Test to assess and prevent the emission of primary synthetic microparticles
(primary microplastics)

Manual and background

27 November 2015

Preface

The *Federal Public Service of Health, Food Chain Safety and Environment* presents to you a manual for a self-test with the goal to help you to evaluate and reduce the emission of microplastics in the aquatic environment. This manual has been developed in cooperation with TAUW consultancy.

What is the purpose of this self-test?

According to the *World Economic Forum*, oceans will contain more plastics than fish by 2050. The reduction of microplastics in products is considered as a relatively quick and obvious partial solution (a quick win) to this major environmental problem.

Are you a company that works with polymer granulate in order to add it to its products, to process it into objects or that uses it in another way during its production process? If yes, please integrate this manual into your environmental management system. That way, you can present yourself as environmentally friendly company.

What companies is it intended for?

Below, you will find the list of sectors to which this self-test applies, in accordance with the European classification used in the E-PRTR (*European Pollutant Release and Transfer Register*) rules.

Activity category	**E-PRTR code**
Producers of plastic granulates including recycled plastic	4.a
Producers of rubber granulates including recycled rubber	4.a
Producers of cosmetics	4.a
Producers of paint and pigments	4.a
Producers of glue	4.a
Producers of varnish	4.a
Producers of food	-
Producers of medicine	4.b
Abrasive cleaning with plastic	2.f, 3.e, 9.e
Abrasive blasting with plastic (metal industry)	2.f, 3.e, 9.e
Production of plastic products by plastic granulates	4.a
Production of rubber products by rubber granulates	4.a
Painting	2.f, 9.c
Varnishing	2.f, 9.c
Gluing	2.f, 9.c
Use of tracers in wind tunnels	-
Use of tracers in chemical processes	4.a, 4.b, 4.c. 4.d, 4.e, 4.f

What kind of microplastics are suitable for the test?

First of all, **all man-made microparticles made from conventional plastics** (which means a polymer that takes a solid form when cooled). Those include materials as PE, PP, PS and PA, which are most often found in ocean water. An extension to elastomers and silicone rubbers is recommended.

The size of the microparticles is also important. For the purposes of this test method, it is recommended to take into account all possible particle sizes below 5 mm. It is not clear yet whether a minimum size should be set (and what it should be).

Physical state: solid and semi-solid materials (check their melting temperature). Sold and semi-solid materials keep their state, so they keep behaving like particles in water. That is why the test also applies to those materials.

Solubility
Only insoluble materials and water absorbing gels should be tested. Materials with a solubility below 1 mg/l are considered as insoluble for this test. Why are gels also taken into account? Because their molecules do not disintegrate when they come into contact with water.

Biomaterials
This test also applies to biopolymers and biodegradable polymers. Biopolymers are made from renewable carbon sources, like plants, but can have the same chemical composition as polymers based on fossil sources (oil or gas). Biodegradable polymers are also tested because the conditions in which they are biodegradable rarely occur in the aquatic environment.

The full definition can be found in the table below:

Criterion	**Included are**	**Recommended for inclusion**	**Reservations for future considerations**
Synthetic materials	Conventional plastic materials (also biobased)	Expansion to elastomers and silicone rubbers	Expansion to other anorganic polymers
Size	< 5mm	100 nm – 5 mm	
Physical state	Solids and semi-solids: melting T > 20 °C		
Biodegradable	Both non-biodegradable and biodegradable		Development of criterions for biodegradability within representative conditions
Solubility	Insoluble in water	<1 mg/L	Research the 1 mg/L threshold

Any questions or suggestions?

Please contact the Product Policy Department (*FPS of Health, Food Chain Safety and Environment, DG for the Environment*): marina.lukovnikova@environment.belgium.be, tel: +32(0)2 524 95 94.

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In order of DG Environment, FPS Health, Food Chain Safety and Environment, Belgium

Responsibility

Title	Test to assess and prevent the emission of primary synthetic microparticles (primary microplastics)
Client	DG Environment, FPS Health, Food Chain Safety and Environment, Belgium
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Contents

1 Introduction

Background
The presence of synthetic microparticles (commonly known as microplastics) (< 5 mm) in the environment (and more specifically in the aquatic environment) is an important environmental topic.

Synthetic microparticles are either released during the use of products as such as cosmetics [1], from (industrial) processes (both primary and secondary micro particles) or are the result from degradation of larger plastic items (secondary micro plastics). Most synthetic micro particles are durable and will not degrade naturally, hence they are accumulating in the environment [2]. There is evidence that these micro particles may have a negative effect on individual animals and can accumulate in the food chain [2] [3].

Although the term ‘microplastics’ refers strictly speaking to materials made of plastics, there is an evidence that other synthetic polymers (such as silicones and rubbers) may pose a risk for aquatic environment [4]. Furthermore, in literature different definitions of the term ‘plastics’ are used. This is the reason why the broader term ‘synthetic microparticles’ is used in this test rather than limiting content to ‘micro plastics’ alone.

Goal
In order to create a future in which the release of synthetic micro particles to the environment is minimised, the Belgian federal government has ordered the design of this test.

This test has been designed to assist companies in assessing their use of synthetic micro particles and in taking measures to prevent the emission of synthetic micro particles to the environment.

Focus on primary microparticles

This test focusses on primary synthetic microparticles. See figure 1.1 for a visual explanation of the differences between primary and secondary synthetic microparticles.

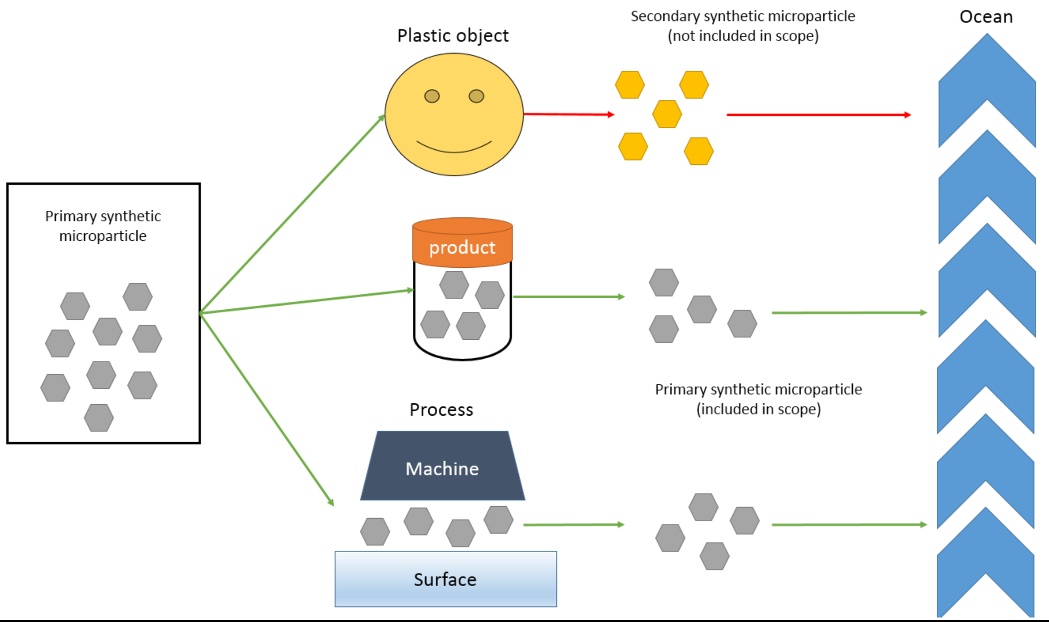


Figure 1.1 Visual representation of difference between primary and secondary synthetic microparticles

Primary synthetic microparticles are particles within the microplastic particle size range (< 5 mm) that are intentionally made in this specific size range for a purpose. They may be released during industrial processes and during the life cycle of products containing primary synthetic microparticles. Primary synthetic microparticles are being used in a variety of products (e.g. lubricants, cosmetics, pigment carriers, and melted into plastics objects such as toys, packaging) and industrial processes (e.g. industrial cleaning and abrasive blasting). Secondary synthetic microparticles are not intentionally made. They are caused by the fragmentation of larger items resulting in particles < 5 mm.

Although it is generally accepted that the release of secondary microparticles into the aquatic environment is more substantial than the release of primary synthetic microparticles, this is not a good reason to ignore the release of primary synthetic microparticles. The primary synthetic microparticles may cause problems in the aquatic environment and therefore should be kept out of the environment [5]. In addition, other approaches for reductions are required for primary and secondary microparticles. Moreover, both primary and secondary emissions should be reduced in order to have a safe aquatic environment. Secondary microparticles will be addressed through other means than this test.

The complete definition of **primary synthetic microparticles** for this test is: *particles (sized between [TO CLARIFY] and 5 mm) made of synthetic materials based on polymers that are insoluble in water, including biobased and biodegradable polymers.*

Note: The elements of the definition between the brackets [] were not defined conclusive during this project. The final definition of microplastic / synthetic microparticle will be set in the future. It might also depend on the goal of the testing exercise, being more or less limitative.

This definition can be broken down in the following important constituents:

Particles means solid [and semi-solid: TO CONFIRM] particles. Physical state should be verified on the hand of melting temperature (transition between semi-solids and liquids). Criterion for inclusion into the scope of the test: the melting temperature > 20°C.

Synthetic means they are manmade. Natural polymers e.g. lignine and cellulose are excluded from the scope unless they are modified in a manmade processes. Non synthetic microparticles are not included in the scope of this project.

Polymers are particles that are made of a repeating monomer. The indicative (not exhaustive) list of the polymers included in this test is given in Appendix 1.

Insoluble means that the constituent molecules within the synthetic microparticles will remain together as a microparticle when mixed with water. If the microparticle falls apart into its constituent molecules it can hardly be spoken of as a microparticle. Polymers forming water absorbing gels are also included in the test, if such a gel does not represents an intermediate step in the dissolution process of the polymer. Cross-linked gels can contain a large amount of water within the gel particle, but they do not fall apart in separate molecules if they come in contact with water. For this test materials with a solubility less than 1 mg/l are considered insoluble.

Water soluble polymers are out of scope for this test, however it should be noted that this does not mean that these soluble compounds are not harmful to the marine environment. More information on how to measure solubility or to make first estimations without doing a solubility test can be found in Appendix 8.

Biobased polymers are within the scope of this test. Biobased polymers are made from renewable carbon sources, e.g. plant material. The resulting material can have the same chemical composition as conventional polymers, which are made from fossil carbon (oil or gas). As a result, biobased polymers typically exhibit the same properties in the aquatic environment as conventional polymers. The term biobased does not infer anything about the biodegradability of the polymer, only the carbon source. Therefore, the emissions of biobased polymers should be reduced in the same way as for conventional polymers.

In theory biodegradable plastics (whether the carbon source is biobased or from fossil oil and gas) should enable degradation into water, carbon dioxide (or methane) and an increasing biomass by microorganisms under specified conditions. However, biodegradability is not an inherent property of materials, but varies with the form or design of a material and according to prevailing conditions in the receiving environment. In particular the conditions necessary for biodegradation are not typically met in the aquatic environment because the term biodegradability can be applied to standards developed for degradation in industrial composters rather than in the environment. Degradation in the environment is variable because of differing temperatures (surface versus column), deoxygenated conditions in the water, bio-fouling and physical energy can all influences the degradation process [6]. Because of the current lack of clarity on this issue, biodegradable plastics are included in the definition of this test.

Who should use this test?

This test was designed to help companies who would like to have an insight into their use of synthetic microparticles and the resulting emissions of these particles.
Categories of companies that are likely to use or produce primary synthetic microparticles are listed in Appendix 7. The categories are based on an inventory and prioritization by RIVM [4].

In this table E-PRTR codes are also included. The E-PRTR code corresponds with a European register that lists industrial activities that emit pollutants. Although synthetic microparticles are not included in the E-PRTR Regulation, the E-PRTR code is useful for selecting companies that might emit synthetic microparticles. Note that a company still may emit synthetic microparticles, even when it officially does not have an E-PRTR code. If a company suspects that synthetic microparticles are being used in their processes this test could help to gain insight.

How to use the test

This test is set up as a series of steps that a company should to follow. This leads to a clear insight of all primary synthetic microparticles used by the company (identification), via all emission pathways (analysis) and in a series of measures to stop these emissions (improvement).
Figure 1.2 gives a simplified overview of the methodology followed by this test.

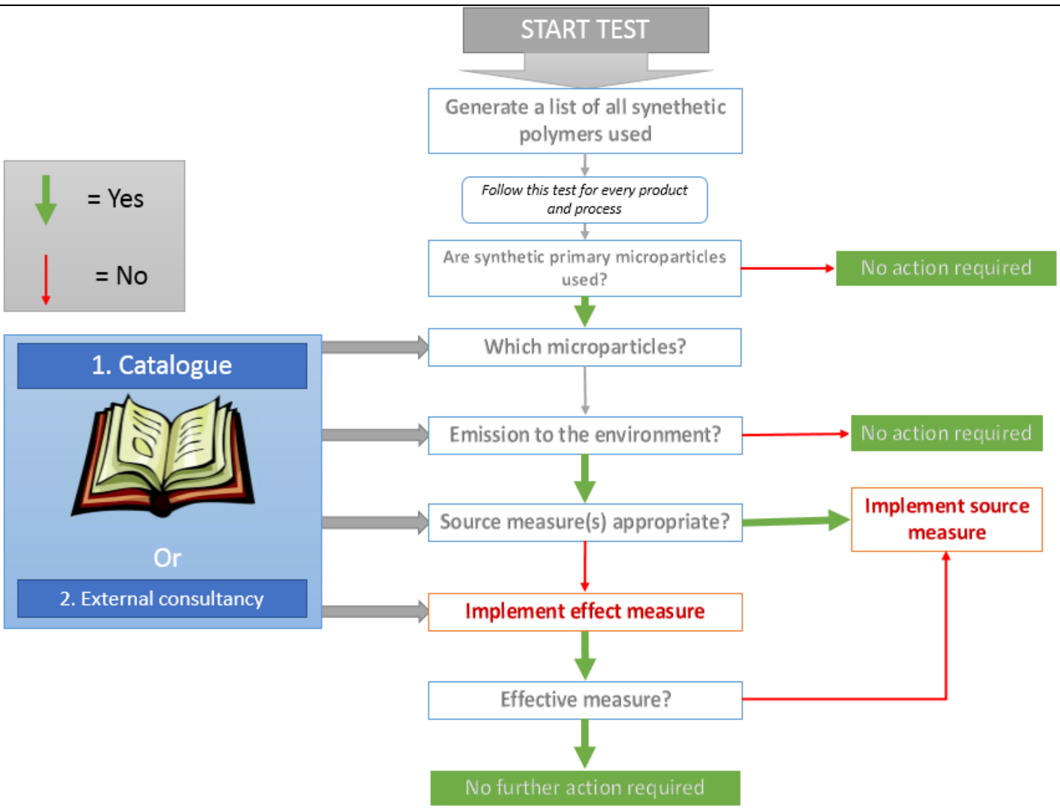


Figure 1.2 Overview of the test

The test has to be applied per product or process in the company. For each product and/or process a results sheet has to be filled in.

To aid the company in executing the test, a catalogue is provided with background information to easily complete the test. This information can be found in Appendices 1 to 4. These appendices give respectively:

1. A list of (most commonly used) synthetic polymers and their application
2. A list of alternatives for synthetic microparticles
3. A description of the emissions of several products in the user phase and the end of life phase
4. Emission reducing measures or end of pipe techniques

2 Test

This chapter contains the complete test instructions. Use the templates from appendices 5 and 6 to fill out the test. In several steps, additional information is required. Part of this information can be found in appendices 1 to 4. If the required information cannot be found in Appendices 1 to 4, other information sources, such as suppliers, should be consulted.

During the execution of this test information about (the properties of) the used synthetic microparticles might not be available yet, for instance the exact size or the density of a polymer based material. In such cases follow the rest of the test. When a strategy is defined to reduce emissions, it might become clear that further insight into the properties of the synthetic microparticles is needed. The necessary information should be made available/researched at that time. The test will become the basis for an iterative process in which as much information as possible is collected to enable to define a sound strategy for emission reduction.

2.1 Step 1 - Review of the list of purchased goods or list of substances

Review the complete list of purchased goods or a list with materials/chemicals present on the site of the company and check for synthetic polymers.
See Appendix 1 for a list of most common synthetic polymers. List all the synthetic polymers that are used in your company per total of products or processes.
Complete the rest of this test for every product containing synthetic polymers and/or every process that makes use of synthetic polymers.

2.2 Step 2 - Check list for synthetic microparticles

Can the particles listed during step 1 be classified as primary synthetic microparticles, considering the definition given in chapter 1?
If additional information is needed: contact your supplier for product details.

☐ Yes → **Proceed with step 3**

☐ No, this is obvious from the available information on the purchase list or from the supplier
→ no further motivation required. **Here ends the enquiry for this product**

☐ No, but not obvious deduced from the available information on the purchase list or from the supplier.
→ Substantiate your answer. **Here ends the enquiry for this product**

Example 1. Filled out product and processes form

General details

Company contact name:	*Mr J. Smith*
Test date:	*31-12-2015*

Products

Name of polymer	**Used in product:**	**Synthetic micro-particles (see definition)?**	**Substantiation**
Polyethylene	*Shampoo*	*Yes*	-
Polyurethane		*No*	Delivered in aerosol can with a nozzle > 5 mm

Processes

Name of polymer	**Used in process:**	**Synthetic micro-particles?**	**Substantiation**
Polyethylene	Abrasive blasting	Yes	-

2.3 Step 3 - Can the synthetic microparticle be phased out?

Is the company able to phase out the use of synthetic microparticles in this product or process and is it known to the company how to technically and economical achieve this?

☐ Yes → **Proceed with Step 9**

☐ No → **Proceed with Step 4**

The quickest and most fundamental way to reduce the emissions of synthetic microparticles is by replacing, removing or excluding them; this avoids the need for other measures. When an organisation confirms that it has removed, excluded or replaced the synthetic microparticles with alternatives, a further inventory of emission reducing measures is not needed.

When an organisation decides not to replace the synthetic microparticles in their product or process a further inventory is needed. A plan with measures to be taken arises from the inventory. This could result in a phase out of synthetic microparticles by that organisation/process anyway.

For cosmetics in almost all cases the inventory will result in the conclusion that synthetic microparticles need to be replaced in the cosmetic product as the emission from the product in its current state cannot be prevented [1]. The removal of microplastics from cosmetics is currently subject to voluntary initiatives of the cosmetics industry.

2.4 Step 4 - Describe the characteristics of the synthetic microparticles

Describe the characteristics of the synthetic microparticles in the product/process. Use the form in Appendix 6 for this step and (if possible) add product sheets from suppliers for each synthetic microparticle. Goal for this step is to collect information, which will be used in the following steps and reduction measures. If all the information is not readily available, collect the easily available information and skip the rest of this step. If more information is needed later on in the test, return to this step and gather more information about the characteristics of the synthetic microparticles.
Additional information: Appendix 1 gives an overview of known synthetic polymers and some of their characteristics.

1. What is the chemical name of the synthetic microparticle?
   Also: note the details of the synthetic microparticles such as molecular weight, structure composition/conformation. If possible, add the product sheet of the supplier

This question helps to identify the type of synthetic microparticles.

Proceed with sub question 2

2. What is the density of the synthetic microparticle in g/cm^3?

The answer can help in defining a strategy to remove the microparticles from a (waste)water stream.

Proceed with sub question 3

3. What size are the synthetic microparticles used?

The answer can help when looking for an appropriate filter technique. Filter techniques are mostly based on size differences, when the size of the particle to be removed from an air or water stream is known a suitable technique can be chosen.

Proceed with sub question 4

4. Function of the synthetic microparticles in the product

☐ Lubricant	→ This product can / cannot be replaced by a non-synthetic microparticle component
☐ Abrasive agent	→ This product can / cannot be replaced by a non-synthetic microparticle component
☐ Scrubbing	→ This product can / cannot be replaced by a non-synthetic microparticle component
☐ See Appendix 1	→ This product can / cannot be replaced by a non-synthetic microparticle component
☐ Other, namely	→ This product can / cannot be replaced by a non-synthetic microparticle component

The answer can help when looking for an appropriate alternative for the currently used synthetic microparticle.

Proceed with step 5

Example 2: Filled out Product result sheet

Product results sheet

General details

Test date:	*31-12-2015*
Product name:	*Alzheimer medicine*
Product code:	*AM-1*

Characteristics of the synthetic microparticle(s)

Name (full chemical name):	*Polybutylacrylate*
Molecular weight[1]	
Structure composition/conformation[1&2]	
Density of the microparticle	Approximately 1,05 g/ml

[1] *Addition of a product sheet from the supplier is a good alternative for answering these questions*

[2] *When it is unclear whether a polymer is soluble or not (which can be influenced by many factors) it would be advisable to write down relevant characteristics (such as structure, molecular weight, and so on) in the identification sheets in order to be able clarify it later after receiving an expert opinion.*

Size of the synthetic microparticles

Nano microparticles < 100 nm	75	%
Fine microparticle 100 nm-100 µm	25	%
Coarse microparticles 100 µm-5 mm	0	%

Goal and/or effect of the synthetic microparticles in this product:

Effect	Replaceable by non-synthetic microparticle component (Yes or No)?
Medicinal vector	Yes, probably, however this means a new application for the food and drugs administration

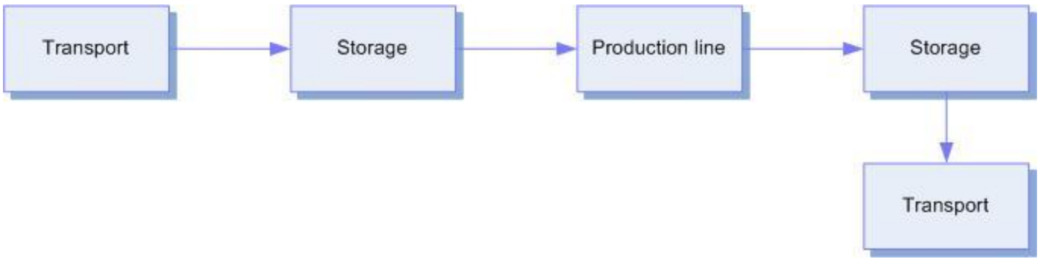
2.5 Step 5 - Make a material flow analysis

Make a material flow analysis (MFA) of the synthetic microparticle(s) during the production process, see for an example below.

MFA is a systematic assessment of the flows and stocks of materials within a system. The aim of this MFA is a clear and simple description and visualisation of what steps are taken with the synthetic particles and it identifies the places where emissions may occur. The easiest way to do this is to make the process visual using a flow sheet. Alternatively, a diagram based on a geographical representation of a site can give a very clear view of the material flows and emissions. Present the amount of synthetic microparticles in the functional unit kg/year. This includes the input from resources, emissions during the process and the output from the process into the product

Note that the user phase and end-of-life phase outside of a production site does not have to be researched extensively. Appendix 3 gives MFA's during the user phase and the end-of-life phase for different types of products which make it possible to easily incorporate this information in the MFA. The information in Appendix 3 can be used to estimate the emissions outside of the production/process site.

Example 3: Flow sheet of a production process



Proceed with step 6

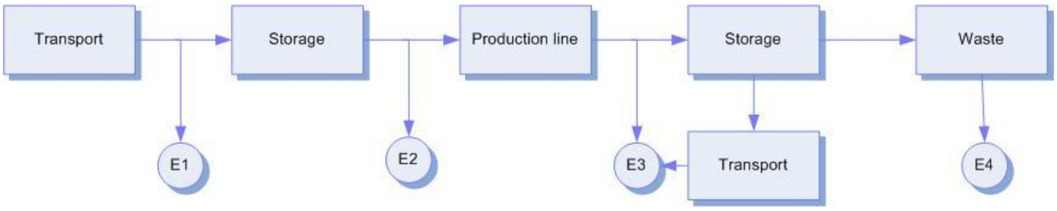
2.6 Step 6 - Quantify the emission of synthetic microparticles

Assign emission percentages to every step of the MFA where emissions may occur and calculate or estimate how many kilograms of synthetic microparticles per year are emitted to the environment. Include a substantiation of the calculations or monitoring methods. Use the MFA data in Appendix 3 for the user phase and the end of life phase.

Quantifying the emissions can be a challenge. Some tips to help with quantification:

- Make a visual examination of the company: Walk through the company and mark on the map where losses might occur. Make an estimate of the potential loss at each location. Estimate how long emissions have been occurring in order to accumulate to the present level
- In some cases the losses can be estimated by making a mass balance. The mass of the input minus the mass of the output, minus the disposed waste is the loss of material
- Another method to estimate the total emissions is to let the staff make an estimate in a daily report or in a shift report at the change of shifts. Adding the emissions per spill will give the emissions per year
- If spills do not occur very often a report per spill can be made. Adding the emissions per spill will give the emissions per year
- When spills happen often, registration should be made as easy as possible. Registration through an app on a mobile phone might make reporting easy
- The amount of spilled material can be measured in wastewater or exhaust streams. However, this might need specialized equipment. Measuring during a shorter period by a specialized measuring company might be a good option. Yearly emissions can be extrapolated from the short term measurements

Example 4: Flow sheet of a production process including emissions



Emission of synthetic microparticles

Step	Phase	%	Kg/year	Calculated/Estimated/Measured
Step 1	Spill when filling industrial containers	1	5	C
Step 2	Spill when dosing to the production line	2	10	C
Step 3	Loss when filling packaging	1	5	C
Step 4	Tearing of packaging in storage	0,5	2,5	E
User phase & end of life				
Step 6	Loss during use	5	25	C
Step 7	Loss during end of life	10	50	E
Step 8				
Step 9				
Step 10				

Proceed with step 7

2.7 Step 7 - Possible source measures

Use Appendix 2 to investigate possible source measures available to replace synthetic microparticles in the product. Is it economically and technologically viable and possible to take source measures to reduce or eliminate the emission of synthetic microparticles?

☐ Yes → List the source measure(s) in the table

Proceed with step 9

☐ No → Substantiate why it is not possible or feasible to take source measures

Proceed with step 8

Example 5: Description of source measures

Applicable source measures

Measure 1	
Source of emission	*Emissions from use of the skin cream*
Countermeasure	*Replace the synthetic microparticles with another material*
Expected emission cut	*100 %*
Planning for adaptation	*Phase out the scrubbing microplastic by 2016. Replace it by ground coconut*
Responsible employee	*J. Smith*
Measure 2	
Source of emission	*Emission from torn packaging sacks when unloading the pallets of synthetic microparticles. E.g. Sacks fall of the pallet or get torn in the process*
Countermeasure	*Use other foil wrap to keep the sacks tightly on the pallet*
Expected emission cut	*90 %*
Planning for adaptation	*Implementation in 2016*
Responsible employee	*J. Smith*

2.8 Step 8 - Identify measures against emission

Identify effect measures for stages in the MFA with a high emission. Use Appendix 4 for input on emission reducing measures.

Proceed with step 9

Example 6: Description of effect measures

Applicable effect measures

Measure 1	
Source of emission	*Emission from torn packaging sacks when unloading the pallets of synthetic microparticles. E.g. sacks fall of the pallet or get torn in the process*
Countermeasure	*Train personnel to clean up spills immediately. Facilitate the cleaning by providing a vacuum cleaner and dustpan and brush*
Expected emission cut	*90 %*
Planning for adaptation	*Implementation in 2016*
Responsible employee	*J. of all Trades*
Measure 2	
Source of emission	*Spillage of synthetic microparticles pellets when unloading. For example when decoupling the hoses are disconnected some pellets are spilled*
Countermeasure	*Use catch trays at every connection. Train personnel to use them in the correct way. Spilled material returned to use or disposed of in closed plastic bags in the industrial waste container*
Expected emission cut	*90 %*
Planning for adaptation	*Implementation second half of 2015*
Responsible employee	*J. of all Trades*

2.9 Step 9 - Make an action plan

Make a plan for the execution of the measures. The following aspects are required:

1. Planned actions
2. A planning including the timing of the actions
3. Contact details for person responsible for the execution
4. Optionally: Allocate a budget for each of the actions

When drawing up the plan a company could focus on the following prioritization:

1. Start with the ‘low hanging fruit’. These are the measures that can be easily implemented while resulting in a quick reduction of emissions
2. If applicable start with preparations for phasing out synthetic microparticles. Phasing out usually is a long process, which should be started as soon as possible
3. If applicable focus on the emissions of the smallest particles. It is possible that smaller particles might cause more damage in the environment than bigger particles
4. The Material Flow Analysis indicates where the greatest emissions occur. It is self-evident that greater emissions should be abated before smaller emissions
5. Point source emissions are easier to abate than diffuse source emissions. Therefore it is advisable to start by reducing point source emissions before setting about diffuse source emissions

The test ends here, start with execution of action plan.

3 Glossary

Biobased polymers are polymers made of renewable biomass. They can be either biodegradable or not biodegradable.

Biodegradable polymers are polymers that can be broken down by micro-organisms into carbon dioxide or methane, mineral salts, water and biomass given the correct environmental conditions. They are not necessarily, and in most cases not biodegradable in the aquatic environment.

Coarse microparticle is a microparticle with a size between 100 micrometer and 5 milimeter.

Fine microparticle is a microparticle with a size between of 100 nanometer and 100 micrometer.

Industrial processes are procedures involving chemical, physical, electrical or mechanical steps to aid in the manufacturing of an item or items, usually carried out on a very large scale.

Material Flow Analyses (MFA) is a systematic assessment of the flows and stocks of materials within a system defined in space and time.

Nanoparticle is a particle with a maximum size in any dimension of 100 nanometer.

Plastic microparticles or microplastrics are particles with a diameter smaller than 5 mm which are made of plastic (elastomers, thermoplastics and thermosets).

Polysaccharide microparticles are particles with a diameter smaller than 5 mm which are made of polysaccharides.

Primary synthetic microparticles particles (sized between [TO CLARIFY by Belgian federal government] and 5 mm) made of synthetic materials based on polymers that are insoluble in water, including biobased and biodegradable polymers.

Processes which use synthetic microparticles are a series of operations performed in the making or treatment of a product. The result of a process is not a product that contains a microparticle. Synthetic microparticles are being used during the process.

Rubber microparticles are particles with a diameter smaller than 5 mm, which are made of rubber (elastomers). In an aquatic environment, they can exhibit the same properties as plastic microparticles; therefore, they are included in the scope of this test.

Secondary synthetic microparticles are plastics formed by the fragmentation of larger synthetic items such as items of packaging and most probably constitute the most substantial source of micro plastic. The secondary synthetic microparticles are the result of degradation of synthetic objects and are not part of the scope of this test.

Semi-solid polymers are polymers where the state of the polymer is between glass transition temperature and the melting point of the polymer.

Silicone microparticles are particles with a diameter smaller than 5 mm, which are made of silicones. In an aquatic environment, they can exhibit the same properties as plastic microparticles; therefore, they are included in the scope of this test.

Synthetic microparticles are synthetic particles produced or existing in the form of particles smaller than 5 mm made of synthetic polymers.

Synthetic polymers (as used in this test) is an umbrella term combining different sort of plastics (thermoset, thermoplastic polymers and elastomers), silicones and adapted polysaccharides that are insoluble in water including biobased and biodegradable polymers.

Water-soluble synthetic microparticles are synthetic microparticles, which fall apart in their constituent molecules when in contact with water. When dissolved in water they do not exhibit the same properties in the aquatic environment as normal synthetic microparticles. The water-soluble synthetic microparticles are therefore excluded from the scope of this test.

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Appendix

1

List of synthetic polymers (non-soluble) that can occur as synthetic microparticles

List of synthetic polymers, which may occur as synthetic microparticles in a product or process

Prefix	Repeating unit	Abbreviation	Application as primary synthetic microparticles	Possible function
Poly	1,4-cis-Isoprene	-	Rubber	Natural rubber
Poly	2-hydroxyethyl methacrylate	HEMA	Paint, drugs	Drug delivery
Poly	2-hydroxypropyl methacrylate	HPMA	Paint, drugs	Drug delivery
Poly	Acrylate	PA	Cosmetics	Viscosity controlling
Poly	Acrylonitrile	-	Synthetic rubber	Rubber
Poly	Acrylonitrile butadiene styrene	ABS	Drugs	Polymer granules for making of products
Poly	Actide	PLA	Drugs	Drug delivery
Poly	Alkyd resins	-	Paint	Binder
Poly	Alkyl stereate/vinyl acetate copolymers	-	Cosmetics	Film formation, hair fixative
Poly	Buthylene/Ethylene/Styrene copolymer	-	Cosmetics	Viscosity controlling
Poly	Butyl acrylate	PBA	Drugs	Drug delivery
Poly	Butyl methacrylate	PMMA	Drugs	Sorbent for delivery of active ingredients
Poly	Butylene terephthalate	PBT	Cosmetics	Film formation, viscosity controlling
Poly	Caprolactam (Nylon 6)	-	Cosmetics	Bulking agent, viscosity controlling
Poly	Cellulose acetate	-	Cosmetics, paints, glue	Gelling and thickening agent
Poly	Cellulose nitrate	-	Cosmetics, paints, glue	Gelling and thickening agent
Poly	Chloroprene	CR	Rubber	
Poly	Dimethylsiloxane (silicone)	PDMS	Cosmetics, food, bulking agent in medical applications	Film formation, viscosity controlling, bulking agent
Poly	Ethyleneimine	PEI	Drugs, cosmetics	Bulking agent, drugs delivery
Poly	Ethylene-glycol	PEG	Drugs	Drug delivery, semi-manufacture
Poly	Elastine-like polypeptide	ELP	Drugs	Drug delivery
Poly	Epoxy resins	-	Paint, glue	
Poly	Ethyl acrylate	-	Paint, textiles, pharmaceutical	
Poly	Ethyl methacrylate	-	Paint, glue	
Poly	Ethylene	PE	Paint, cleaning, tracing, leaving voids after burning	Abrasive blasting, film forming, viscosity controlling, binder for powders, scrubbing, tracing

Prefix	Repeating unit	Abbreviation	Application as primary synthetic microparticles	Possible function
Poly	Ethylene methylactylate copolymer	-	Cosmetics	Film formation
Poly	Ethylene terephthalate	PET	Divers, cosmetics	Adhesive, film formation, hair fixative; viscosity controlling, aesthetic agent
Poly	Ethylene vinyl acetate	EVA	Glue	Adhesive
Poly	Ethylene/acrylate copolymer	-	Cosmetics	Viscosity controlling
Poly	Ethylene/propylene/styrene copolymer	-	Cosmetics	Viscosity controlling
Poly	ε-caprolactone		Medical	Drug delivery, filling agent
Poly	Formaldehyde (Oxymethylene)	-		
Poly	Glycolic Acid			
Poly	Isobornyl acrylate	-		
Poly	Isobornyl methacrylate	-		
Poly	Isobutyl methacrylate	-		
Poly	Isobutylene	-		
Poly	Isoprene	-	natural rubber	
Poly	Lactic acid	PLA	Medical	Drug delivery / filling agent
Poly	Laurolactam (Nylon 12 or Amide-12)	-	Cosmetics	Bulking, viscosity controlling, opacifying
Poly	Lauryl methacrylate	-		
Poly	Methacrylated hyaluronic acid	MA-HA	Drugs	Drug delivery
Poly	Methacrylonitrile	MAN		
Poly	Methyl acrylate	OMA	Drugs	Drug delivery
Poly	Methyl methacrylate	-		
Poly	n-Hexyl methacrylate	-	Paint, glue	
Poly	N-isopropylacrylamide	NIPAM	Drugs	Drug delivery
Poly	Octyl methacrylate	-		
Poly	Pentaerythrityl terephthalate	-	Cosmetics	Film formation
Poly	Propyl acrylate	-		
Poly	Propyl methacrylate	-		
Poly	Propylene	PP	Marco plastic products, cosmetics	Polymer granules for making of products, Bulking agent, viscosity increasing agent
Poly	Propylene oxide	-	Marco plastic products	

Prefix	Repeating unit	Abbreviation	Application as primary synthetic microparticles	Possible function
Poly	Propylene terephthalate	PPT	Diverse, Cosmetics	Emulsion stabilising, skin conditioning
Poly	Stearyl methacrylate	-	Coating, textile	
Poly	Styrene	PS	Marco plastic products, cosmetics, tracers	Film formation, polymer graduents
Poly	Styrene/Acrylate copolymer	-	Cosmetics	Aesthetic, coloured microspheres
Poly	Tetrafluoroethylene (Teflon)	PTFE	Lubricant agent in drilling fluid, cosmetics, bulking agent in medical applications	Bulking agent, slip modifier, binding agent, skin conditioner, lubrication, bulking agent in medical applications
Poly	Tetrahydrofuran	THF		Further processing chemicals
Poly	Trimethylsiloxysilicate (Silicone resin)	TMSS	Cosmetics	Film formation
Poly	Urethane	PUR	Cosmetics, paints, Marco plastic products	Film formation, Polymer granules for making of products
Poly	Vinyl acetate	PVA	Paints, coatings, textiles	Used for adhesivedition
Poly	Vinyl alcohol	PVOH	Paint	Stabilizer
Poly	Vinyl chloride	PVC	Macro plastic products	Polymer granules for making of products
Poly	Vinylidene chloride	PVDC	Coating, cleaning	Used as waterbased coating
Poly	Vinylpolypyrrolidon	PVPP	Clarifier	Clarifying of beverages e.g. beer, wine, fruit juices
	Ethylene vinyl alcohol copolymer	Tegress	Medical bulking agent	

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(Websites visited between 1st of June and 28th of August 2015)

Appendix

2

List of alternatives to synthetic microparticles

Alternative for synthetic microparticles	Application	Replaces which particle?	Reference
Aniseed	Cosmetics (scrubbing)	Polyethylene	Plastic Soup Foundation
Coconut	Cosmetics (scrubbing)	Polyethylene	Plastic Soup Foundation
Polyhydroxyalkanoate	Cosmetics (scrubbing, reology), Medical (vector)	Polyethylene	Website Metabolix
Oatmeal	Cosmetics (scrubbing)	Polyethylene	Plastic Soup Foundation
Salt crystals	Cosmetics (scrubbing)	Polyethylene	Plastic Soup Foundation
Sand	Cosmetics (scrubbing), Industrial (abrasive blasting)	Polyethylene	Plastic Soup Foundation
(Fumed) Silica	Cosmetics (scrubbing)	Polyethylene/Polypropylene	Website Evonik/Aerosil
The ground product of cherry stone	Cosmetics (scrubbing)	Polyethylene	Plastic Soup Foundation
The ground product of the shell of bamboo	Cosmetics (scrubbing)	Polyethylene	Plastic Soup Foundation
The ground product of the shell of nuts	Cosmetics (scrubbing)	Polyethylene	Plastic Soup Foundation
Walnut and pecan nut shell	Industrial (abrasive blasting)	Polyethylene/Polypropylene	Website Dennis Dawson
Cherry stone	Industrial (abrasive blasting)	Polyethylene/Polypropylene	Personal contact: Unicorn Industrial Cleaning Solutions
Silica	Viscosity controlling		Website Aerosil, BASF
Talc	(Cosmetics, pharmaceuticals) lubricant, carrier, thickener, strengthening filler, smooth filler, adsorbent		Website Eurotalc, mineralstechnologies
Clay	Paints (Reology modifier) filler	Polyurethanes, styrene, butadiene, PVA	BSF website, Mineral Technologies website
Natural Cellulose (not modified)	Paints (Reology modifier)	Polyurethanes, styrene, butadiene, PVA	BASF website

Alternative for synthetic microparticles	**Application**	**Replaces which particle?**	**Reference**
Gums (Guar, xanthan, cellulose, Locust bean, acacia) ASA, HASA	Paints (Rheology modifiers)	Polyurethanes, styrene, Butadiene, PVA	AkzoNobel website
Saccharides	Paints (Rheology modifier)	Polyurethanes, styrene, Butadiene, PVA	Mirexus website
Sulfonates (Sodium or calcium)	Paints (Rheology modifier)	Polyurethanes, styrene, Butadiene, PVA	Lubrizol website
Proteins	Paints (Rheology modifier), cosmetics (Film former)	Polyurethanes, styrene, Butadiene, PVA	Lonza Website
Modified Castor Oil	Paints (Rheology modifier)	Polyurethanes, styrene, Butadiene, PVA	BASF website
carbon-coated zirconiumdioxide beads	Medical bulking agent	PTFE, PDMS	Seralidze et al.
(Durasphere), calcium hydroxyapatite	Medical bulking agent	PTFE, PDMS	Seralidze et al.
Ceramic micro spheres	Paints (Rheology modifier)		Website Zeeosphere
Ground calcium Carbonate	Paint (Filling agent)		Website Mineralstech
Precipitated calcium carbonate	Paint (Filling agent)		Website Mineralstech

The above table is not a one-on-one substitution table, but gives a direction where to search for a compatible substitute. In most applications synthetic microparticles where chosen for a specific reason. Substituting the synthetic microparticle will probably mean that the rest of the recipe of a product must be changed.

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Appendix

3

Emissions of synthetic microparticles to the environment in use phase and end-of-life phase

Emissions of synthetic microparticles to the environment in use phase and end-of-life phase

First, all industrial processes are assessed in the internal MFA and therefore not included (in detail) in the use and end-of-life phase of the products. In this section, the use and end-of-life phase of synthetic microparticles in certain products are visualized. With this information, a producer can assess whether the synthetic microparticles are used for products can end up in the environment (as a primary micro plastic) after leaving the production facility.

The visualization of the different pathways is given with the following symbols:

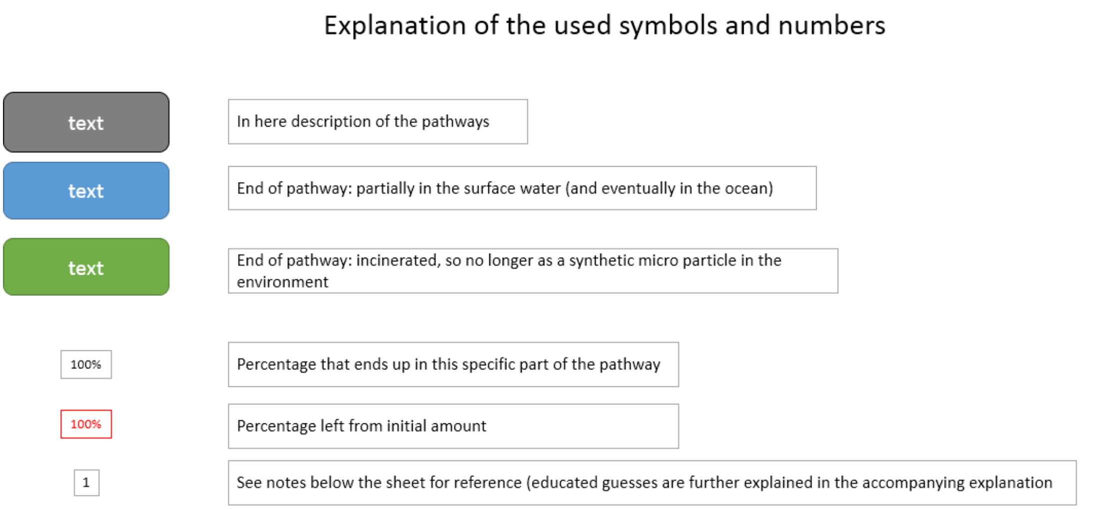

Figure A3.4.1 Overview of used symbols and numbers

Not that the illustrated life cycles are based on limited investigation and educated guesses and can be different from actual percentages.

1.1 Cosmetics (where residues are likely to be rinsed down the sink)

The product is used on the skin and rinsed off after the use. For example: shampoo, shower cream, soap, and so on. figure A3.4.1 gives the life cycle. Use and end-of-life phase for product is:

- Application of the product and rinsing the product after use through the sink. The assumption is made that all of the product ends up in the household wastewater
- In the Netherlands and Belgium, almost 100 % of the household wastewater is transported to communal wastewater treatment [7]

- The exact fate of synthetic microparticles at a sewage treatment plant is poorly researched. The only research available concludes that 90 % of the synthetic microparticles available in the influent of a RWZI will end up in the sewage sludge and 10 % will stay in the effluent water (which is released to a surface water and will eventually end up in the ocean) [7]
- According to Dutch law, all communal sewage sludge is eventually incinerated [8] [9]

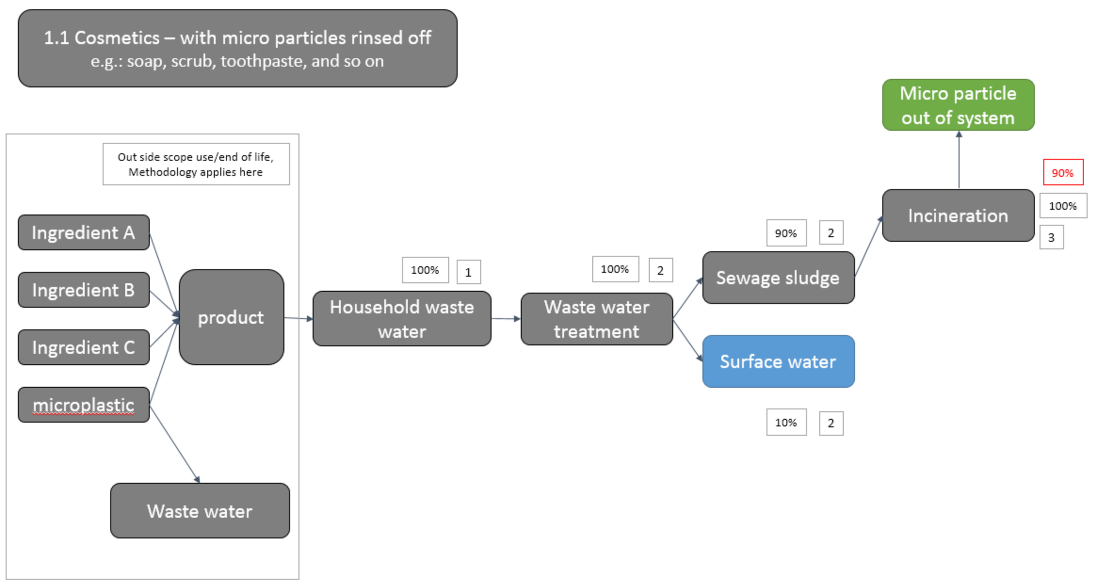

Figure A3.4.1 Life cycle of synthetic microparticles in cosmetics that are rinsed off

1.2 Cosmetics applied on the skin

Product is applied to the skin, but not directly rinsed-off. For example: sunscreen, body lotion. We had trouble to find references on where the product ends up after the appliance. The life cycle is depicted in figure A3.4.3. Educated guess of the researches end up in the following life cycle:

- The product is applied. After this multiple possibilities:
  - Product stays on the skin till being rinsed off after showering, washing clothes, and so on. Educated guess: 89 % ends up in house hold waste water
  - Product is rinsed off directly in surface water (e.g. sunscreen after swimming). Educated guess: in this way 9 % of the product is released directly to the surface water
  - Product is partially absorbed by the body (note: this should be small particles, (smaller than 1 µm [10]) [11]

  Educated guess: 1 % of the products synthetic microparticles are absorbed by the body

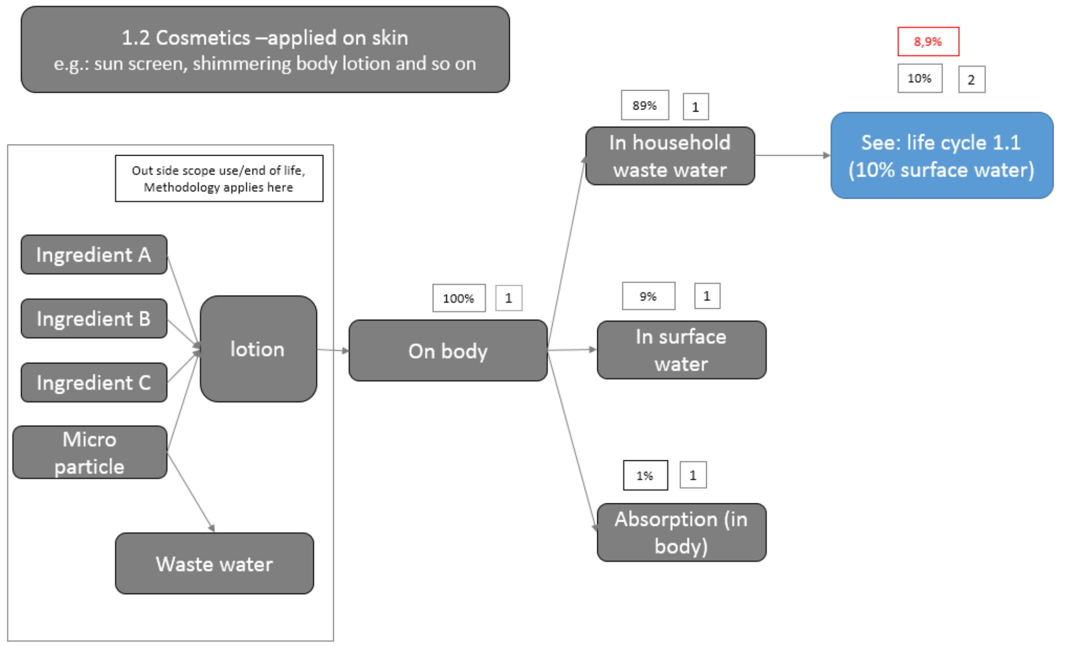

Figure A3.4.2 Life cycle of synthetic microparticles in cosmetics, applied on skin

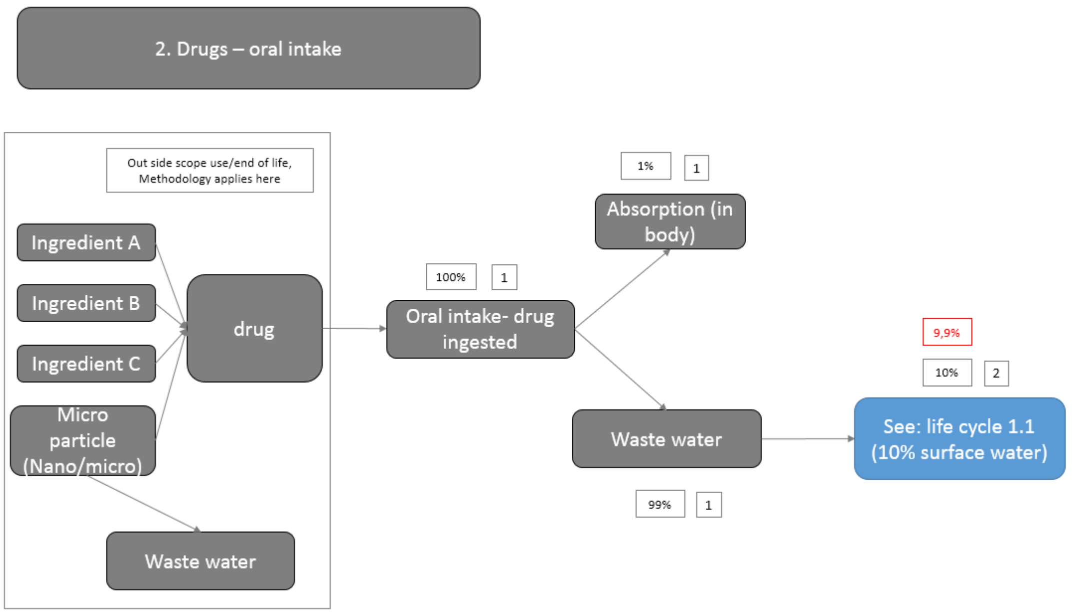

Figure A3.4.3 Life cycle of synthetic microparticles in drugs, oral intake

2. Drugs

The end-of-life fate of medicine is not very clearly described in literature. And the fate of the synthetic microparticles varies widely between applications. Based on the literature we consulted, only assumptions can be made:

- Drugs are ingested (oral intake) or injected
- Part is absorbed by the body. Educated guess → 1 %
- Part is finding its' way to the wastewater. Educated guess → 99 %
- When synthetic microparticles are in the wastewater: see assumptions for wastewater plant (1.1 cosmetics that are rinsed off)

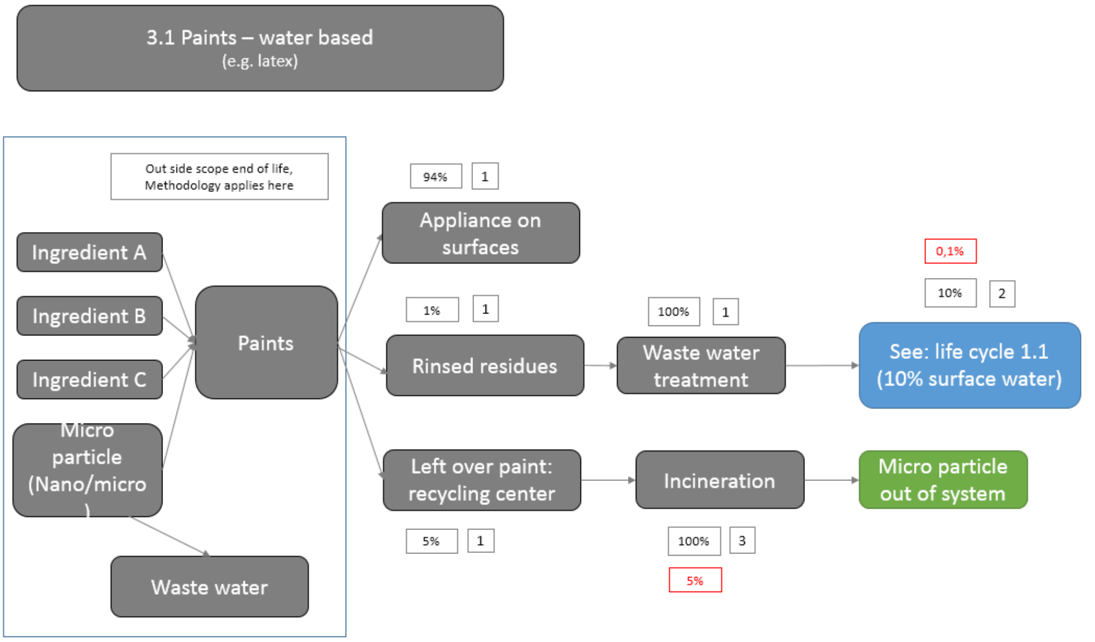

Figure A3.4.4 Life cycle of synthetic microparticles in water based paints

3.1 Water based (Acrylic) paints:

- Assumed that there are three paths in which the paint can (eventually) come in the environment:
  - During the abrasion of painted surface (assumption: 94 %)
  - When the paint is washed away through the sink while washing hands/brushes (assumption: 1 %)
  - When the paint is disposed and eventually incinerated (assumption: 5 %)
- For all three paths, assumptions are made about where the synthetic microparticles end up in the aquatic environment

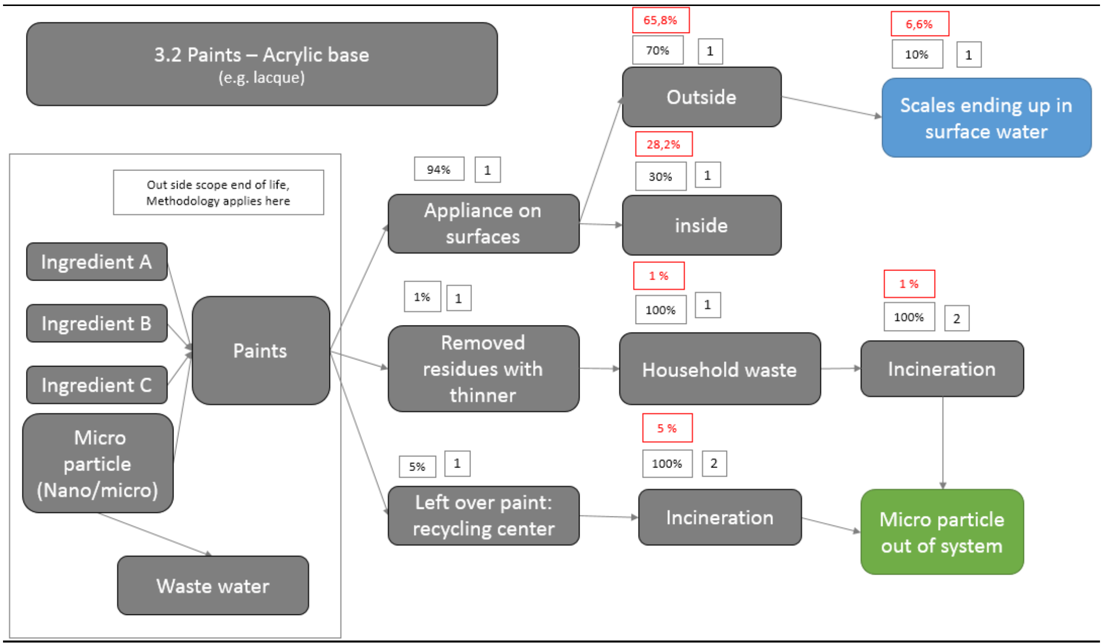

Figure A3.4.5 Life cycle of synthetic microparticles in alkyd/alkyd resin based paints

3.2 Alkyd/Alkyd resin based paints:

- Assumed that there is path in which the paint can (eventually) enter the environment:
  - On a painted surface (assumption: 94 %)
  - Only if the painting is done outside and the microparticle stays in its original form (primary mircoparticle) after painting. (assumptions: 70 % of painting done outside, 10 % of the paint (scales) ending up in environment)
- Other pathways that lead to incineration:
  - Removing the residues with thinner (1 %). Although these residues should be brought to a municipal waste treatment, we assume that people dispose this waste at home. Either way, it will be incinerated eventually
  - The leftover paint brought to the recycling centre will eventually be incinerated (5 %)

Appendix

4

Measures to reduce emissions of synthetic microparticles

Measures to reduce emissions of synthetic microparticles

This Appendix gives some general information on prevention of emission of synthetic microparticles. For more information on appropriate measures, see operation clean sweep at www.opcleansweep.eu. Operation clean sweep aims to reduce the emission of pellets of nurdles, but some of the measures can be used when working with other types of synthetic microparticles.

Emissions of synthetic microparticles to the aquatic environment can occur in three ways:

1. Directly into the water
2. Through or over the ground or soil
3. Through the air

This Appendix lists the measures that can be taken to reduce the emissions of synthetic microparticles. The measures are given in the order of the above emission paths.

The strategy to prevent emissions should always start at the source and can be simplified to:

1. Prevent emissions (i.e. use a closed process)
2. Prevent spreading (i.e. use a leak proof floor and clean any spills)
3. Shield the environment (i.e. use a filter in the sewage system)

Direct emission to the water

1. Make sure that synthetic microparticles are not spilled into water
   a. No loading and unloading of loose materials that contain synthetic microparticles above surface water. Always use suitable packaging or a conveying method that prevents emissions
   b. Do not stockpile loose materials that contain synthetic microparticles near water. Keep loose materials that contain synthetic microparticles at least 50 meters from surface water

2. Make sure that synthetic microparticles are not discharged through the sewer system
   a. Fit all the drains with suitable particle traps, e.g. sink-float separation or particulate filters
   b. Alternatively, fit the main discharge pipe with suitable particle traps, e.g. sink-float separation or particulate filter
   c. Implement a suitable maintenance cycle for the particle traps

Explanatory notes

Suitable particle traps are adapted to the specific properties of the micro plastic to be contained. The essential properties are the particle density for sink-float separation and the particle size for particulate filters. Particle traps should be dimensioned for peak discharge to prevent overflow in heavy rainfall.

A suitable maintenance or cleaning cycle is essential. Lack of maintenance or cleaning can lead to emissions of synthetic microparticles.

Figure A4.1 below shows the separation processes related to the size of the microparticles. This figure can be used to make a first selection of a separation technology.

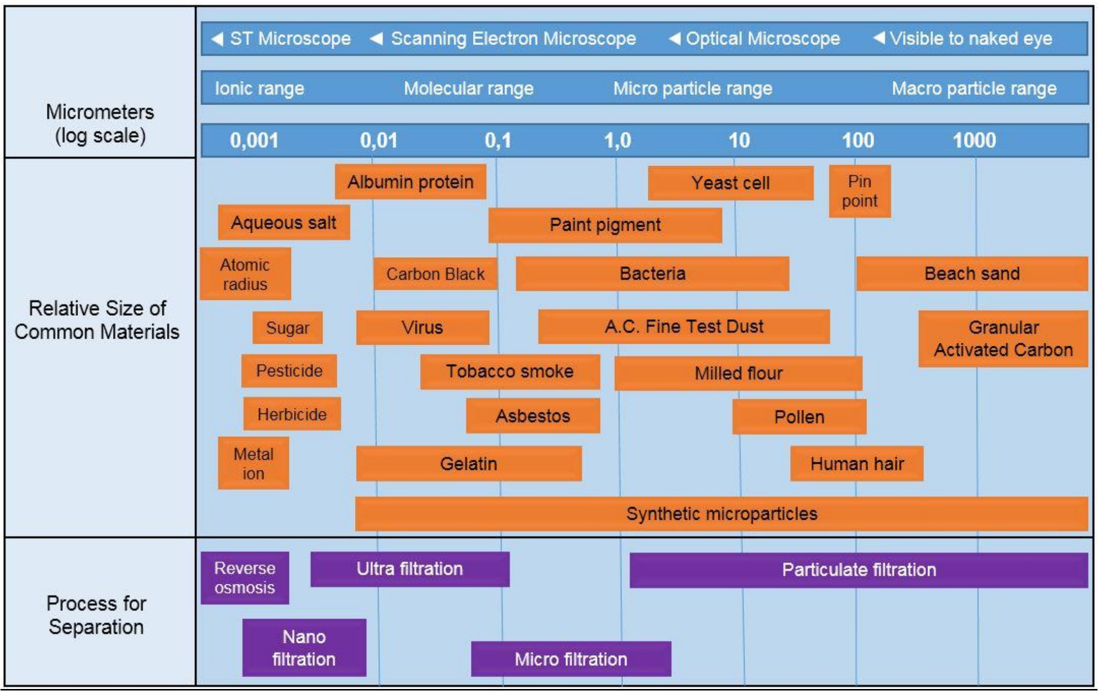

Figure A4.1 Visual representation of particle sizes and separation processes

Through or over the ground or soil

1. Make sure that materials containing synthetic microparticles cannot be spilled.
   a. Use closed production facilities so synthetic microparticles will be contained within the process. E.g. closed conveyors, closed storage silos, et cetera
   b. Use valves if it is possible that lines are disconnected
   c. Use suitable packaging for materials that contain synthetic microparticles. E.g. barrels instead of bags, use packaging that cannot be easily pierced

2. Make sure that spills can be cleaned easily
   a. All surfaces where spills of synthetic microparticles can easily occur should be paved so synthetic microparticles can be collected easily, e.g. no open joints or seams
   b. Where spills can occur frequently a secondary containment or catch tray should be implemented
   c. Provide cleaning materials like brooms, dust pans, shovels, vacuum cleaners, et cetera
   d. After loading trucks synthetic microparticles might be left on fenders or other parts of a truck. An automatic truck wash, or blowing station might prevent emission of particles by trucks

3. Make sure that spills will be cleaned:
    a. Instruct all personnel how to clean spilled materials
    b. Instruct all personnel to clean the spilled material promptly
    c. Instruct all personnel how to dispose of the cleaned materials so secondary emissions will be prevented
    d. Regularly check for spills

Explanatory notes
Prevention of synthetic microparticles spills is essential. All process operations should be designed to prevent emissions. Personnel must be instructed on the need to keep process operations closed and on proper operating procedures when the process operation needs to be opened.

Should a spill occur, it is essential to be able to clean the spill. A rough surface will make cleaning of synthetic microparticles nearly impossible. A smooth surface will facilitate cleaning of a spill. The organisation should implement a procedure on how to clean up a spill. Most important is to instruct all personnel that cleaning is an important task that should not be delayed.

Through the air
Smaller synthetic microparticles, e.g. dusty materials, or expanded plastics can easily be transported through the air.

1. Make sure that materials containing synthetic microparticles are not be emitted to the air:
    a. Use sealed production facilities in order to contain synthetic microparticles within the process. E.g. closed conveyors, closed storage silos, et cetera
    b. Use valves if it is possible that lines are disconnected
    c. Use suitable packaging for materials that contain synthetic microparticles. E.g. barrels instead of bags, use packaging that cannot be easily pierced
    d. If applicable, suspending the micro plastic in a liquid can prevent emissions of the micro plastic to the air. Applicability depends on the process

2. Make sure that materials containing synthetic microparticles cannot be spread through the air:
    a. Work only indoors with synthetic microparticles that can easily be spread through the air. Restrict the places where emissions can occur to a limited area of the installation. E.g. use screens or netting around places where emissions can occur
    b. Use adequate (local) aspiration combined with adequate collection equipment like dust filters or cyclones
    c. Implement suitable emergency (shut down) procedures to minimize the emissions of synthetic microparticles through the air. E.g. automatic switching to a back-up filter or automatic closing of emergency fire doors

3. Make sure that synthetic microparticles in the air can be cleaned up:
   a. Operate/install vacuum cleaners/air cleaners to remove emissions in the air indoors
   b. Instruct all personnel what to do if synthetic microparticles are emitted to the air
   c. Instruct all personnel to remove the emitted material promptly
   d. Instruct all personnel how to dispose of the cleaned materials so secondary emissions will be prevented
   e. Install leak detection technology to detect spills or instruct personnel to report on dust emissions and take corrective measures

Explanatory notes

Synthetic microparticles that can be transported through the air are difficult to clean up should an emission occur. Focus therefore should be on the prevention of emission from the process. A closed process is generally the best option and has as the advantage that it prevents loss of raw materials as well as resulting in a better working environment. If a closed process is not possible, the process operation that cannot be sealed should be located indoors in a designated area away from the rest of the process. This area should be cleaned regularly.

Appendix

5

Fill out form listing products and processes

General overview of products and processes

General details

Company name:	
Company address:	
Company contact name:	
Company contact phone number:	
Test date:	

Products

Name of polymer	**Used in product:**	**Synthetic microparticles?**	**Substantiation**

Processes

Name of polymer	Used in process:	Synthetic microparticles?	Substantiation

Appendix

6

Product / process result sheet

Product results sheet

General details

Company contact name:	
Test date:	
Product name:	
Product code:	
Total amount produced per year	

Characteristics of the micro plastic(s)

Name:	
	Yes/No and substantiation
Molecular weight[1]	
Structure composition/conformation[1&2]	
Size	
Density	
Other information	

Name:	
	Yes/No and substantiation
Molecular weight[1]	
Structure composition/conformation[1&2]	
Size	
Density	
Other information	

[1] *Addition of a product sheet from the supplier may help in answering these questions*

[2] *When it is unclear whether a polymer is soluble or not (which can be influenced by many factors) it would be advisable to write down relevant characteristics (such as structure, molecular weight, and so on) in the identification sheets in order to be able clarify it later after receiving an expert opinion.*

Goal and/or effect of the synthetic microparticles in this product:

Effect	Replaceable by non-micro plastic component (Yes or No)?
Lubricant	
Abrasive agent	
Tracer	
Scrubbing	
Film forming	
Polymer granules for making of products	
Viscosity controlling	
Binding agent for powders	
Adhesive	
Gellant	
Hair fixative	
Suspending agent	
…….	

Material flow analysis schematic

Emission of synthetic microparticles

Step 1			%		kg

Step 2			%		kg
Step 3			%		kg
Step 4			%		kg
Step 5			%		kg
Step 6			%		kg
Step 7			%		kg
Step 8			%		kg
Step 9			%		kg
Step 10			%		kg
Step 11			%		kg
Step 12			%		kg

Text field for substantiation:

Applicable source measures

Measure 1	
Source of emission	
Countermeasure	
Expected emission cut	
Planning for adaptation	
Responsible employee	
Measure 2	
Source of emission	
Countermeasure	
Expected emission cut	
Planning for adaptation	
Responsible employee	
Measure 3	
Source of emission	
Countermeasure	
Expected emission cut	
Planning for adaptation	
Responsible employee	

Applicable effect measures

Measure 1	
Source of emission	
Countermeasure	
Expected emission cut	
Planning for adaptation	
Responsible employee	
Measure 2	
Source of emission	
Countermeasure	
Expected emission cut	
Planning for adaptation	
Responsible employee	
Measure 3	
Source of emission	
Countermeasure	
Expected emission cut	
Planning for adaptation	
Responsible employee	

Appendix 7

Categories of companies that may use primary synthetic microparticles

Categories of companies that might use synthetic microparticles

Number	Product category	E-PRTR-code[1]
1	Producers of plastic granulates including recycled plastic	4.a
2	Producers of rubber granulates including recycled rubber	4.a
3	Producers of cosmetics	4.a
4	Producers of paint and pigments	4.a
5	Producers of glue	4.a
6	Producers of varnish	4.a
7	Producers of food	No E-PRTR code available for food industry
8	Producers of medicine	4.b
9	Abrasive cleaning with plastic	2.f, 3.e, 9.e
10	Blasting with plastic (metal industry)	2.f, 3.e, 9.e
11	Production of plastic products by plastic granulates	4.a
12	Production of rubber products by rubber granulates	4.a
13	Painting	2.f, 9.c
14	Varnishing	2.f, 9.c
15	Gluing	2.f, 9.c
16	Use of tracers in wind tunnels	-
17	Use of tracers in chemical processes	4.a, 4.b, 4.c. 4.d, 4.e, 4.f
18	Importers of possible microplastic-containing products from one of the listed categories from non-Ospar countries	-

Note that a company still may emit synthetic microparticles, even when it officially does not have an E-PRTR code. A company may not have an E-PRTR code because it may be below the capacity threshold and therefore doesn't need to report about environmental emissions under the E-PRTR Regulation.

[1] For overview of E-PRTR codes and desriptions of activities, see Appendix 1 of the guidance document for the implementation of the European E-PRTR, 31 May 2006

Appendix

8

Solubility of synthetic microparticles

Brief explanation of insolubility of synthetic microparticles

All the synthetic particles mentioned in this test under Appendix 1 are assumed to be non-soluble synthetic (micro) particles.

Solubility of polymer can be verified in polymer/product information sheets, safety data sheets etc. If not found, a brief prediction of solubility can be made based on polymer type and Hildebrand solubility parameter. A more substantial verification requires a solubility test.

Polymers can be divided in three classifications (thermoplastics, elastomers and thermosets) according to their properties. Elastomers (e.g. rubber) and thermosets (e.g. resins) are not soluble in water. They are network polymers. Therefore, they can swell when in contact with a water, but they cannot fall apart as the polymer chains are linked together.

In contrast with elastomers and thermosets, thermoplastic polymers can be linear or branched polymers and can or cannot be soluble in water. The solubility of the polymer will depend on the miscibility or bonding with the solvent. In order to get an idea whether the plastics are soluble, the Hildebrand solubility parameter (Hildebrand SP) can give an outcome. The difference between the Hildebrand SP's of the solvent and the plastic give an impression of the solubility. When the Hildebrand SP value of the polymer is between 43 $MPa^{1/2}$ and 53 $MPa^{1/2}$ it is probable that the polymer dissolves.

When it is unclear whether a polymer is soluble or not (which can be influenced by many factors) it would be advisable to write down relevant characteristics (such as structure, molecular weight, and so on) in the identification sheets in order to be able to clarify it later after receiving an expert opinion. It is also possible to execute a solubility test.

If a company believes that a considered polymer is soluble in the aquatic environment and thus should be excluded from this test, this has to be extensively substantiated by evidence and/or data provided by the company. For example, a solubility test can be performed according to

- ISO 25179:2010 Adhesives -- Determination of the solubility of water-soluble or alkali-soluble pressure-sensitive adhesives
- OECD Guidelines for the Testing of Chemicals, Section 1 Physical-Chemical properties, Test No. 105: Water Solubility
- EPA: Product Properties Test Guidelines OPPTS 830.7840 Water Solubility: Column Elution Method; Shake Flask Method

A water soluble polymer is not considered to be a synthetic micro particle in the scope of this manual.