# Making polyester circular


GR3N SA

Alessandro Sanzone PhD

Head of Chemistry R&D


EU GREEN WEEK 2021 PARTNER EVENT

ZERO POLLUTION #EUGreenWeek

for healthier people and planet

REDUCE, REUSE, RECYCLE

# Problem:
# Today's PET/polyester lifecycle is not a closed loop

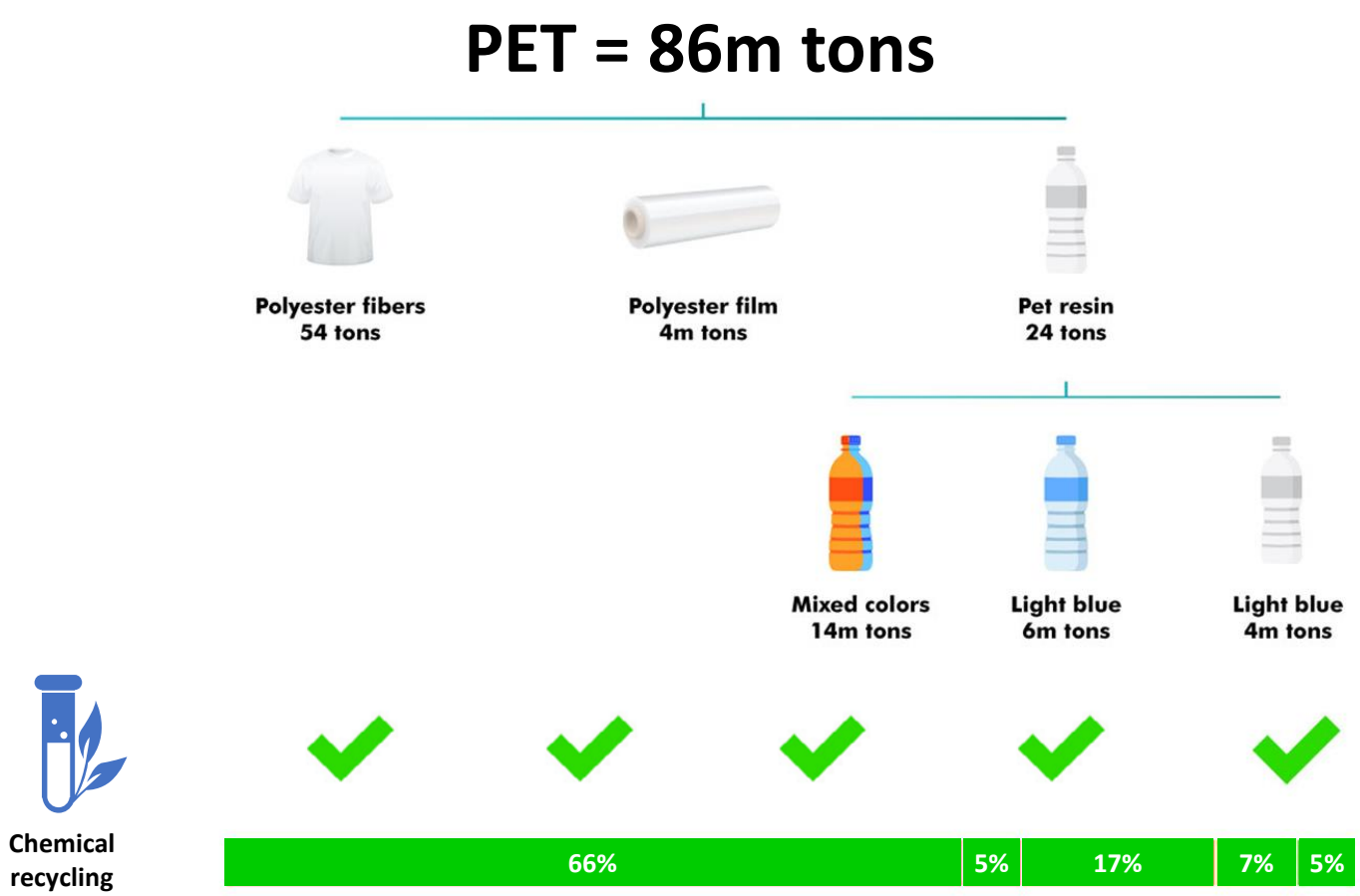

*Source: ICIS 2017 data and Petcore*

**~180m tons**
*from virgin PET production*

**18bn € of social costs**
*(100 €/ton of $CO_2$)*

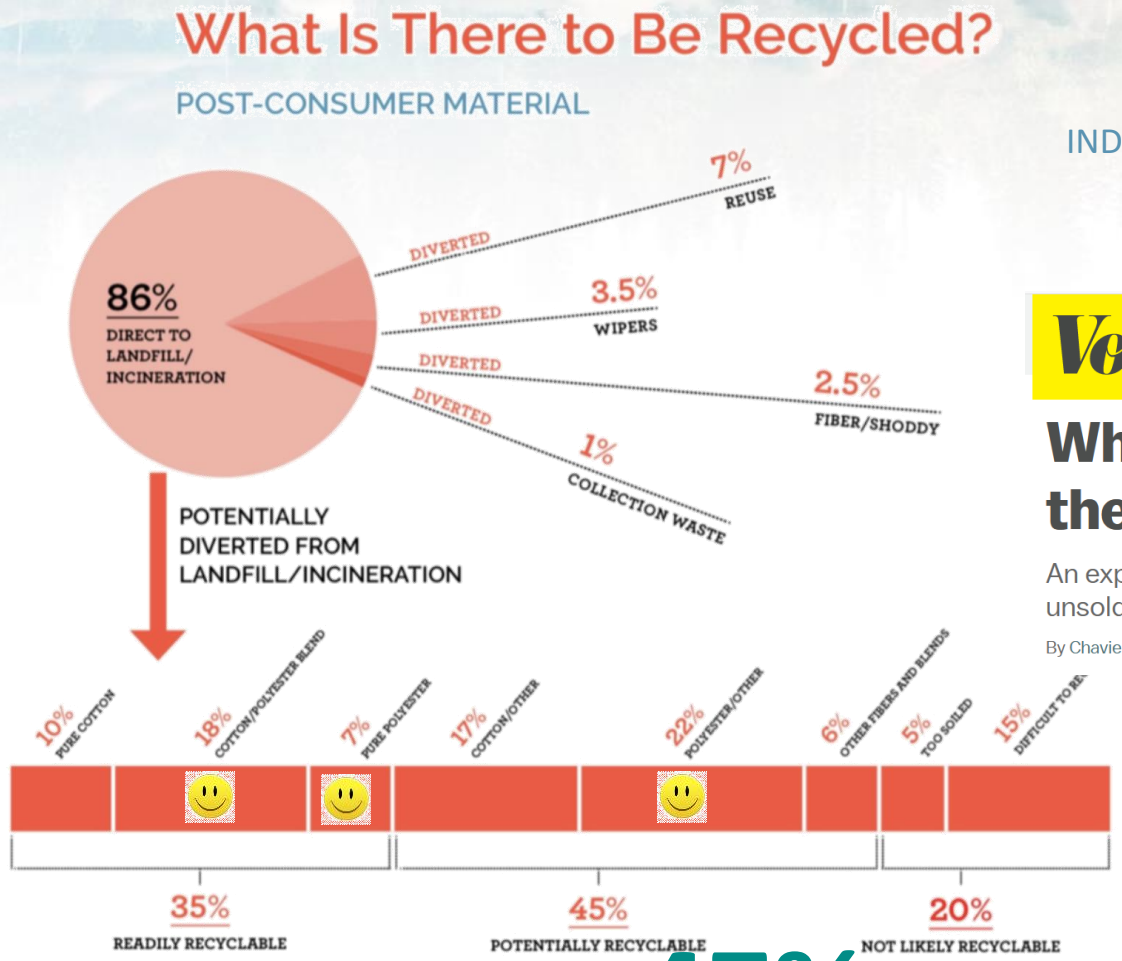
- **Mechanical recycling** is suitable for treating only a **small percentage** of items (~ 15-20% of total production)
- All the remaining items are **incinerated, landfilled or dispersed into the environment** after use
- More than **70% of recycled PET** produced (about 10m tons per year) is **down-cycled or cascaded** for the production of fibre, which in their turn could not be recycled anymore

# Solution:
# gr3n up-cycling technology!




- **gr3n** enables the **chemical recycling of plastics**
- Virtually **all treatable PET as feedstock**: ODR packaging, polyester, coupled plastics, film, …
- **Virgin grade monomers** obtained, thus **new virgin grade plastic** could be produced **endlessly** out of waste without recurring to depletable fossil fuels
- **PET equivalent monomers price competitive** with oil-based

# How much textile can we recycle?




INDUSTRIAL WASTE MATERIAL


by 2025 all European municipalities will have to organize separate collection for textile waste

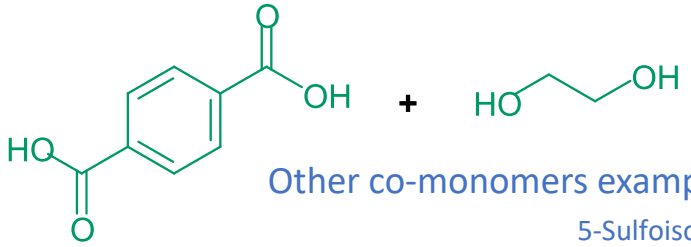
We can recycle the **47%** of the post-consuming textile material

# basic concepts:
# How PET/polyester is produced?

OIL

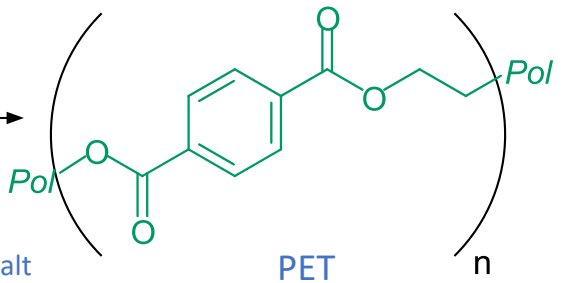
PET monomers

Terephthalic Acid (PTA)  Ethylene Glycol (MEG)



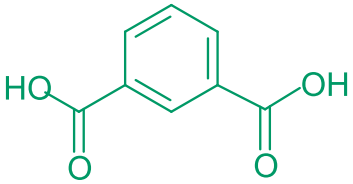

polymerization

PET polymer chain

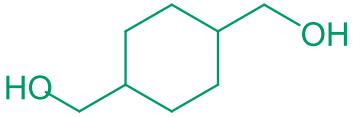



Other co-monomers examples

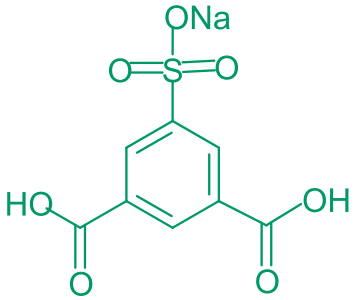
isophthalic Acid (IPA)



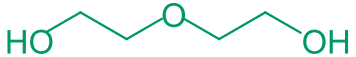

Cyclohexanedimethanol (CHDM)




5-Sulfoisophthalic acid sodium salt



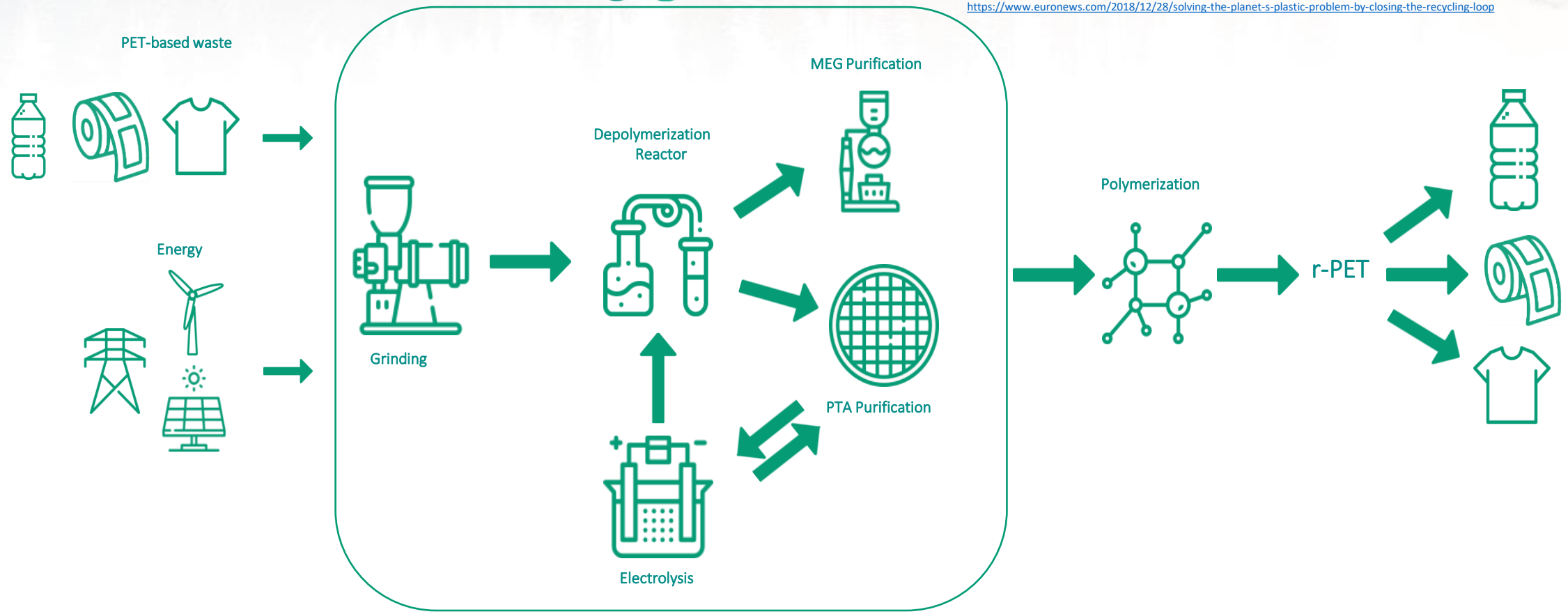

diethylene glycol (DEG)




PET resins

# The core:
# Chemical Recycling process

Watch the video from euronews.
https://www.euronews.com/2018/12/28/solving-the-planet-s-plastic-problem-by-closing-the-recycling-loop



# Circularity through electrolysis

Electrolysis is the enabling technology to make the process **circular** and **profitable**

NaOH and HCl are provided by chloro-alkali system instead of being bought on the market


NaCl (process waste) instead of being a cost becomes a resource

# Depolymerization and r-monomers purification Tests
# Sample list

Mix Colored Bottles


Mix Colored Bottles

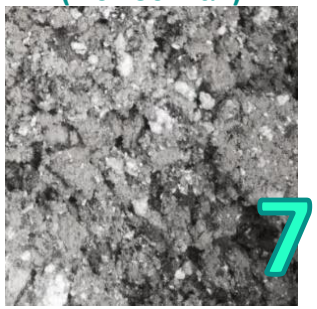

White Opaque Bottles


Yellow Opaque Bottles

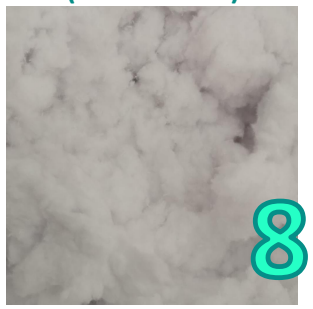

Plastic Trays


Textile Superficial Treatment byproduct

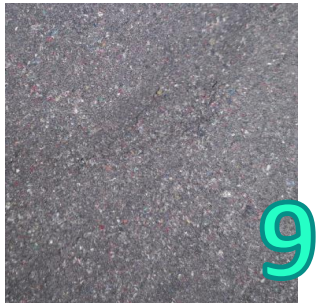

PET-PU Blends ( 70 : 30 wt%)




Polycotton (60 : 40 wt%)




Post-consuming Clothes Collection




Mix Fabrics For Technical Outerwear


Multilayer BOPET film


Adhesive Label-waste


PET-based foam

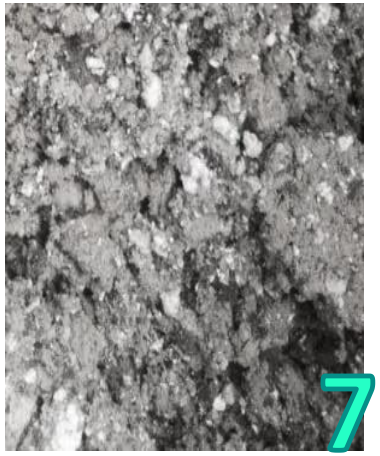

We collect starting material from Packaging and Textile companies in order to have **high variability in PET contaminants**

Purpose of tests :
Prove **robustness** of gr3n chemical recycling process
especially for **purification steps** of the r-monomers

# Depolymerization and r-monomers purification Tests
# Sample list

**Textile Superficial Treatment byproduct**


**PET-PU Blends ( 70 : 30 wt%)**

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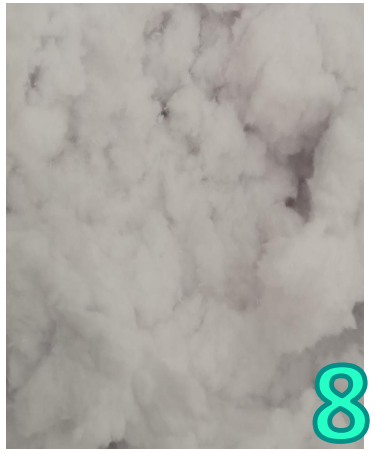
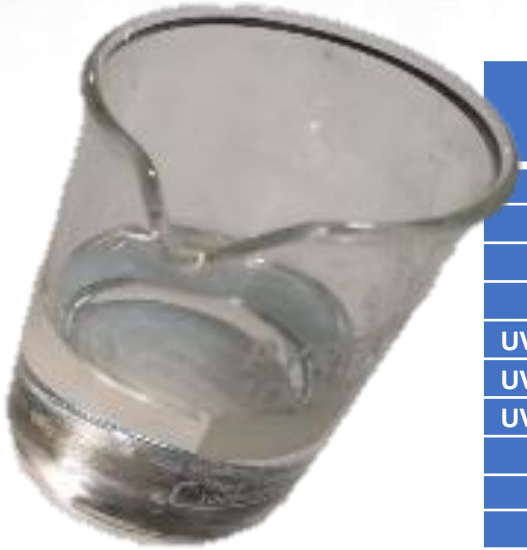



**Post-consuming Clothes Collection**


**Mix Fabrics For Technical Outerwear**

# gr3n pilot plant tests (10 Kg scale) r-MEG analysis results

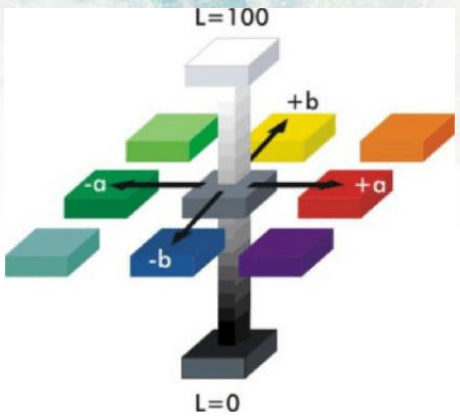


| PARAMETERS | STANDARD METHOD | Typical Values For MEG From Oil | Typical Values Gr3n r-MEG samples |
|---|---|---|---|
| Acid Number [mg KOH/g] | WN-B010-1046D | ≤ 0.03 | ≤ 0.01 |
| Chlorides [mg/kg] | WN-B010-1011D | ≤ 2 | 0.76 |
| Sulfates [mg/kg] | WN-B010-1017D | ≤ 20 | 6.2 |
| Water content [wt %] | WN-B010-1065D | ≤ 0.2 | 0.1 |
| UV Trasmittance at 220 nm [%] | ASTM E-2193 | ≥70 | 46* |
| UV Trasmittance at 250 nm [%] | ASTM E-2193 | ≥90 | 91 |
| UV Trasmittance at 275 nm [%] | ASTM E-2193 | ≥95 | 95 |
| Diethylen Glycol [wt%] | WN-B010-1020D | ≤ 0.05 | ≤ 0.05 |
| Acetaldehyde [mg/kg] | WN-B010-1089D | ≤ 10 | ≤ 10 |
| APHA Color | WN-B010-1052D | ≤ 5 | ≤ 5 |
| APHA Color after 4 h boiling | WN-B010-1052D | ≤ 20 | ≤ 20 |

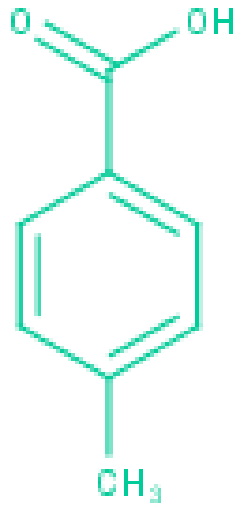
* quality parameter is out of the specification range, non-critical for PET production

# gr3n pilot plant tests (10 Kg scale) r-TA analysis results

| PARAMETERS | STANDARD METHOD | TYPICAL VALUES FOR PTA FROM OIL | Gr3n r-PTA samples |
|---|---|---|---|
| Acid Number [mg KOH/g] | WN-B010-1027D | 674(± 3) | 675(± 3) |
| Colour L (hunterlab) | WN-B010-1144D | >97 | >97 |
| Colour b | WN-B010-1144D | ≤ 10 | 1.5 (± 0.6) |
| Water content [wt %] | WN-B010-1028D | ≤ 0.2 | 0.09 (± 0.04) |
| Para-Toluic acid [mg/Kg] | WN-B010-1148D | <150 | 27(± 17) |
| Fe [mg/Kg] | ICP-OES | < 2 | < 0.65 |
| Mo [mg/Kg] | ICP-OES | < 1 | < 0.35 |
| Cr [mg/Kg] | ICP-OES | < 1 | < 0.9 |
| Ni [mg/Kg] | ICP-OES | < 1 | < 0.42 |
| Mn [mg/Kg] | ICP-OES | < 1 | < 0.97 |
| Co [mg/Kg] | ICP-OES | < 1 | < 0.92 |
| Ti [mg/Kg] | ICP-OES | < 1 | < 1.06 |

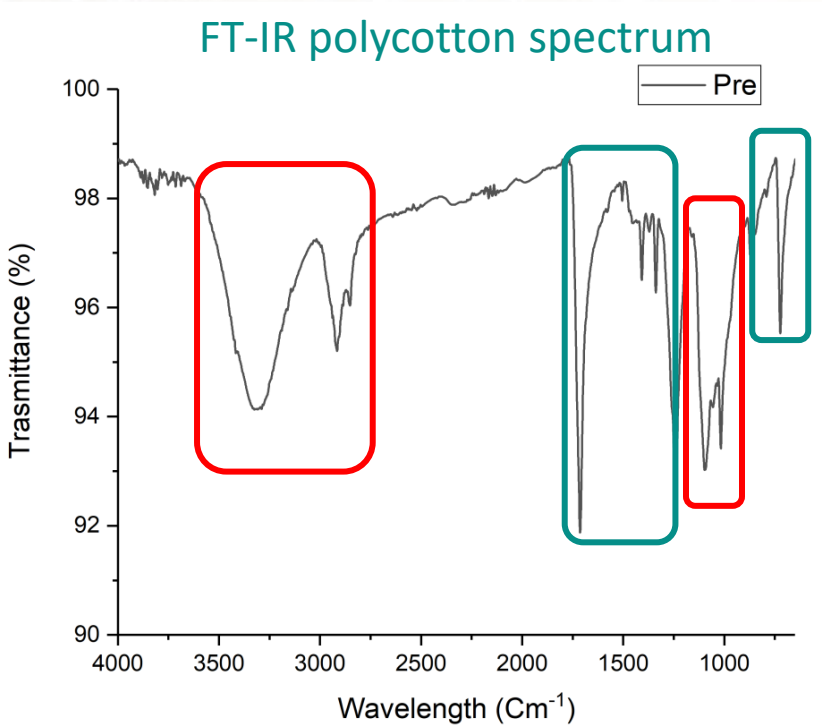



Hunter Lab Color Space




P-Toluic Acid

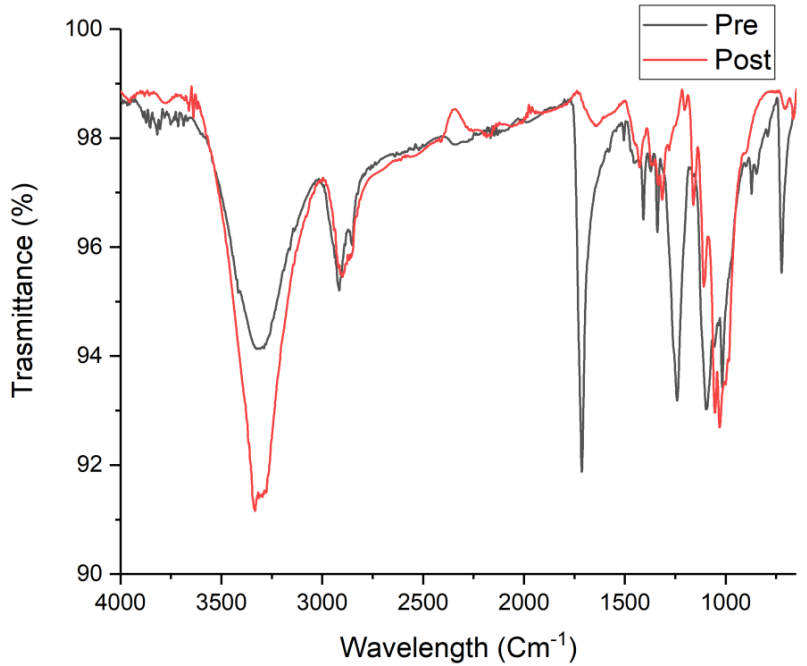
# Polycotton Sample: Cotton recovery trial


PET and Cotton characteristic peak

# Polycotton Sample: Cotton recovery trial

weashed and dried unreacted material sample 8




| Recovery cotton | Initial Sample weight [g] | Final Residue weight [g] | Cellulose Weight [g] | Cellulose content [%] | Residual content [%] |
|---|---|---|---|---|---|
| 1 | 1.0045 | 0.00330 | 0.99715 | 99.67 | 0.33 |
| 2 | 1.0002 | 0.00414 | 0.99606 | 99.59 | 0.41 |
| Average | | | | 99.63 | 0.37 |

SAXCELL

Cellulose content
> 99,6%

Suitable for production of r-Rayon

# gr3n pilot plant test (10 Kg scale) r-MEG analysis results

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# gr3n pilot plant test (10 Kg scale) r-TA analysis results

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| Ti [mg/Kg] | ICP-OES | < 1 | < 1.06 |

# gr3n
# details and contact

*Kommission für Technologie und Innovation, KTI*
*Confederazione Svizzera*
*Label received 09.04.2014*

**Overall Winner 2018**

## Thanks for your attention


**gr3n** sa

CHE-218.379.125

via Probello 19

6963 Lugano

Switzerland

http://gr3n-recycling.com/



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*Project Start Date: 1st of September 2015*

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*Call identifier: H2020 – SPIRE-09-2017*
*Project Start Date: 1st of September 2017*

*Grant agreement: 828217*
*Call identifier: H2020 – SME Inst*
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