

Odor characterization, monitoring, control and removal from recycled plastics – **Introduction and techniques**

MSc. Tiago Belé – ESR 8 – Chair of Aroma and Smell Research



This Project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No. 859885



What we are going to see in this μ Teaching:

- Why odor characterization is an important part for this project
- How odor compounds are formed during plastic recycling
- What are the main technologies to remove odor compounds
- How odor compounds are characterized
- Extraction techniques
- Further plans

Host Institution - Chair of Aroma and Smell Research



FAU - Supervisor:
Prof. Dr. Andrea Büttner



Mentoring:
Dr. Helene Loos

Planned secondments:



Ghent University –

Supervisor:

Prof. Dr. S. De Meester

Prof. Dr. Andrea Büttner

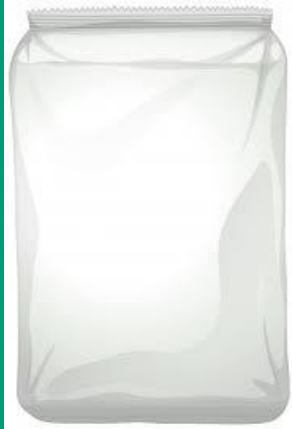
Dr. Tilman Sauerwald

Introduction:

- Europe is moving towards a circular economy
- More than 15 millions tons of plastic processed in Germany alone in 2018
- Low-grade outdoor use in the agriculture and construction sector shows the highest application amount of recycled plastics

Introduction:

- Demand for high-quality recyclates in new products
- Recycling processes often cannot produce the recycled quality required by the packaging industry (free of odors/contamination)



Created by Adrien Coquet
from Noun Project



Images licenses:
<https://unsplash.com/license>



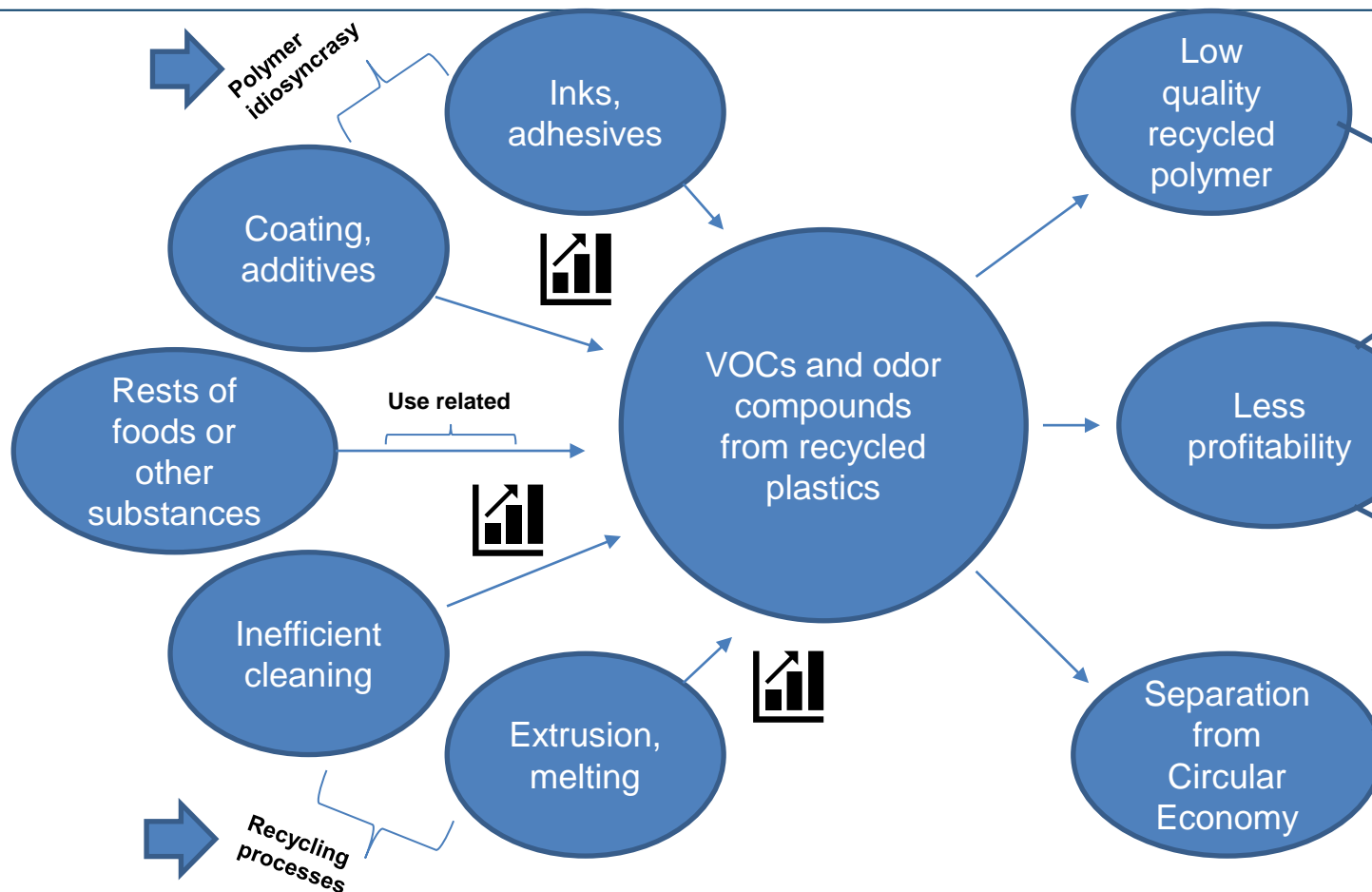
**Recycled plastic must be enhanced in quality to fit
a closed-loop process!**



How odor compounds are formed:

Usually by several chemical reactions ranging from degradation processes to microbiological influences





No permission for reproduction or any use. Only C-PlaNet website and the owner!

Creator:
Tiago Belé



Several odor compounds have been reported...

Several polymers across processing		
Compounds	OD Factor	Quality
dimethyl trisulfide	≥2187	garlic-like, cabbage-like
3-mercapto-2-pentanone	≥2187	cat urin-like, black currantlike
methional	≥2187	cooked potato-like
butanoic acid	≥2187	cheesy, sweaty
3-methylbutanoic acid	≥2187	cheesy
pentanoic acid	≥2187	cheesy, fruity
α-Isomethylionone	≥2187	rose-like
trans-4,5-epoxy-(E)-dec-2-enal	≥2187	Metallic
p-cresol	≥2187	fecal, horse stable-like
skatole	729	fecal, mothball like

Miriam Strangl et.al.

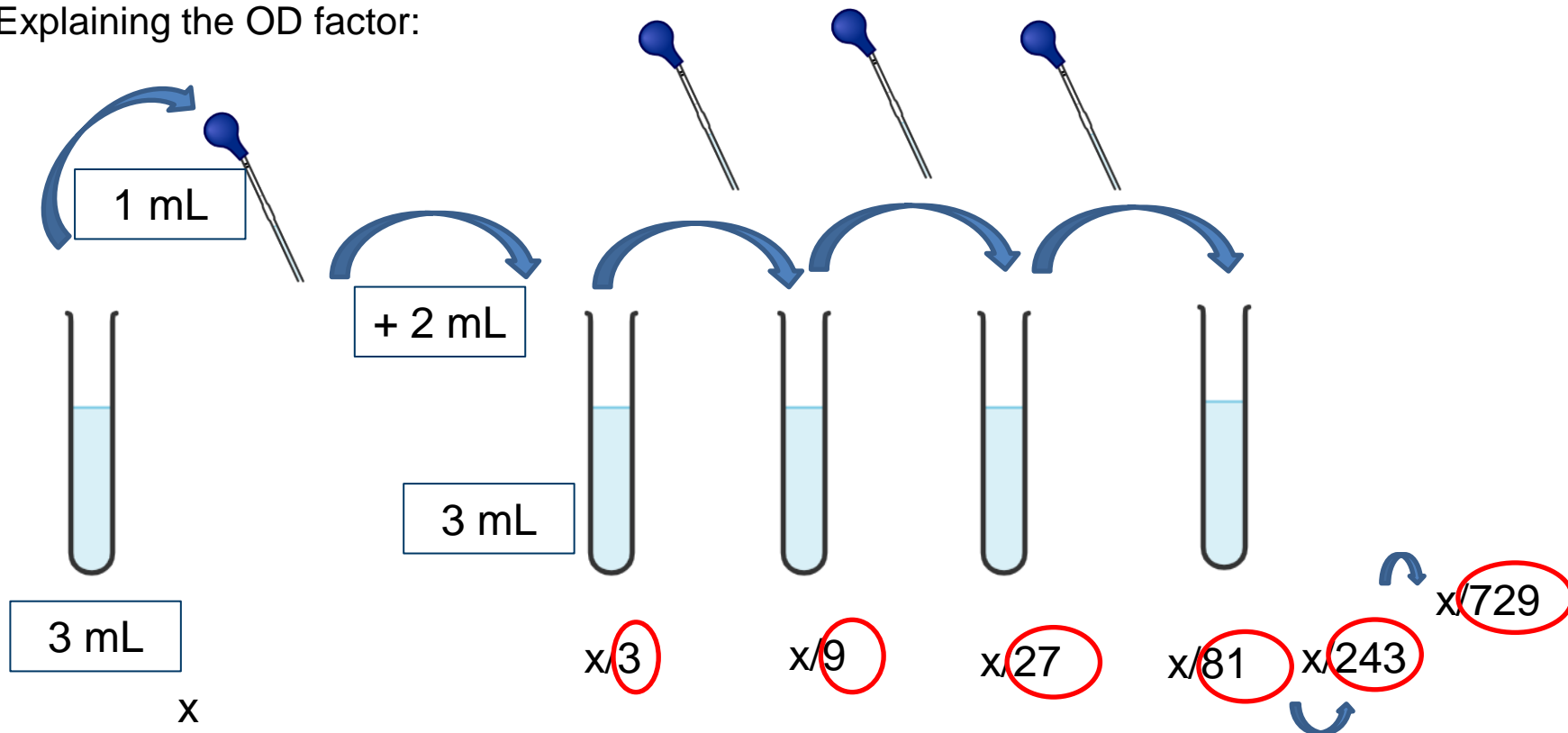
Evaluation of the efficiency of odor removal from recycled HDPE using a modified recycling process

July 2019 Resources Conservation and Recycling 146:89-97

DOI: 10.1016/j.resconrec.2019.03.009



Explaining the OD factor:



Several odor compounds have been reported...

Several polymers across processing

Compounds	OD Factor	Quality
dimethyl trisulfide	≥2187	garlic-like, cabbage-like cat urin-like, black currantlike
3-mercapto-2-pentanone	≥2187	
methional	≥2187	cooked potato-like
butanoic acid	≥2187	cheesy, sweaty
3-methylbutanoic acid	≥2187	cheesy
pentanoic acid	≥2187	cheesy, fruity
α-Isomethylionone	≥2187	rose-like
trans-4,5-epoxy-(E)-dec-2-enal	≥2187	Metallic
p-cresol	≥2187	fecal, horse stable-like
skatole	729	fecal, mothball like

Miriam Strangl et al.

Evaluation of the efficiency of odor removal from recycled HDPE using a modified recycling process

July 2019 Resources Conservation and Recycling 146:89-97

DOI: 10.1016/j.resconrec.2019.03.009

PPs (different colors, processes applied)

Compounds	OD Factor	Quality
α-damascone	2187	apple juice-like
α-Isomethylionone	2187	flowery, roselike
verdyl acetate	2187	banana like
β-ionone	2187	violet-like, flowery
trans-4,5-epoxy-(E)-2-decenal	2187	metallic
methylcyclomyrcetone isomer	2187	flowery, eucaliptus
phenylacetic acid	2187	bee wax-like, honey like
linalool	729	foapy, citrus-like
verdyl propionate	729	banana like
p-cresol	729	fecal, horse stable-like

Miriam Strangl et al.

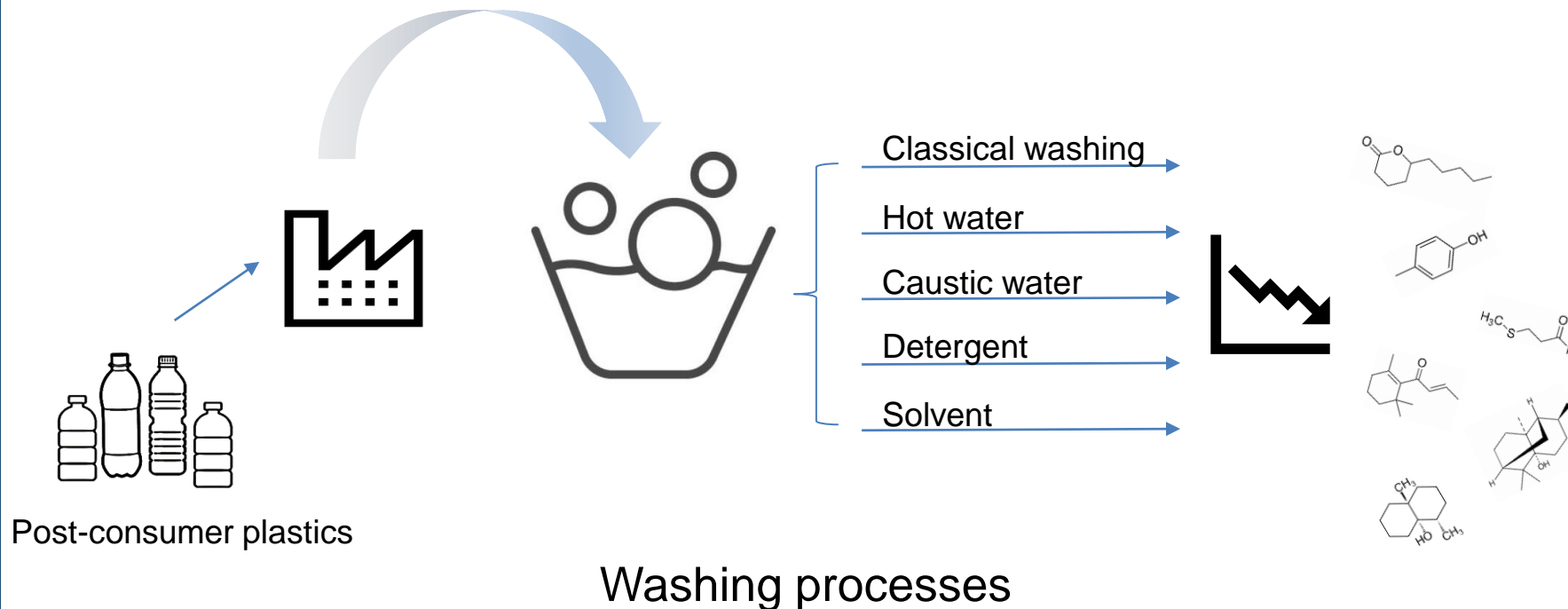
Odorant composition of post-consumer LDPE bags originating from different collection systems

January 2020 Waste Management 104:228-238 Follow journal

DOI: 10.1016/j.wasman.2020.01.021

What are the current technologies to remove odor compounds from recycled plastics?

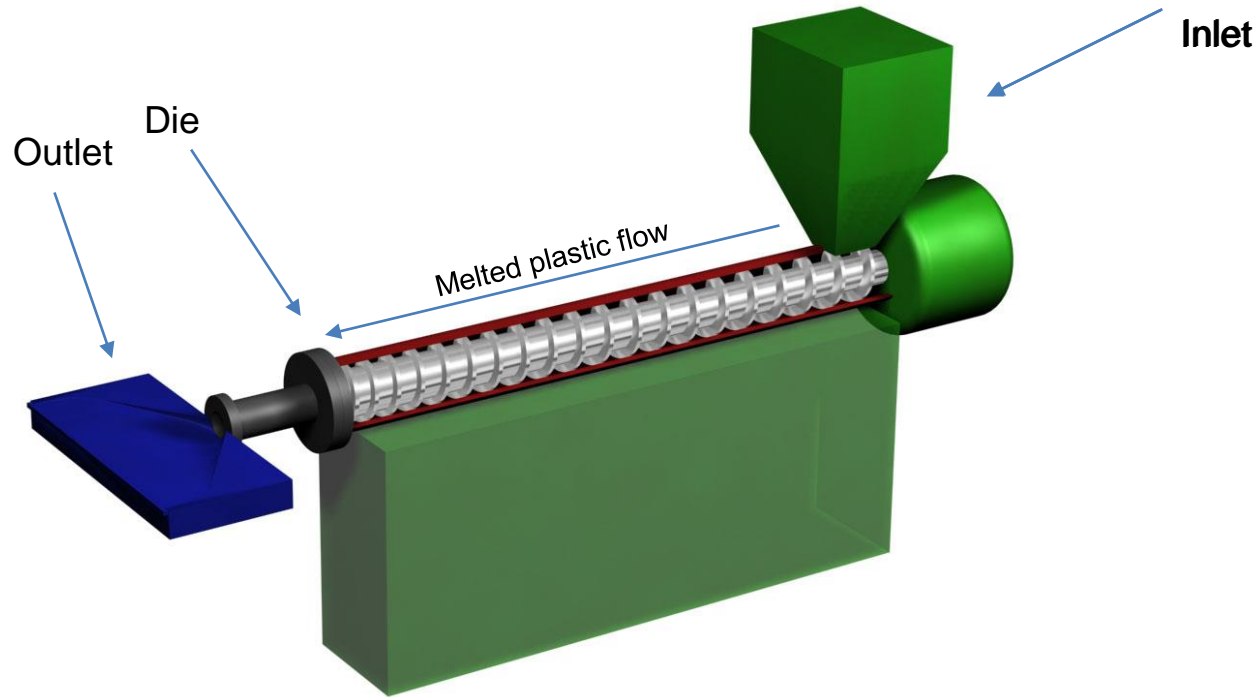
What are the current technologies to remove odor compounds from recycled plastics?



What are the current technologies to remove odor compounds from recycled plastics?

Devolatization

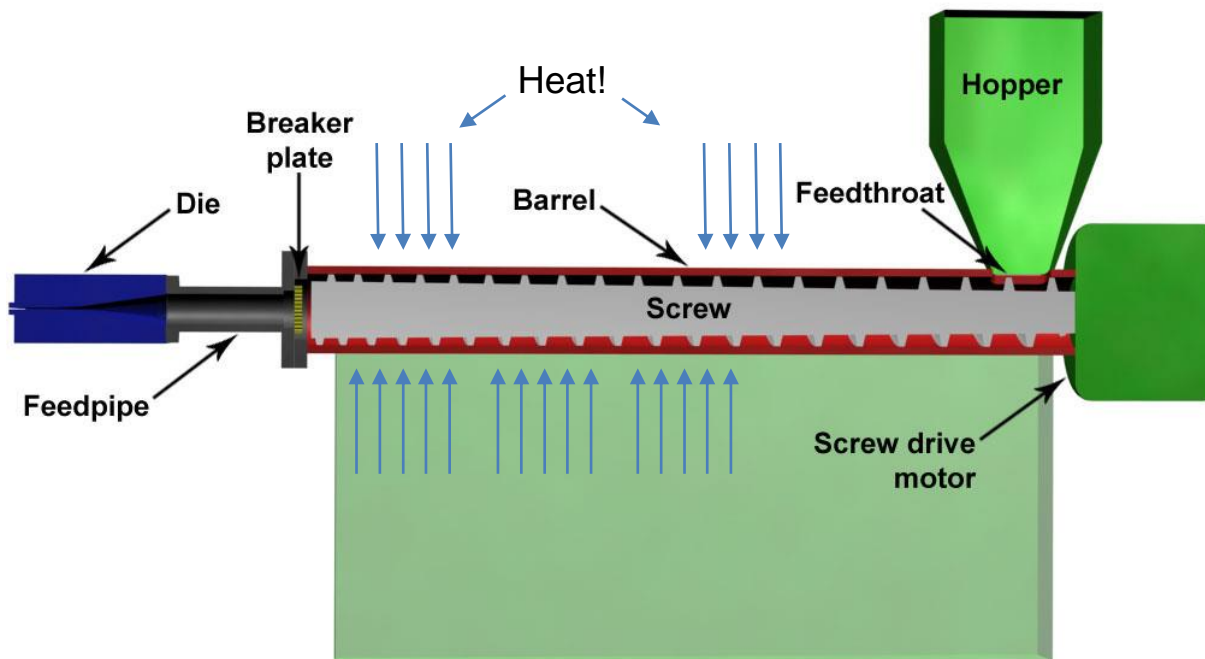
What are the current technologies to remove odor compounds from recycled plastics?



Devolatilization
during extrusion

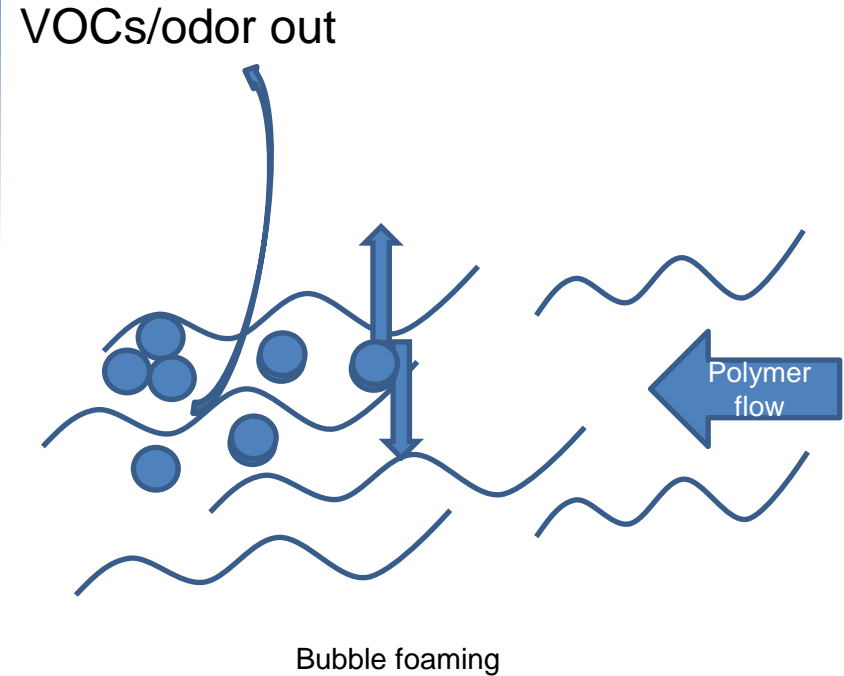
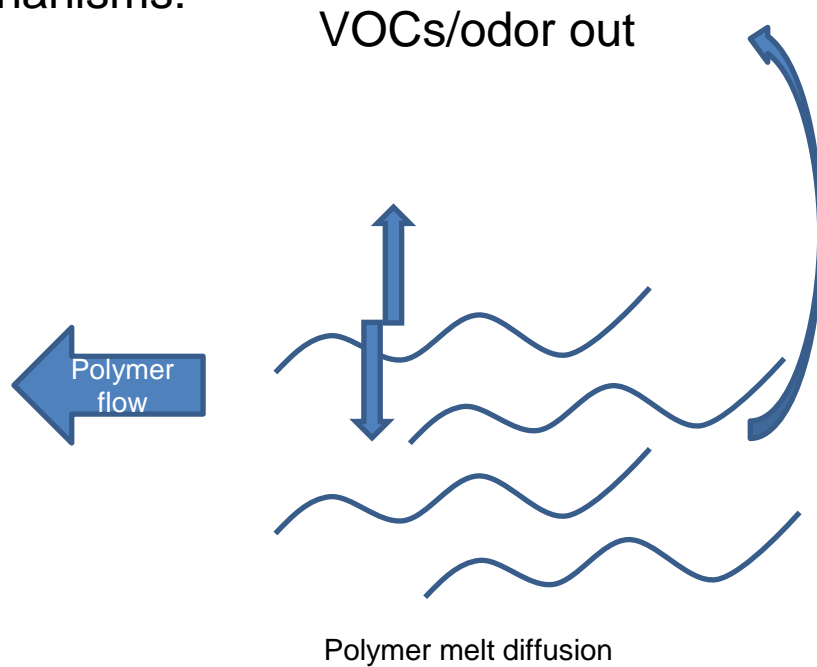
What are the current technologies to remove odor compounds from recycled plastics?

Devolatization during extrusion:

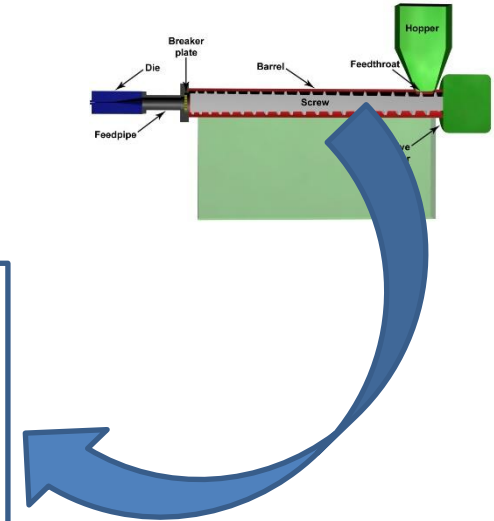
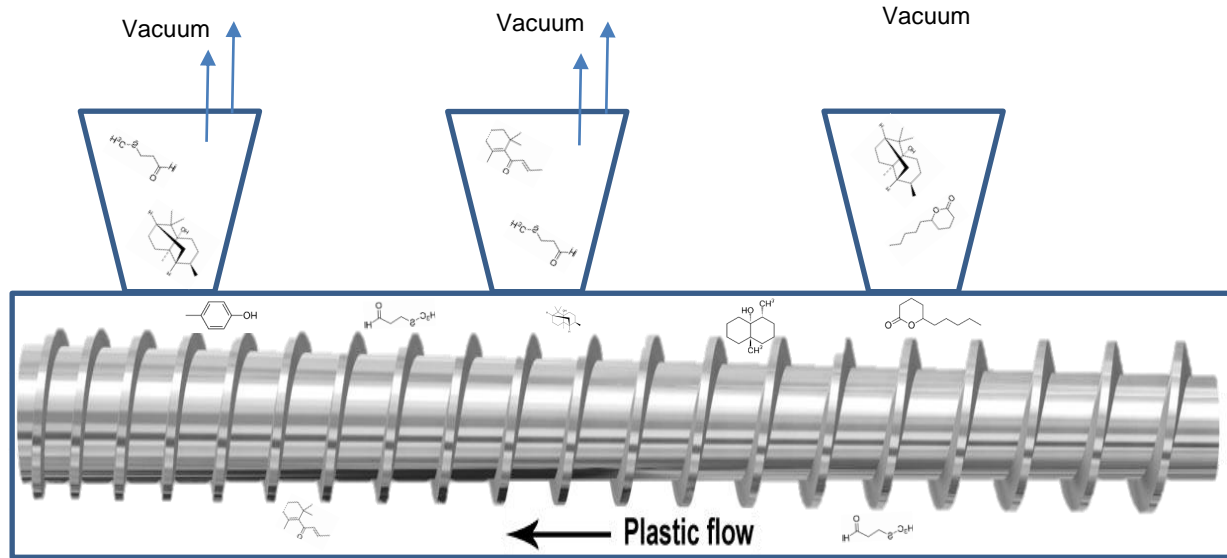


What are the current technologies to remove odor compounds from recycled plastics?

Mechanisms:



What are the current technologies to remove odor compounds from recycled plastics?



What are the current technologies to remove odor compounds from recycled plastics?

A few more are...

Temperature increase 

Use of adsorbents

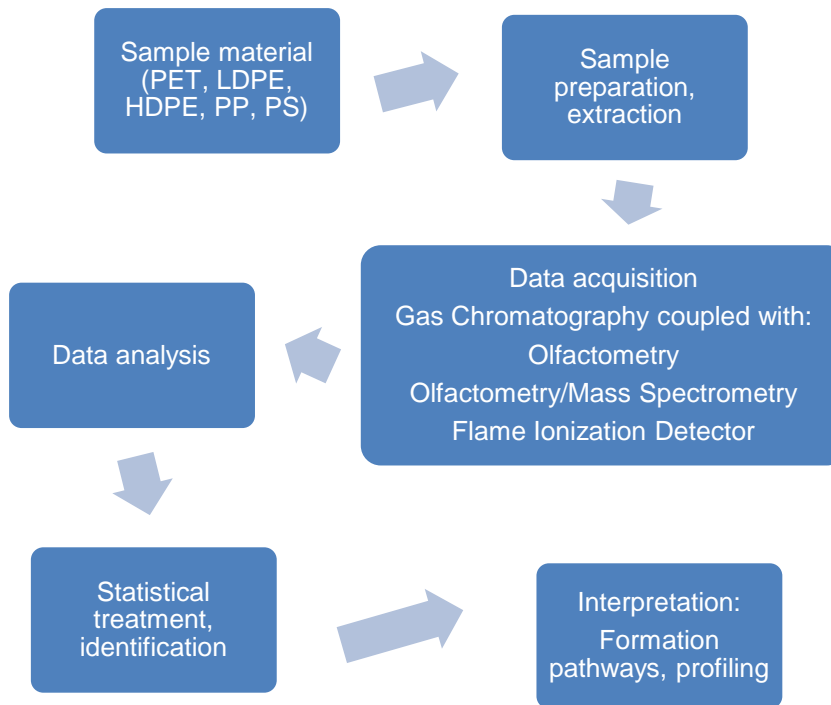
Supercritical CO₂



Ok... Now, how can we measure them?



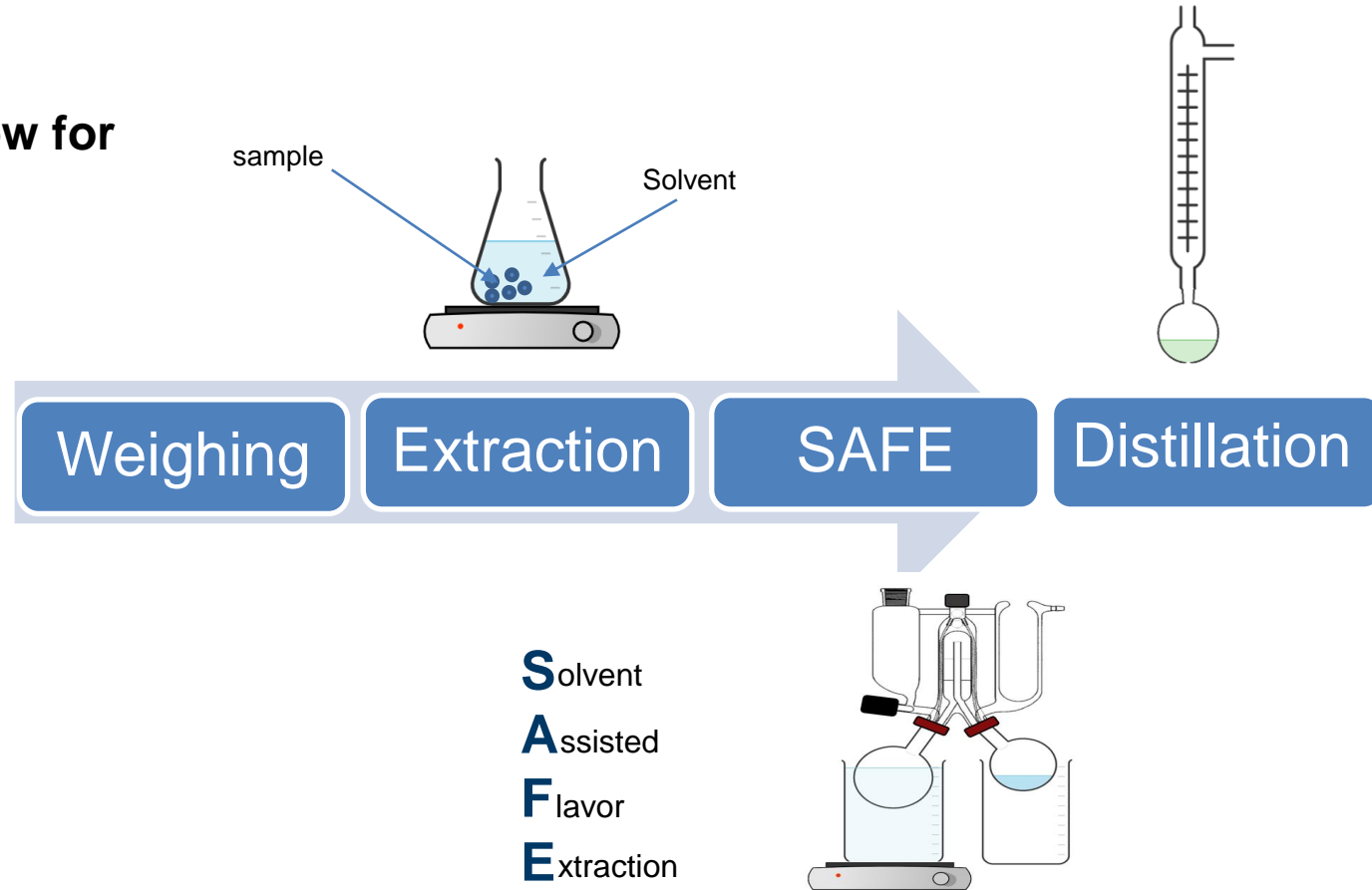
Typical workflow for the analysis of vocs and odor compounds from recycled polymers



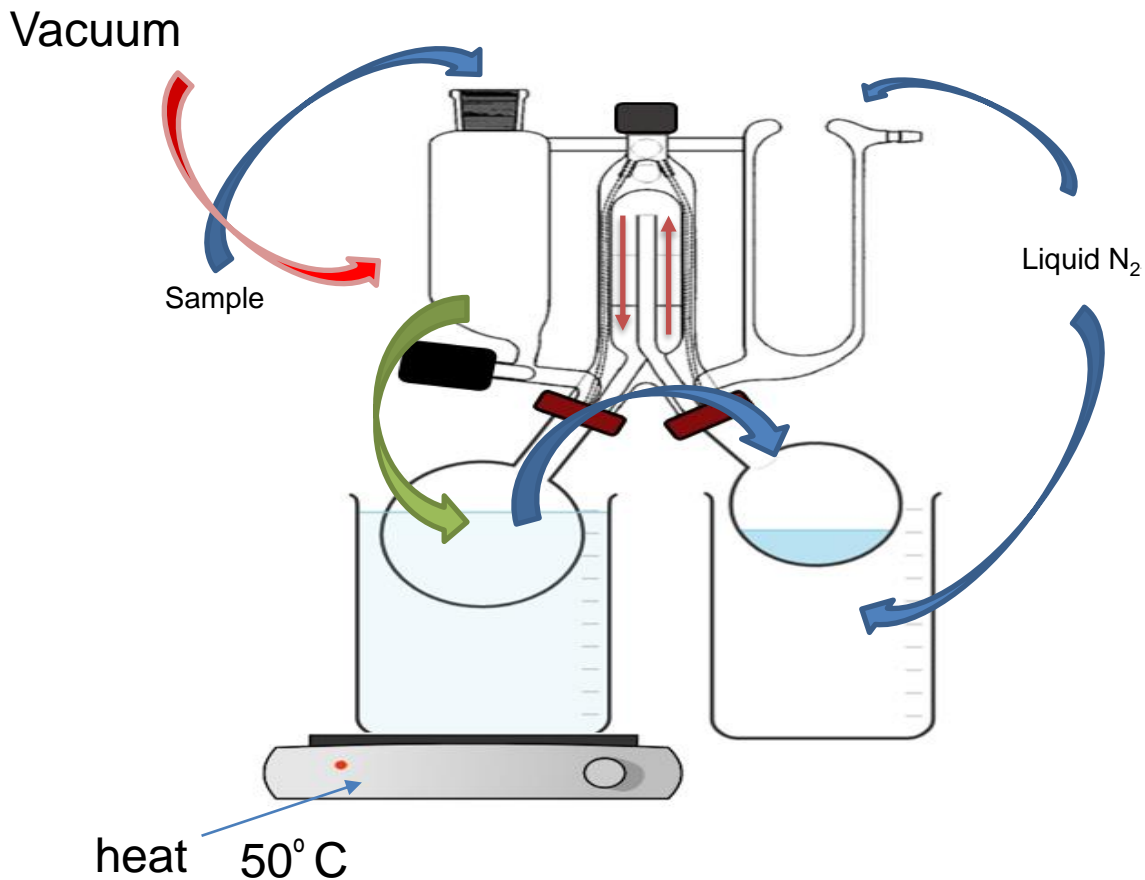
No
permission
for
reproduction
or any use.
Only C-
PlaNet
website and
the owner!

Creator:
Tiago Belé

Extraction work-flow for a SAFE procedure:



Solvent Assisted Flavor Extraction



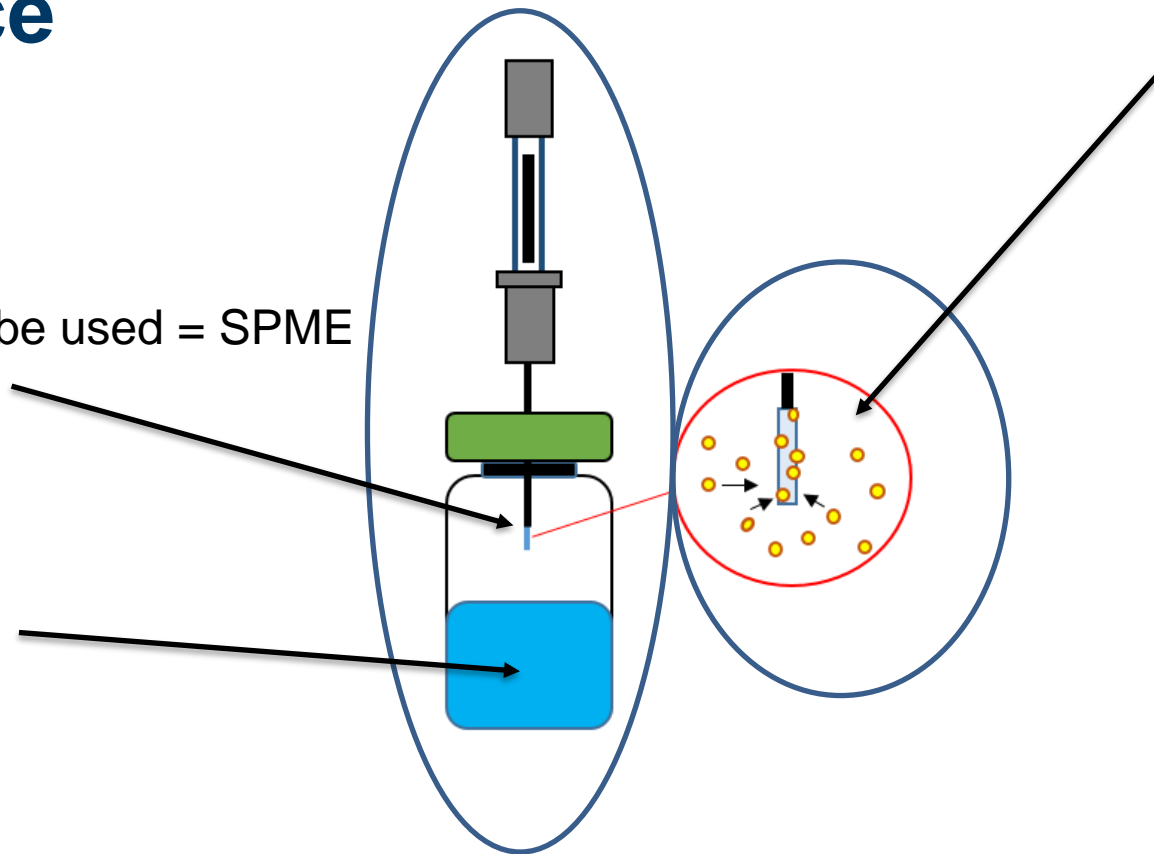
No
permission
for
reproduction
or any use.
Only C-
PlaNet
website and
the owner!

Creator:
Tiago Belé

Headspace

An adsorbent can be used = SPME

sample



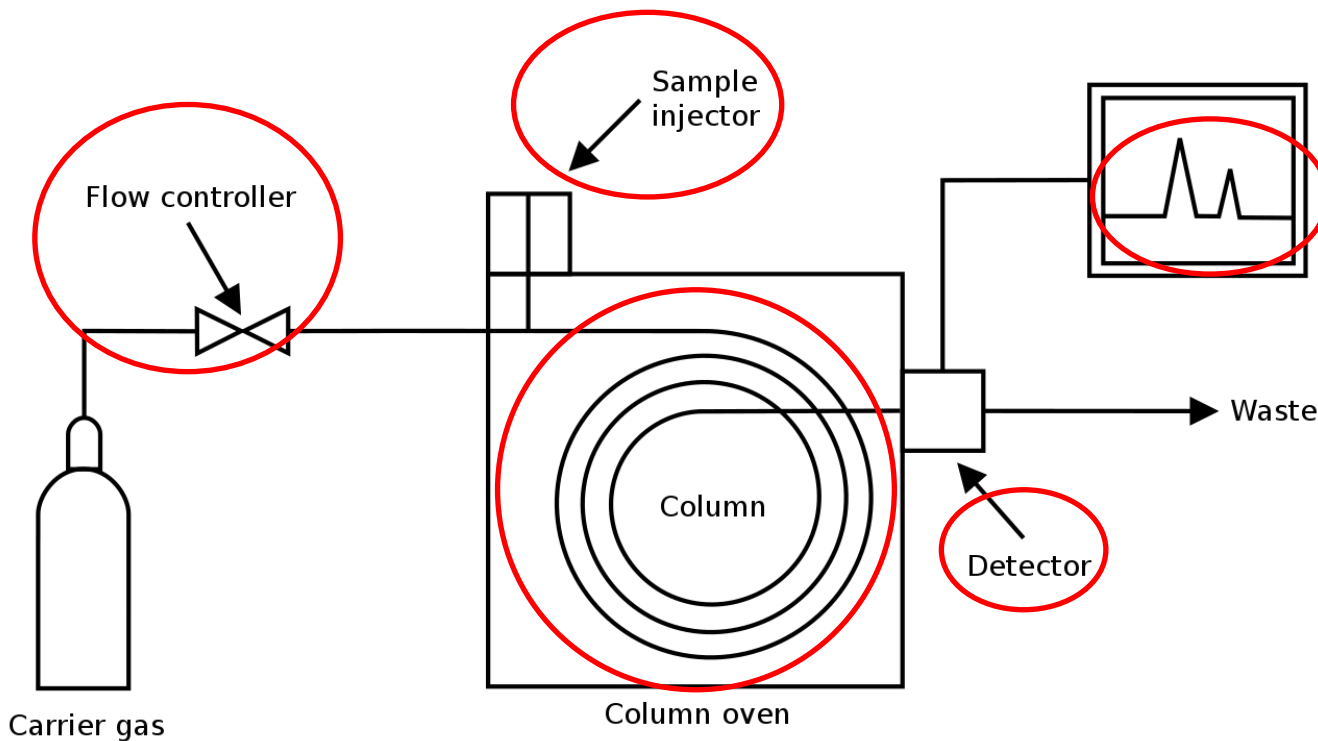
Now, we analyse it on the proper
equipment - GC



How does a GC-O work?

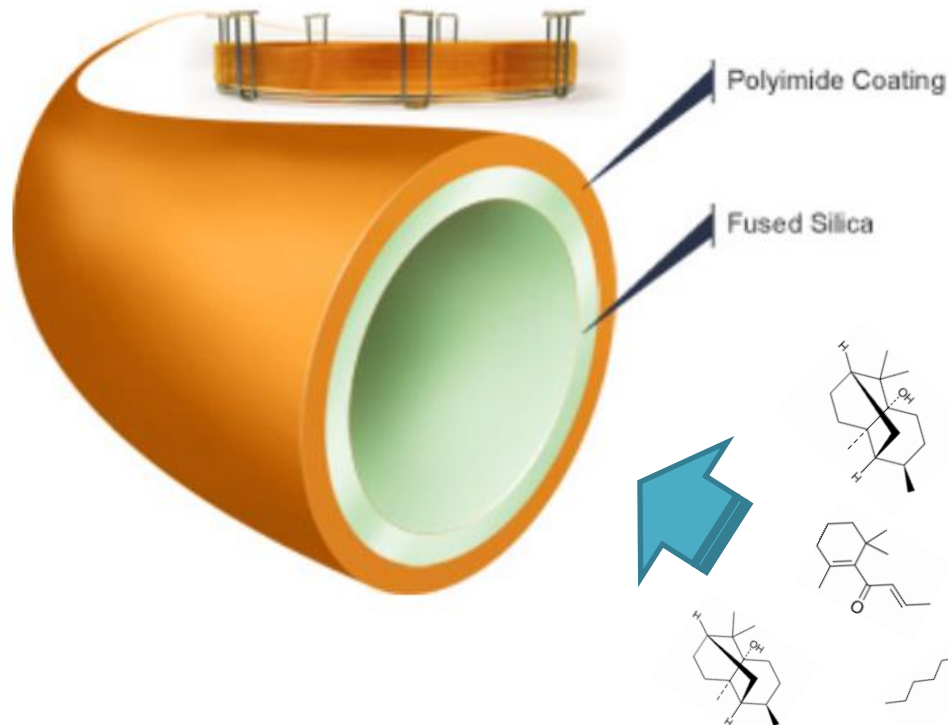
Basic scheme of a GC:

How does a GC-O work?



How does a GC-O work?

Inside a GC column:





How does a GC-O work?



To detector

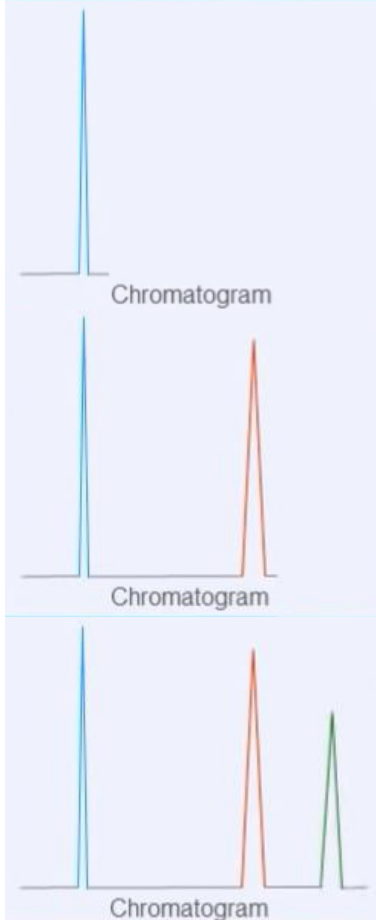


Image origin: <https://www.youtube.com/watch?v=iX25exzwKhI>
License: <https://creativecommons.org/licenses/by/3.0/legalcode>



How does a GC-O work?

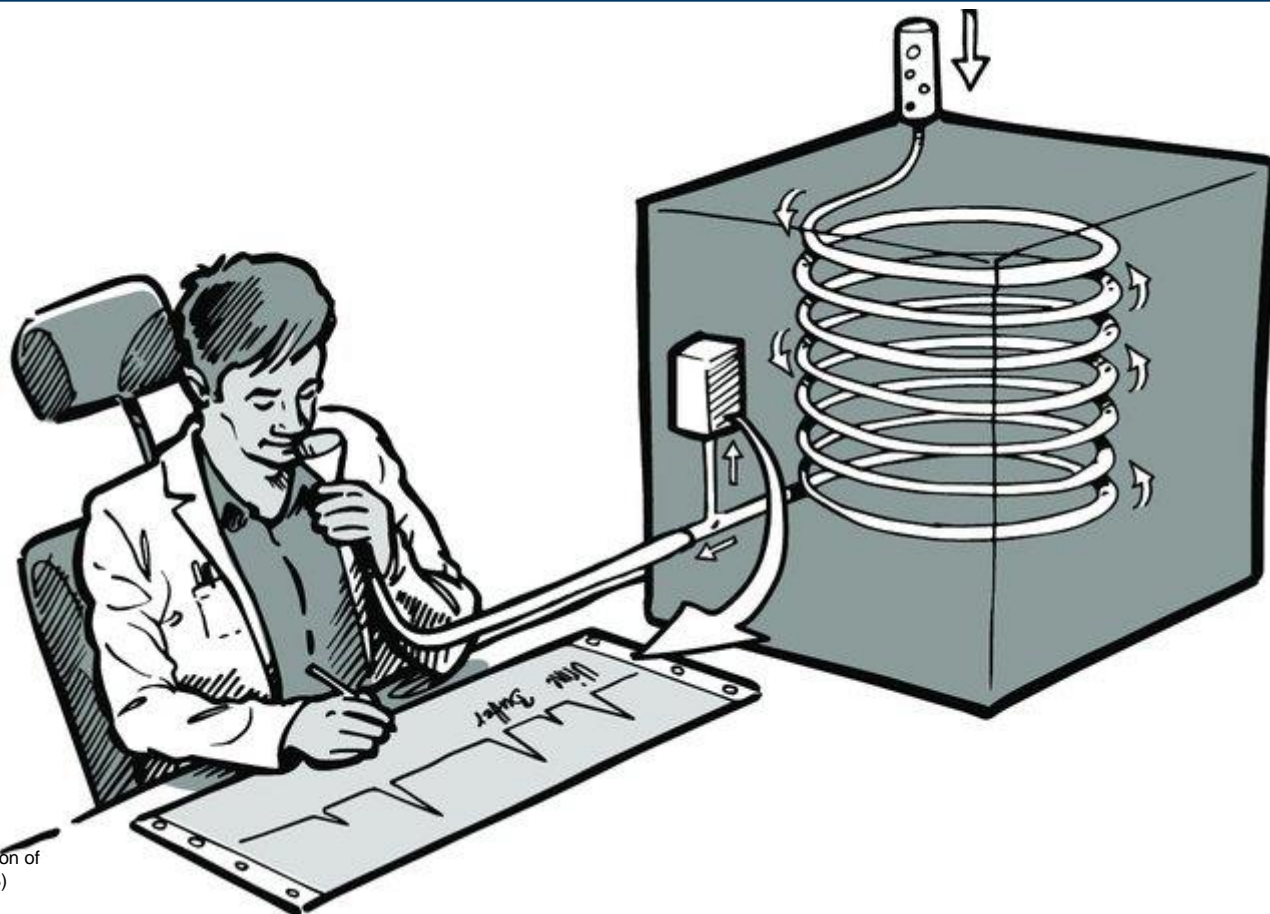
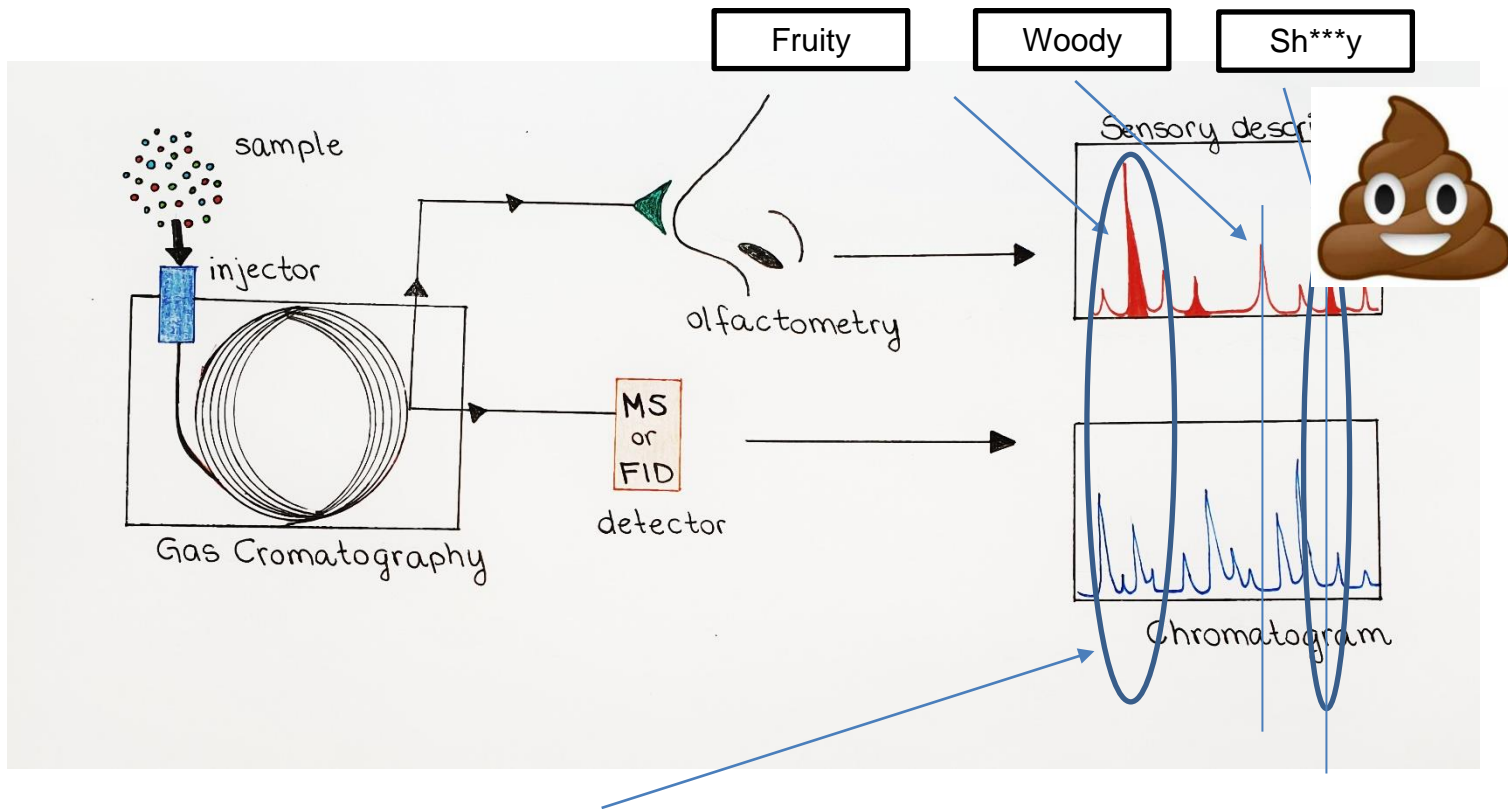


Image from:

Identification of Key Odorants in Used Disposable Absorbent
Incontinence Products. March, 2017
Journal of wound, ostomy, and continence nursing: official publication of
The Wound, Ostomy and Continence Nurses Society / WOCN 44(3)
DOI: 10.1097/WON.0000000000000325
License: CC BY-NC 4.0

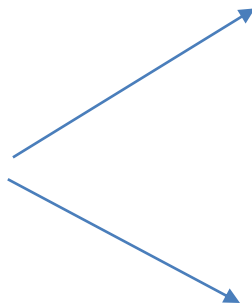
How does a GC-O work?



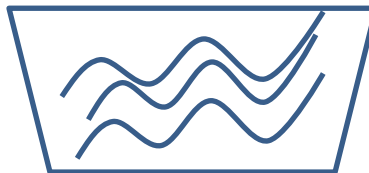
As coelution can occur, 2 dimensional GC is often used



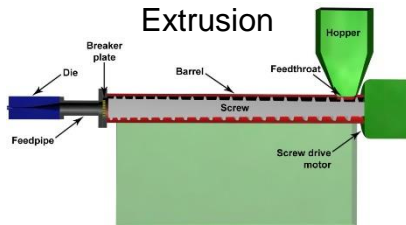
Sensor development for appliance in recycling processes



Washing process

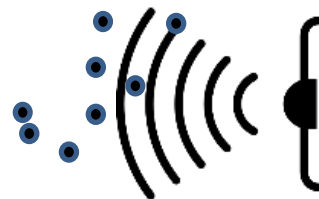


Extrusion



Questions:

Which media?
Water?
Air?
Gas phase?





Closing summary:

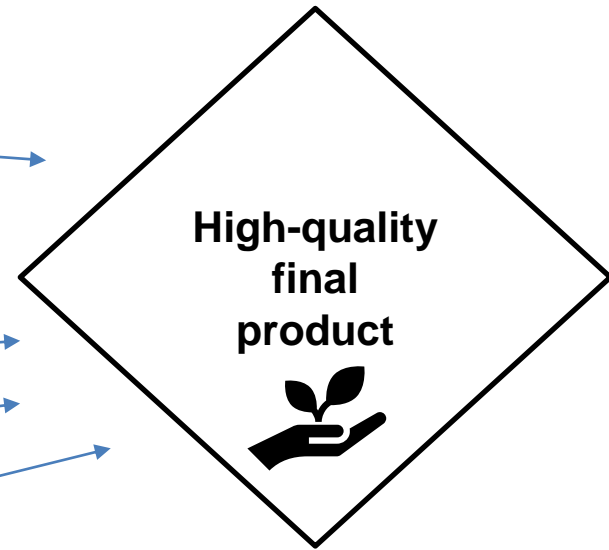
1- Importance of odor

2- Technologies for removal

3- Extraction methods

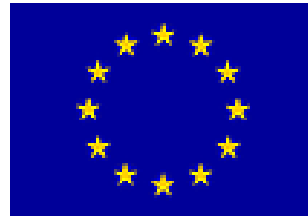
4- Analytical

5- Further plans





C-PlaNeT
CIRCULAR PLASTICS NETWORK
FOR TRAINING



Thank you for your attention!

tiagogomesbele@fau.de

This Project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No. 859885