PASS
Alkan		15,54	0,053	1,8	PASS
Alkan		15,57	0,012	1,8	PASS
Alkan		17,38	0,037	1,8	PASS
Alkan		19,05	0,037	1,8	PASS
Inconclusive substances					
39 Unidentified substances					

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PACK 9 SMALL M-ABS

Migration tests by filling – Volume of simulant= 420 ml – surface in contact = 2.17 dm²

Simulant		Testing Conditions	1st migration	2nd migration	3rd migration	Conclusion
3 % Acetic Acid	ech 1	2h -100°C	0	0	0	
	ech 2		0	0	0	
	Average		**0**	**0**	**0**	PASS
50 % ethanol	ech 1	2h -100°C	5,00	2,66	0	
	ech 2		9,16	1,89	0	
	Average		**7,08**	**2,22**	**0**	PASS
95% Ethanol	ech 1	4h- 60°C	71,37	53,27	16,98	
	ech 2		74,66	56,66	14,85	
	Average		**73,09**	**54,97**	**15,92**	FAIL
Isooctane	ech 1	2h -60°C	2,18	1,5	0,46	
	ech 2		3,72	0,92	0,17	
	Average		**2,95**	**1,21**	**0,31**	PASS
Olive Oil	Average	1h -121°C	**11,57**	**14,7**	**15,13**	
	M1		11,57			
	M2-M1		3,13			
	M3-M2		**0,43**			PASS
SM PAA (amines)		AA 3% - 2h-100°C	< 0,002 mg/kg	< 0,002 mg/kg	< 0,002 mg/kg	PASS
SENSORY TEST	odor	water 2h -100°C	**3**			FAIL
	taste		**3,0 (chemical, 2x fruity, glue, burnt, putrid)**			

The overall migration OM in 95% Ethanol (fatty substitute) is Failed with very high value of residue. We chose to perform another test in olive oil with OM as tasting conditions (1h at 121°C). The result in olive oil is passed (M3-M2 < 10 mg/dm² and M3-M2 < M2-M1 < M1). The simulant ethanol 95% would dissolve the matter and false the result of OM. For the study, we will compare the results of migration in ethanol 95% to see if the use influences the results of OM.

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NIAS migration in 95% ethanol - 2h-60°C follow by 24h-40°C

Substances	CAS n°	retention time	result	limit	Conclusion
		min	mg/kg	mg/kg	
Identified substances (listed in Regulation (EU) No. 10/2011)					
Styrene	100-42-5	5,44	0,012	60	PASS
Benzaldehyde	100-52-7	6,81	0,047	60	PASS
Acrylic acid, dodecyl ester	2156-97-0	15,04	2,9	60	PASS
Acids, fatty (C8-C22) from animal or vegetable fats and oils, esters with alcohols, linear, aliphatic, monohydric, saturated, primary (C1-C22)		17.11 18.54 18.59 18.73 19.05 19.09	4,1	60	PASS
Acids, fatty (C8-C22) from animal or vegetable fats and oils, esters with branched alcohols, aliphatic, monohydric, saturated, primary (C3-C22)		19,19	0,15	60	PASS
Stearic acid, butyl ester	123-95-5	20,64	0,087	60	PASS
Octadecyl 3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate	2082-79-3	27,76	1,1	6	PASS
Thiodipropionic acid, didodecyl ester	123-28-4	27,87	5,2	5	In conclusive
Identified substances – NIAS (not listed in Regulation (EU) No. 10/2011)					
1-phenylethanone	98-86-2	8,1	0,03	1,8	PASS
Nonanal	124-19-6	8,52	0,035	1,8	PASS
1-methyl-4-propan-2-ylcyclohexan-1-ol	3901-93-7	9,05	0,064	0,09	PASS
2-(4-methylcyclohexyl)propan-2-ol	498-81-7	9,16	0,045	0,09	PASS
4-methyl-1-propan-2-ylcyclohexan-1-ol	470-65-5	9,19	0,037	0,09	PASS
Dimethyl 2-methyl-5-methylidenehexanedioate	4513-62-6	11,15	1,9	0.09	FAIL
Cyclohex-3-en-1-ylbenzene	4994-16-5	11,41	0,088	0,09	PASS
Naphthalene-2-carbonitrile	613-46-7	13,25	0,063	0,09	PASS
3-phenylpropylbenzene-	1081-75-0	14,81	0,12	0,09	FAIL
(2-phenylcyclobutyl)benzene	3018-21-1	15,18 15,93	0,024 0,054	0,05	PASS
(3-phenylcyclobutyl)benzene	25558-23-0	15,22	0,049	0,05	PASS
4-phenylbuta-1,3-dienyl]benzene	538-81-8	16,14	0,01	0,05	PASS
1,2,3,4-tetrahydronaphthalene-1-carbonitrile	57964-40-6	18,27	2,1	0,09	FAIL
Alkan		15,00	0,43	1,8	PASS
Alkan		16,04	0,028	1,8	PASS
Inconclusive substances					
155 Unidentified substances					

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PACK 7 SMALL TRITAN

Migration tests by filling – Volume of simulant= 310 ml – surface in contact = 1.97 dm²

Simulant		Testing Conditions	1st migration	2nd migration	3rd migration	Conclusion
3 % Acetic Acid	ech 1	2h -100°C	0	0,73	0,77	
	ech 2		0,61	0,58	0,37	
	Average		**0,31**	**0,66**	**0,57**	PASS
50 % ethanol	ech 1	2h -100°C	0,77	0,42	0	
	ech 2		0,3	0,89	0,14	
	Average		**0,53**	**0,66**	**0,07**	PASS
95% Ethanol	ech 1	4h- 60°C	0,67	0,12	0,01	
	ech 2		0,83	0,2	0,17	
	Average		**0,76**	**0,16**	**0,1**	PASS
Isooctane	ech 1	2h -60°C	0	0	0,06	
	ech 2		0,4	0,43	0	
	Average		**0,2**	**0,21**	**0,03**	PASS
SM PAA (amines)		AA 3% - 2h-100°C	< 0,002 mg/kg	< 0,002 mg/kg	< 0,002 mg/kg	PASS
SENSORY TEST	odor	water 2h -100°C	**0**			PASS
	taste		**0**			

NIAS migration in 95% ethanol - 2h-60°C follow by 24h-40°C

Substances	CAS n°	retention time	result	limit	Conclusion
		min	mg/kg	mg/kg	
Identified substances (listed in Regulation (EU) No. 10/2011)					
acids, fatty (C8-C22) from animal or vegetable fats and oils, esters with alcohols, linear, aliphatic, monohydric, saturated, primary (C1-C22)		17.67 19.05 19.24	0,11	60	PASS
Identified substances – NIAS (not listed in Regulation (EU) No. 10/2011)					
Nonanal	000124-19-6	8.53	0,024	1,8	PASS
2,6,10,15,19,23-Hexamethyl-2,6,10,14,18,22-tetracosahexaene	000111-02-4	23.42	0,071	1,8	PASS
Alkan		16,76	0,044	1,8	PASS
Inconclusive substances					
17 Unidentified substances					

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PACK 8 SMALL BLACK PBT

Migration tests by filling – Volume of simulant= 310 ml – surface in contact = 1.97 dm²

Simulant		Testing Conditions	1st migration	2nd migration	3rd migration	Conclusion
3 % Acetic Acid	ech 1	2h -100°C	1,08	1,68	0,69	
	ech 2		1,16	1,44	0,69	
	Average		**1,12**	**1,55**	**0,69**	PASS
50 % ethanol	ech 1	2h -100°C	2,18	1,2	0,53	
	ech 2		2,34	0,97	0,69	
	Average		**2,27**	**1,09**	**0,61**	PASS
95% Ethanol	ech 1	4h- 60°C	0,67	0,83	0,49	
	ech 2		0,83	0,67	0,57	
	Average		**0,76**	**0,75**	**0,53**	PASS
Isooctane	ech 1	2h -60°C	0	0	0	
	ech 2		0,32	0,39	0	
	Average		**0,16**	**0,22**	**0**	PASS
SM PAA (amines)		AA 3% - 2h-100°C	< 0,002 mg/kg	< 0,002 mg/kg	< 0,002 mg/kg	PASS
SENSORY TEST	odor	water 2h -100°C	**1.5**			PASS
	taste		**2.5**			

NIAS migration in 95% ethanol - 2h-60°C follow by 24h-40°C

Substances	CAS n°	retention time	result	limit	Conclusion
		min	mg/kg	mg/kg	
Identified substances (listed in Regulation (EU) No. 10/2011)					
acids, fatty (C8-C22) from animal or vegetable fats and oils, esters with alcohols, linear, aliphatic, monohydric, saturated, primary (C1-C22)		17.67 18,73 19.24	0,083	60	PASS
Identified substances – NIAS (not listed in Regulation (EU) No. 10/2011)					
Inconclusive substances					
24 Unidentified substances					

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PACK 10 PET

Migration tests by filling – Volume of simulant= 320 ml – surface in contact = 2.27 dm²

Simulant		Testing Conditions	1st migration	2nd migration	3rd migration	Conclusion
3 % Acetic Acid	ech 1	10 days at 40°C	0,07	0	0,58	
	ech 2		0,35	0	0,22	
	ech 3		0,07	0	0,51	
	Average		**0,16**	**0**	**0,44**	PASS
50 % ethanol	ech 1	10 days at 40°C	0,38	0	0,08	
	ech 2		0,1	0	0	
	ech 3		0,1	0	0,1	
	Average		**0,19**	**0**	**0,03**	PASS
95% Ethanol	ech 1	10 days at 40°C	12,49	12,19	11,61	
	ech 2		13,55	11,56	10,56	
	ech 3		15,45	11,77	11,83	
	Average		**13,82**	**11,84**	**11,33**	PASS
Isooctane	ech 1	2 days at 20°C	9,87	9,58	7,11	
	ech 2		8,31	7,61	6,62	
	ech 3		7,33	7,75	6,84	
	Average		**8,5**	**8,32**	**6,86**	PASS
SENSORY TEST	odor	Water 10 days at 40°C	**0**			PASS
	taste		**0**			

NIAS migration in 95% ethanol - 2h-60°C follow by 24h-40°C

Substances	CAS n°	retention time	result	limit	Conclusion
		min	mg/kg	mg/kg	
Identified substances (listed in Regulation (EU) No. 10/2011)					
Acids, fatty (C8-C22) from animal or vegetable fats and oils, esters with alcohols, linear, aliphatic, monohydric, saturated, primary (C1-C22)		17.66 19.03	0,1	60	PASS
Identified substances – NIAS (not listed in Regulation (EU) No. 10/2011)					
Inconclusive substances					
6 Unidentified substances					

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PACK 4 TRITAN

Migration tests by filling – Volume of simulant= 215 ml – surface in contact = 1.65 dm²

Simulant		Testing Conditions	1st migration	2nd migration	3rd migration	Conclusion
3 % Acetic Acid	ech 1	2h -100°C	0,74	0	0,28	
	ech 2		0,15	0	0,47	
	Average		**0,43**	**0**	**0,38**	PASS
50 % ethanol	ech 1	2h -100°C	0,67	0	0,01	
	ech 2		0,35	0,07	0	
	Average		**0,58**	**0,04**	**0,01**	PASS
95% Ethanol	ech 1	4h- 60°C	4,09	2,58	2,93	
	ech 2		6,24	2,85	3,18	
	Average		**4,83**	**2,72**	**3,06**	PASS
Isooctane	ech 1	2h -60°C	0,74	0,63	2,19	
	ech 2		0,35	0,3	3,62	
	Average		**0,53**	**0,46**	**2,91**	PASS
SENSORY TEST	odor	water 2h -100°C	**0**			PASS
	taste		**1**			

NIAS migration in 95% ethanol - 2h-60°C follow by 24h-40°C

Substances	CAS n°	retention time	result	limit	Conclusion
		min	mg/kg	mg/kg	
Identified substances (listed in Regulation (EU) No. 10/2011)					
Identified substances – NIAS (not listed in Regulation (EU) No. 10/2011)					
Inconclusive substances					
9 Unidentified substances					

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PACK 11 BOTTLE WHITE PE

Migration tests by filling – Volume of simulant= 1050 ml – surface in contact = 5.91 dm²

Simulant		Testing Conditions	1st migration	2nd migration	3rd migration	Conclusion
3 % Acetic Acid	ech 1	2h -100°C	0	0	0,23	
	ech 2		0	0	0	
	Average		**0**	**0**	**0,12**	PASS
50 % ethanol	ech 1	2h -100°C	0	0	0	
	ech 2		0	0	0	
	Average		**0**	**0**	**0**	PASS
95% Ethanol	ech 1	4h- 60°C	0,33	0	0	
	ech 2		0,07	0	0	
	Average		**0,2**	**0**	**0**	PASS
Isooctane	ech 1	2h -60°C	0,8	0	0	
	ech 2		0,7	0	0	
	Average		**0,75**	**0**	**0**	PASS
SM PAA (amines)		AA 3% - 2h- 100°C	< 0,002 mg/kg	< 0,002 mg/kg	< 0,002 mg/kg	PASS
SENSORY TEST	odor	Water 10 days at 40°C	**0**			PASS
	taste		**0**			

For sensory test in Water during 2 h at 100°C, the Solution was unclear (white) after migration even the Pack 11 bottle white PE was rinsed before testing -It was not possible to evaluate the taste. We changed testing conditions with lower conditions 10 days at 40°C.

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NIAS migration in 95% ethanol - 2h-60°C follow by 24h-40°C

Substances	CAS n°	retention time	result	limit	Conclusion
		min	mg/kg	mg/kg	
Identified substances (listed in Regulation (EU) No. 10/2011)					
Identified substances – NIAS (not listed in Regulation (EU) No. 10/2011)					
Methyl 3-(3,5-ditert-butyl-4-hydroxyphenyl)propanoate	719-22-2	12,8	0,028	0,54	PASS
,7-di(propan-2-yl)naphthalene	94133-80-9	15,42	0,014	0,09	PASS
Methyl 3-(3,5-ditert-butyl-4-hydroxyphenyl)propanoate	6386-38-5	17,17	0,015	0,09	PASS
Alkan		9,72	0,97	1,8	PASS
Alkan		10,92	0,057	1,8	PASS
Alkan		11,72	0,033	1,8	PASS
Alkan		12,05	3,5	1,8	FAIL
Alkan		13,12	0,03	1,8	PASS
Alkan		13,59	0,046	1,8	PASS
Alkan		13,65	0,098	1,8	PASS
Alkan		13,78	0,022	1,8	PASS
Alkan		13,85	0,075	1,8	PASS
Alkan		14,14	4	1,8	FAIL
Alkan		14,59	0,013	1,8	PASS
Alkan		15,51	0,08	1,8	PASS
Alkan		15,57	0,13	1,8	PASS
Alkan		15,7	0,023	1,8	PASS
Alkan		15,76	0,087	1,8	PASS
Alkan		16,03	3,4	1,8	FAIL
Alkan		17,23	0,028	1,8	PASS
Alkan		17,25	0,058	1,8	PASS
Alkan		17,49	0,071	1,8	PASS
Alkan		17,73	2,6	1,8	FAIL
Alkan		18,81	0,04	1,8	PASS
Alkan		18,85	0,049	1,8	PASS
Alkan		18,91	0,11	1,8	PASS
Alkan		19,08	0,063	1,8	PASS
Alkan		19,29	1,9	1,8	FAIL
Alkan		20,27	0,05	1,8	PASS
Alkan		20,31	0,042	1,8	PASS
Alkan		20,37	0,1	1,8	PASS
Alkan		20,53	0,051	1,8	PASS
Alkan		20,73	1,3	1,8	PASS
Alkan		21,88	0,039	1,8	PASS
Alkan		22,05	0,86	1,8	PASS
Alkan		23,29	0,52	1,8	PASS
Alkan		24,44	0,27	1,8	PASS
Alkan		25,52	0,1	1,8	PASS
Inconclusive substances					
Unidentified substances					

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Annex 2: Details of NIAS Results for T0/T5/T10/T20

PACK 6 SMALL PP

Substances (mg/kg)	**CAS n°**	limit	Result T0	Result T5	Result T10	Result T20
Identified substances (listed in Regulation (EU) No. 10/2011)						
acids, fatty (C8-C22) from animal or vegetable fats and oils, esters with alcohols, linear, aliphatic, monohydric, saturated, primary (C1-C22)		60	0.68	0.23	0.29	0.17
Identified substances – NIAS (not listed in Regulation (EU) No. 10/2011)						
2,4-ditertbutylphenol	96-76-4	1.8	0.01	/	/	/
Alkanes						
		1.8	12 alkanes	8 alkanes	29 alkanes	6alkanes
Inconclusive substances						
Unidentified substances			39 substances	43 substances	31 substances	36 substances

Presumably Origins of NIAS

Substances	comments
acids, fatty (C8-C22) from animal or vegetable fats and oils, esters with alcohols, linear, aliphatic, monohydric, saturated, primary (C1-C22)	Fatty acid esters can be used as lubricants
2,4-ditertbutylphenol	Degradation product of the antioxidants Irgafos 168 and Irganox 1010 in food contact materials.

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PACK 9 SMALL M-ABS

Substances (mg/kg)	**CAS n°**	limit	Result T0	Result T5	Result T10	Result T20
Identified substances (listed in Regulation (EU) No. 10/2011)						
Styrene	100-42-5	60	0,012	0,024	/	0,024
Benzaldehyde	100-52-7	60	0,047	0,066	0.06	0,038
Acrylic acid, dodecyl ester	2156-97-0	60	2,9	/	/	/
acids, C2-C24, aliphatic, linear, monocarboxylic, synthetic and their mono-, di- and triglycerol esters		60	/	0,25	0.41	0,12
Acids, fatty (C8-C22) from animal or vegetable fats and oils, esters with alcohols, linear, aliphatic, monohydric, saturated, primary (C1-C22)		60	4,1	5,2	6.13	15
alcohols, aliphatic, monohydric, saturated, linear, primary (C4-C22)		60	/	/	/	23
acids, fatty, from animal or vegetable food fats and oils		60	/	52	51.4	**75**
Acids, fatty (C8-C22) from animal or vegetable fats and oils, esters with branched alcohols, aliphatic, monohydric, saturated, primary (C3-C22)		60	0,15	/		/
Stearic acid, butyl ester	123-95-5	60	0,087	0,13	0.13	0,18
erucamide	112-84-5	60	/	0,19	0.16	0,19
Octadecyl 3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate	2082-79-3	6	1,1	1,7	2.6	4,7
Thiodipropionic acid, didodecyl ester	123-28-4	5	**5,2**	**14**	**14**	**21**
Identified substances – NIAS (not listed in Regulation (EU) No. 10/2011)						
1,3,5,7-Cyclooctatetraene	629-20-9	1.8	/	0,0084	**/**	/
1-phenylethanone	98-86-2	1,8	0,03	0,045	/	0,045
Nonanal	124-19-6	1,8	0,035	/	/	/
4-Isopropyl-1-methylcyclohexanol	21129-27-1	1.8	/	0,161	/	/

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2-(trans-4-Methylcyclohexyl)-2-propanol	5114-00-1	1.8	/	0,045	/	/
1-methyl-4-propan-2-ylcyclohexan-1-ol	3901-93-7	0,09	0,064	/	0.073 0.10	/
2-(4-methylcyclohexyl)propan-2-ol	498-81-7	0,09	0,045	/	/	/
4-methyl-1-propan-2-ylcyclohexan-1-ol	470-65-5	0,09	0,037	/	/	/
Dimethyl 2-methyl-5-methylidenehexanedioate	4513-62-6	0.09	**1,9**	**2,4**	**2.2**	**1,5**
Cyclohex-3-en-1-ylbenzene	4994-16-5	0,09	0,088	/	/	/
2-Tridecen-1-ol	74962-98-4	1.8	/	/	/	0,01
1-Isocyanonaphthalene	1984-04-9	0.09	/	/	**0.17**	/
Naphthalene-2-carbonitrile	613-46-7	0,09	0,063	/	0.041 0.042	/
3-phenylpropylbenzene	1081-75-0	0,09	**0,12**	**0,13**	**0.16**	/
Tridecyl acrylate	3076-04-8	0.09	/	**2,8**	/	/
(2-phenylcyclobutyl)benzene	3018-21-1	0,05 [a]	0,024 0,054	/	**0.066**	**0,15**
(3-phenylcyclobutyl)benzene	25558-23-0	0,05 [a]	0,049	/	/	/
1,1'-(1,3-Cyclobutanediyl)dibenzene	363171-86-2	0.05 [a]	/	**2,1**	/	/
Tricyclo[8.2.2.24,7]hexadeca-1(12),4,6,10,13,15-hexaenej	1633-22-3	0.05 [a]	/	**0,86**	**0.99**	/
1-Phenyl-1,2,3,4-tetrahydronaphthalene	3018-20-0	0.05 [a]	/	**0,041** [b]	**0,049** [b]	**0,044** [b]
1-Phenyl-1,2-dihydronaphthalene	16606-46-5	0.05 [a]	/	**0,058**	/	/
4-phenylbuta-1,3-dienyl]benzene	538-81-8	0,05 [a]	0,01	/	/	**0,025**
Icosanal	2400-66-0	1.8	/	/	/	0,061
1,2,3,4-tetrahydronaphthalene-1-carbonitrile	57964-40-6	0,09	**2,1**	**3,3**	**12**	/
4-(1-Cyanoethyl)-1,2,3,4-tetrahydro-1-naphthalenecarbonitrile	57964-39-3	0.09	/	/	**11**	/
(6Z,10E,14E,18E)-2,6,10,15,19,23-Hexamethyl-2,6,10,14,18,22-tetracosahexaene	7683-64-9	1.8	/	0,057	/	/

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2,6,10,15,19,23-Hexamethyl-2,6,10,14,18,22-tetracosahexaene	111-02-4	1.8	/	/	/	0,019
Cholest-5-ene	570-74-1	-	/	0.015	/	/
Alkanes						
		1,8	2 substances	7 substances	5 substances	11 substances
Inconclusive substances						
Unidentified substances			155 substances	173 substances	202 substances	247 substances

[a] Sum migration limit for styrene oligomers (BfR Opinion 023/2016 of 21 April 2016).

[b] Fail, because the exposure of the styrene oligomers in total exceeds the sum migration limit for styrene oligomers.

Presumably Origins of NIAS

Substances	comments
Styrene	The detected amounts might be related to an incomplete polymerisation reaction during production.
Benzaldehyde	Listed for use as additive or polymer production aid Also, listed in Regulation (EC) No. 1334/2008 as flavoring Fl 05.013 Notes on verification of compliance: There is a risk that the migration of the substance deteriorates the organoleptic characteristics of the food in contact and then, that the final product does not comply with Article 3(1) c of the Framework Regulation (EC) No 1935/2004.
Acrylic acid, dodecyl ester	Presumambly degradation product of fatty acid
acids, C2-C24, aliphatic, linear, monocarboxylic, synthetic and their mono-, di- and triglycerol esters	Can be used as surface plasticizer or lubricant.
Acids, fatty (C8-C22) from animal or vegetable fats and oils, esters with alcohols, linear, aliphatic, monohydric, saturated, primary (C1-C22)	Fatty acid esters can be used as lubricants
alcohols, aliphatic, monohydric, saturated, linear, primary (C4-C22)	Alcohols can be used in the production of plasticizers.
acids, fatty, from animal or vegetable food fats and oils	Fatty acids can be used as lubricants.
Acids, fatty (C8-C22) from animal or vegetable fats and oils, esters with branched alcohols, aliphatic, monohydric, saturated, primary (C3-C22)	Fatty acid esters can be used as lubricants

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Stearic acid, butyl ester	Fatty acid esters can be used as lubricants
erucamide	Presumably used as a slip agent, anti-fogging agent or lubricant for plastic films. Additive in slip agents.
Octadecyl 3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate	Presumambly used as plasticizer / antioxidant
Thiodipropionic acid, didodecyl ester	Presumambly a degradation product of antioxidant
1,3,5,7-Cyclooctatetraene	Can be used to make rubber. 1,3,5,7-Cyclooctatetraene is used in the synthesis of highly organic film for silicon surfaces to improve its chemical and physical properties.
1-phenylethanone	Can be used as solvent or as a catalyst.
Nonanal	Listed in Regulation (EC) No. 1334/2008 as flavoring Fl 05.025 Notes on verification of compliance: There is a risk that the migration of the substance deteriorates the organoleptic characteristics of the food in contact and then, that the final product does not comply with Article 3(1) c of the Framework Regulation (EC) No 1935/2004 Presumably degradation product of fatty acids. Fatty acids can used i.a. as lubricant or filler.
4-Isopropyl-1-methylcyclohexanol	Can be used as fragrance
2-(trans-4-Methylcyclohexyl)-2-propanol	Can be used as fragrance and flavouring agent.
1-methyl-4-propan-2-ylcyclohexan-1-ol	Classified as monoterpenoid.
2-(4-methylcyclohexyl)propan-2-ol	Listed in Regulation (EC) No. 1334/2008 as flavoring Fl 02.171 Notes on verification of compliance: There is a risk that the migration of the substance deteriorates the organoleptic characteristics of the food in contact and then, that the final product does not comply with Article 3(1) c of the Framework Regulation (EC) No 1935/2004.
4-methyl-1-propan-2-ylcyclohexan-1-ol	Classified as monoterpenoid
Dimethyl 2-methyl-5-methylidenehexanedioate	Reaction product of methyl methacrylate.
Cyclohex-3-en-1-ylbenzene	Reaction product of styrene
2-Tridecen-1-ol	

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1-Isocyanonaphthalene	Is classified as a polyaromatic hydrocarbon (PAH) with a nitrile functional group.
Naphthalene-2-carbonitrile	Naphthalene is used mainly as a precursor to derivative chemicals
3-phenylpropylbenzene-	Classified as styrene dimer. Present as an impurity in polystyrene plastics. Liberated on heating.
Tridecyl acrylate	Can be used as comonomer (e.g. for lubricating oil additives).
(2-phenylcyclobutyl)benzene	Classified as styrene dimer. Present as an impurity in polystyrene plastics. Liberated on heating.
(3-phenylcyclobutyl)benzene	Classified as styrene dimer. Present as an impurity in polystyrene plastics. Liberated on heating.
1,1'-(1,3-Cyclobutanediyl)dibenzene	Presumably a dimer of Styrene.
Tricyclo[8.2.2.24,7]hexadeca-1(12),4,6,10,13,15-hexaenej	Presumably a dimer of Styrene.
1-Phenyl-1,2,3,4-tetrahydronaphthalene	Presumably a dimer of Styrene. Polycyclic aromatic hydrocarbons (PHA) are often present in food packaging. Classified as styrene-trimer. Presumably, the trimers are formed during the polymerization process.
1-Phenyl-1,2-dihydronaphthalene	Presumably a dimer of Styrene.
4-phenylbuta-1,3-dienyl]benzene	Classified as styrene dimer. Present as an impurity in polystyrene plastics. Liberated on heating.
Icosanal	Is classified as a fatty acid aldehyde.
4-(2-Cyanoethyl)-1,2,3,4-tetrahydro-1-naphthalenecarbonitrile	Naphthalene is used mainly as a precursor to derivative chemicals The chemical is a component of the Styrene-acrylonitrile Trimer (SAN Trimer). Styrene-acrylonitrile trimer (SAN Trimer) is a mixture of isomers formed by the condensation of two moles of acrylonitrile and one mole of styrene. The mixture is composed of two structural forms: 4-cyano-1,2,3,4-tetrahydro-a-methyl-1-naphthaleneacetonitrile (THNA, CAS No. 57964-39-3) and 4-cyano-1,2,3,4-tetrahydro-1-naphthalenepropionitrile (THNP, CAS No. 57964-40-6) The SAN Trimer is a by-product of specific manufacturing processes for polymers of styrene and acrylonitrile.
4-(1-Cyanoethyl)-1,2,3,4-tetrahydro-1-naphthalenecarbonitrile	
(6Z,10E,14E,18E)-2,6,10,15,19,23-Hexamethyl-2,6,10,14,18,22-tetracosahexaene	Can be used as an intermediate e.g. for organic coloring agents, rubber chemicals, aromatics, and surface active agents.
2,6,10,15,19,23-Hexamethyl-2,6,10,14,18,22-tetracosahexaene	Can be used as intermediate in the manufacture of pharmaceuticals, organic coloring materials, rubber chemicals, aromatics and surface active agents.
Cholest-5-ene	Cholest-5-ene is a cholestanoid. A cholestanoid is a steroid based on a cholestane skeleton.

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PACK 7 SMALL TRITAN

Substances (mg/kg)	**CAS n°**	limit	Result T0	Result T5	Result T10	Result T20
Identified substances (listed in Regulation (EU) No. 10/2011)						
acids, fatty (C8-C22) from animal or vegetable fats and oils, esters with alcohols, linear, aliphatic, monohydric, saturated, primary (C1-C22)		60	0.11	0.055	0.18	/
acids, fatty (C8-C22) from animal or vegetable fats and oils, esters with branched alcohols, aliphatic, monohydric, saturated, primary (C3-C22)		60	/	/	0.49	/
Identified substances – NIAS (not listed in Regulation (EU) No. 10/2011)						
Nonanal	000124-19-6	1.8	0.024	/	/	/
2,6,10,15,19,23-Hexamethyl-2,6,10,14,18,22-tetracosahexaene	000111-02-4	1.8	0.071	/	/	/
Tributyl -1-propene-1,2,3-tricarboxylate	7568-58-3	1.8		/	0.026	/
Alkanes						
		1.8	1 alkane	2 alkanes	1 alkane	2 alkanes
Inconclusive substances						
Unidentified substances			17 substances	51 substances	26 substances	12 substances

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Presumably Origins of NIAS

Substances	comments
acids, fatty (C8-C22) from animal or vegetable fats and oils, esters with alcohols, linear, aliphatic, monohydric, saturated, primary (C1-C22)	Fatty acid esters can be used as lubricants
acids, fatty (C8-C22) from animal or vegetable fats and oils, esters with branched alcohols, aliphatic, monohydric, saturated, primary (C3-C22)	Fatty acid esters can be used as lubricants
Nonanal	Presumably degradation product of fatty acids. Fatty acids can used i.a.. As lubricant or filler
2,6,10,15,19,23-Hexamethyl-2,6,10,14,18,22-tetracosahexaene	Triterpene, which can occur in plant oils.
Tributyl -1-propene-1,2,3-tricarboxylate	Degradation product of tributyl acetylcitrate, which is a plasticizer.

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PACK 8 SMALL BLACK PBT

Substances (mg/kg)	**CAS n°**	limit	Result T0	Result T5	Result T10	Result T20
Identified substances (listed in Regulation (EU) No. 10/2011)						
acids, fatty (C8-C22) from animal or vegetable fats and oils, esters with alcohols, linear, aliphatic, monohydric, saturated, primary (C1-C22)		60	0.083	0.024	0.04	0.055
Identified substances – NIAS (not listed in Regulation (EU) No. 10/2011)						
Alkanes						
		1.8	/	1 alkane	3 alkanes	2 alkanes
Inconclusive substances						
Unidentified substances			24 substances	15 substances	10 substances	48 substances

Presumably Origins of NIAS

Substances	comments
acids, fatty (C8-C22) from animal or vegetable fats and oils, esters with alcohols, linear, aliphatic, monohydric, saturated, primary (C1-C22)	Fatty acid esters can be used as lubricants

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PACK 4 TRITAN

Substances (mg/kg)	**CAS n°**	limit	Result T0	Result T5	Result T10	Result T20
Identified substances (listed in Regulation (EU) No. 10/2011)						
acids, fatty (C8-C22) from animal or vegetable fats and oils, esters with alcohols, linear, aliphatic, monohydric, saturated, primary (C1-C22)		60	/	0.018	0.022	0.041
Identified substances – NIAS (not listed in Regulation (EU) No. 10/2011)						
Alkanes						
			/	/	1 substance	/
Inconclusive substances						
Unidentified substances			9 substances	8 substances	7 substances	7 substances

Presumably Origins of NIAS

Substances	comments
Acids, fatty (C8-C22) from animal or vegetable fats and oils, esters with alcohols, linear, aliphatic, monohydric, saturated, primary (C1-C22)	Fatty acid esters can be used as lubricants

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