TOWARDS IMPROVED DEODORIZATION OF POST-CONSUMER PLASTIC WASTE: IDENTIFYING THE INDUSTRIAL HURDLES

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OUR GOAL: ACHIEVING CLOSED-LOOP RECYCLING

- Inks
- Adhesives
- VOCs
- Additives
- Residues
- Contaminants
- ...

Closing the loop

Who are we?

Started in 2016 by prof. Steven De Meester
Now a team of around 25 PhD students & 4 technicians
Focus on organic waste, plastics, and textiles

https://www.lcpe.ugent.be/
OVERVIEW RESEARCH

Quantification method
Benchmarking industrial washing efficiency
Kinetic study on deodorization
Comparing ≠ washing media for ≠ polymers
Modelling and optimizing water treatment

Effect of temperature and ≠ process parameters

https://doi.org/10.1016/j.resconrec.2020.104907
https://doi.org/10.1016/j.wasman.2020.10.021
https://doi.org/10.1016/j.scitotenv.2021.152467
https://doi.org/10.1016/j.resconrec.2022.106267
QUANTIFYING DEODORIZATION

- Development of an analytical method to quantify odour removal in plastic waste recycling processes
- 3 different sampling techniques followed by GC-MS analysis
  1. SPME ⇒ Identification of VOCs
  2. Activated charcoal + solvent desorption
  3. Tenax-TA tubes + thermal desorption

Quantifying VOC removal efficiencies

[Diagram showing air in, adsorption, and GC-MS analysis steps]
Benchmarking current industrial washing

**Conclusion:**

- Apolar and high-boiling components are still present after washing
- After extrusion, most of the components are again detected
Lab-scale washing

- Water is least efficient
- NaOH + detergent is efficient for PET based packaging
- Detergent is efficient for PO based packaging (mimicking PET recycling is not the best option)

Methodology

1. Plastic material
2. Washing medium
   - Adding plastics and washing medium in flask
   - Washing plastics on a shaking and heating plate
3. Separation of washing medium and plastics
4. Transferring AC in GC vial
   - Solvent desorption
   - GC-MS analysis
   - Dynamic headspace sampling
Kinetic study for PE films with different media at different $T^\circ$

Linking isotherm and kinetic models to experimental results

<table>
<thead>
<tr>
<th>Isotherm models</th>
<th>Equation</th>
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<tbody>
<tr>
<td>Langmuir</td>
<td>$q_e = \frac{K_L \times q_m \times C_a}{1 + K_L \times C_a}$</td>
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<tr>
<td>Freundlich</td>
<td>$q_e = K_f \times \frac{1}{1 + \frac{C_a}{C_m}}$</td>
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<tr>
<td>Temkin</td>
<td>$q_e = \frac{R}{b_T} \times \ln(A_T + C_a)$</td>
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<tr>
<td>Dubinin-Radushkevich</td>
<td>$q_e = q_m - A_e \times \ln(1 + \frac{C_a}{C_m})$</td>
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<table>
<thead>
<tr>
<th>Kinetic models</th>
<th>Equation</th>
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<tr>
<td>Zero order</td>
<td>$\frac{dq}{dt} = -k_{0,des}$</td>
</tr>
<tr>
<td>First order</td>
<td>$\frac{dq}{dt} = -k_{1,des} \times q$</td>
</tr>
<tr>
<td>Second order</td>
<td>$\frac{dq}{dt} = -k_{2,des} \times q^2$</td>
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Efficiency:

$\text{NaOH} < \text{H}_2\text{O} < \text{CTAB} = \text{NaOH} + \text{CTAB} < \text{EtOAc}$
Kinetic study on deodorization

**Reversible** first order model best-fitted kinetic model

- Desorption AND adsorption determine the efficiency of the deodorization process via reversibility of the sorption process

\[
\frac{dq}{dt} = -k_{RFO,1} \cdot q + k_{RFO,2} \cdot C
\]

\[
\frac{dq}{dt} = -k_{RFO,1} \cdot q + k_{RFO,2} \cdot \frac{(q_0 - q) \cdot m}{V}
\]

Washing with ‘dirty’ medium will not result in high removal efficiencies, even at high temperatures and with caustic.
But: often high recirculation rates of water

ASPEN simulation:

RR > 60% → drop in removal efficiency (currently >90%)

Current research

Recycling plant

Medium treatment
Take home messages

1) Washing medium should be **tailored** on plastic type

2) Washing with **dirty water** does **NOT** result in **odour-free plastics**

3) **Water management** is key towards efficient and cost-effective washing