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Towards closed-loop recycling of multilayer and coloured PET plastic waste

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Flow of plastics

Open-loop recycling

Process losses

4%

10%

Chemical recycling

Closed-loop mechanical recycling

14%

Collected for recycling

Virgin feedstock

Production

Use phase

14% Incineration

40% Landfill

32% Leakage

Ellen McArthur Foundation, 2021. The New Plastics Economy: Rethinking the future of plastics, 2013. URL https://emf.thirdlight.com/link/cmy2sfpast1d-bid6vx

Why can’t we close the loop?

- Plastics are complex materials!

Additives

Colorants

Multilayers

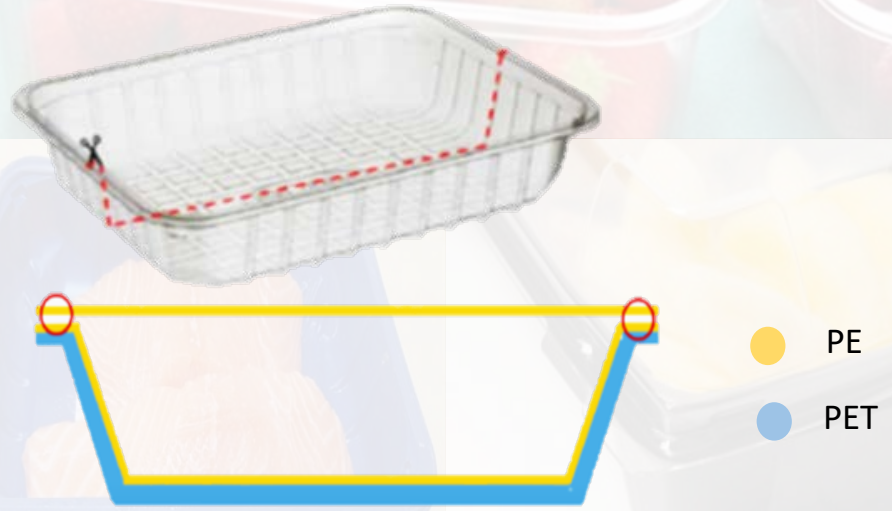
Non-Intentionally added substances

- ❑ Limited functionality
- ❑ Lower physiochemical properties
- ❑ Potential leaching of substances
- ❑ Incompatibility issues
- ❑ Formation of odorous components
- ❑ Degradation of embedded substances

Pretreatment of plastics!

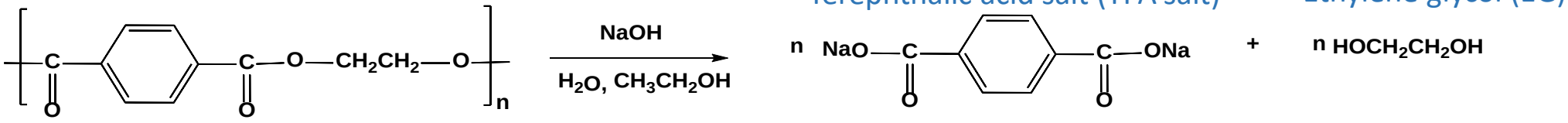
PET trays

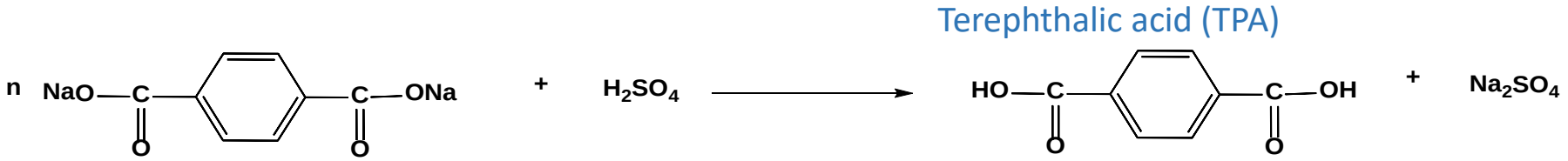
- 70-80% used for food and 20-30% for non-food products
- Multilayers
- Various colors (blue, green, black etc.)
- Sticky labels (paper or plastic)
- Recovery and purity of monomers
- Mainly landfilled and incinerated



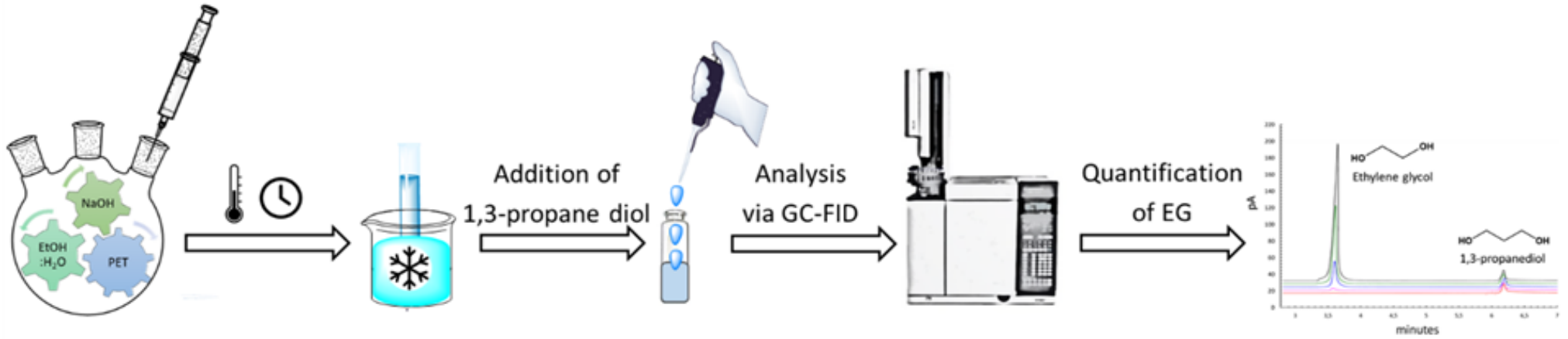
Delamination of PET plastic waste

- Alkaline hydrolysis of PET in an aqueous media as a promising solution to recycling problems

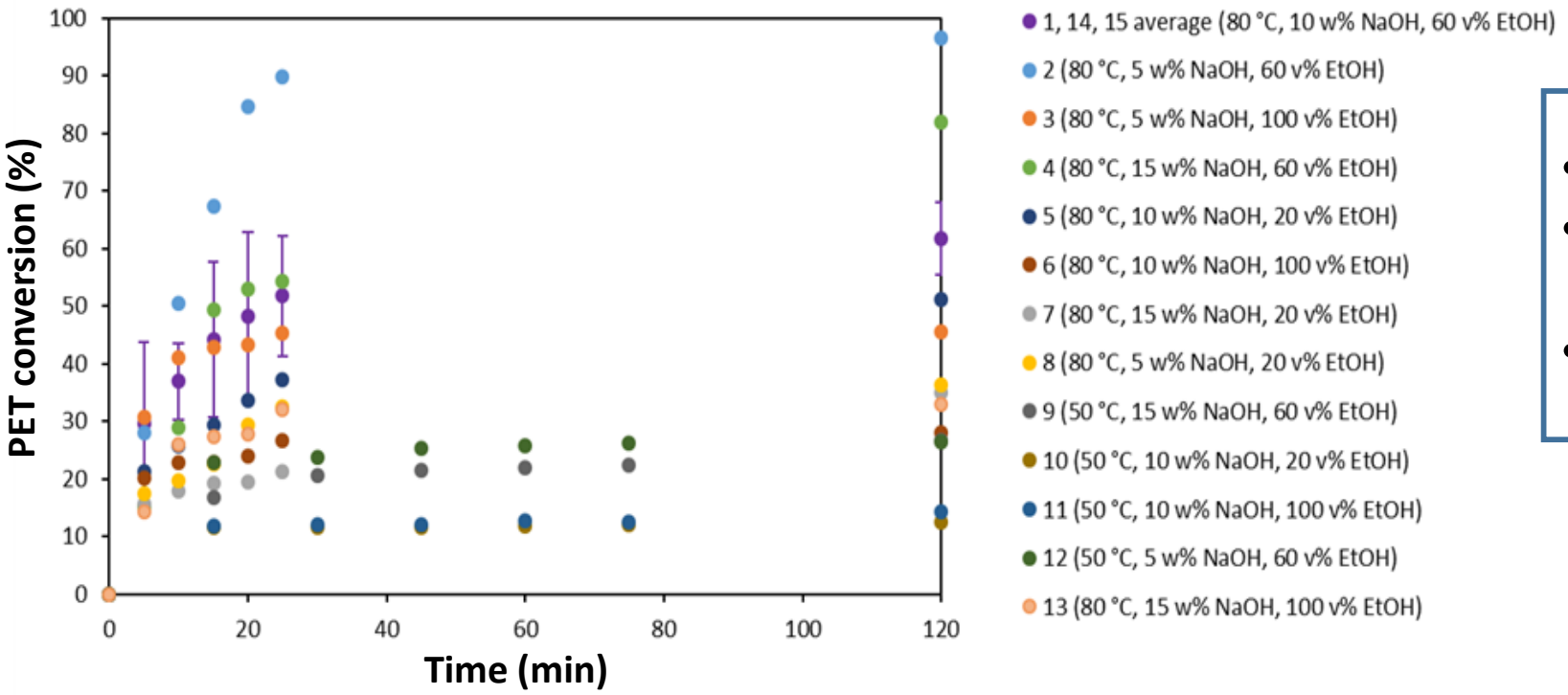




- Identification of main relevant conditions based on 3 factors: NaOH w%, EtOH/H_2O v% and T



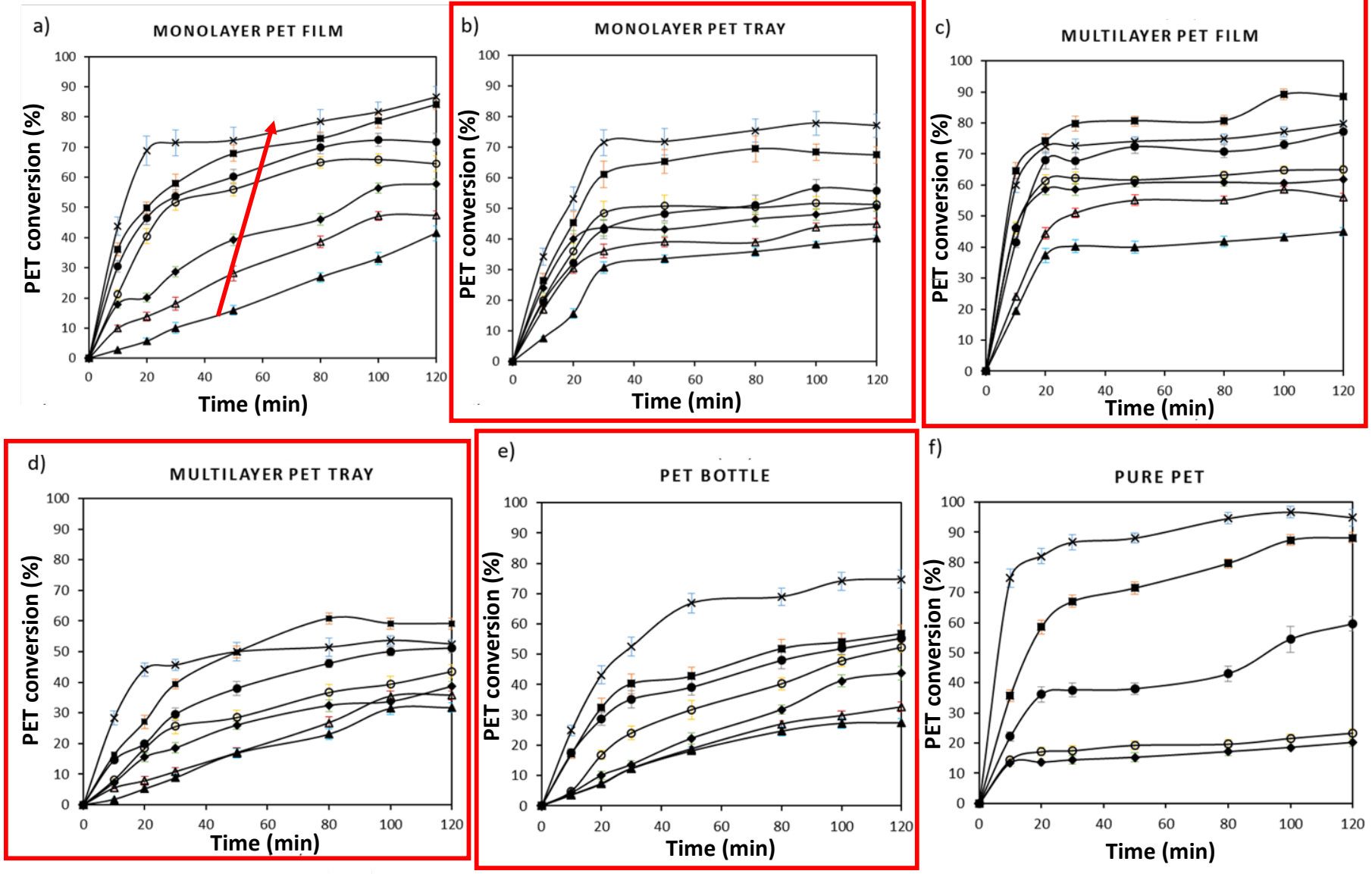
Delamination of PET plastic waste



- PET conversion $\propto$ T
- Higher EtOH v% results in higher PET conversion
- There is limit on the NaOH w%

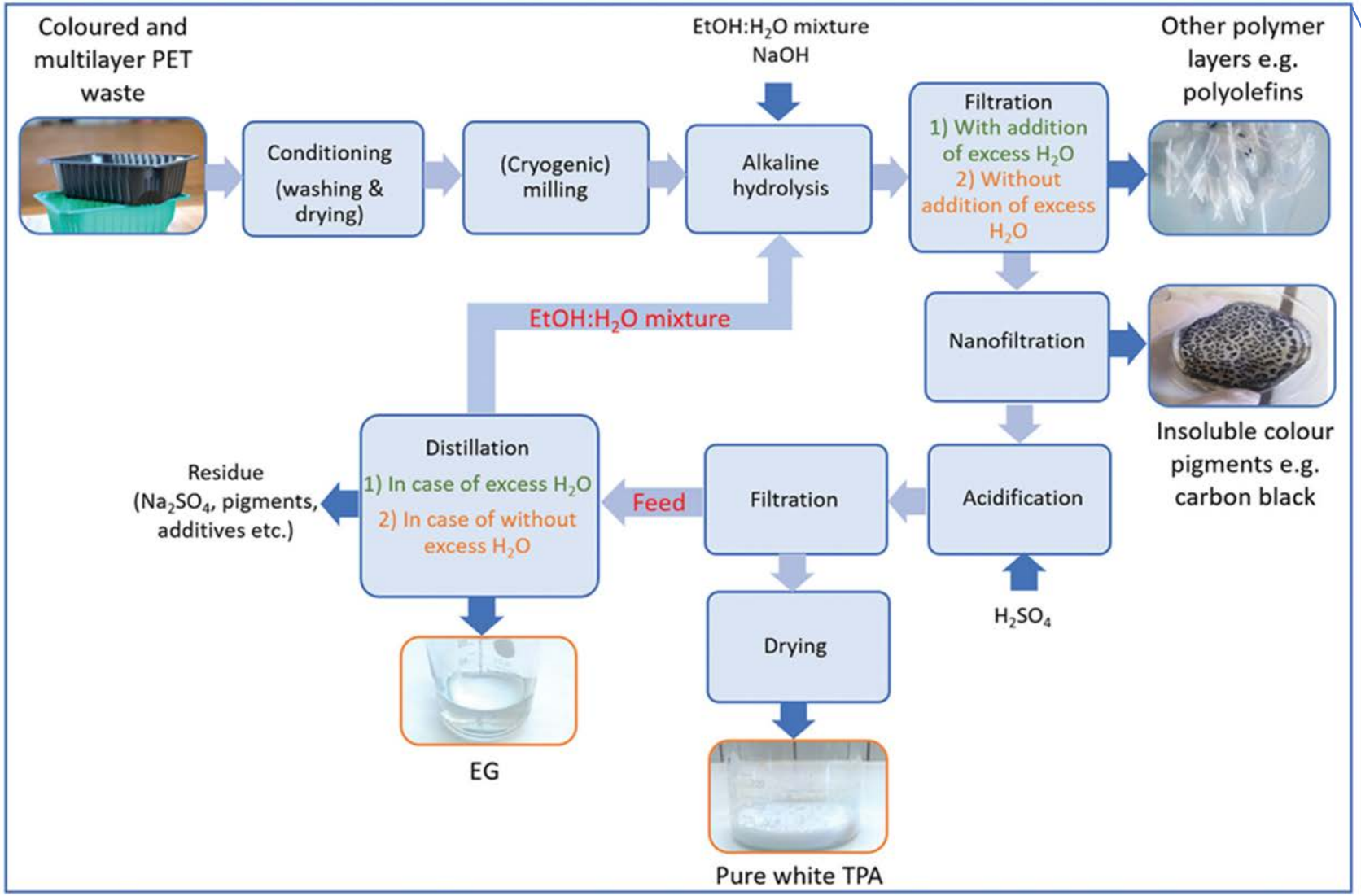
- Characterization of degradation products (GC, NMR, UV-VIS)
- Testing optimized hydrolysis conditions on the 'real' PET samples

Delamination of PET plastic waste



- Particle size ↑ conversion % ↓
- Conversion % of monolayer > multilayer
- Higher thickness and crystallinity, lower PET conversion

Delamination of PET plastic waste

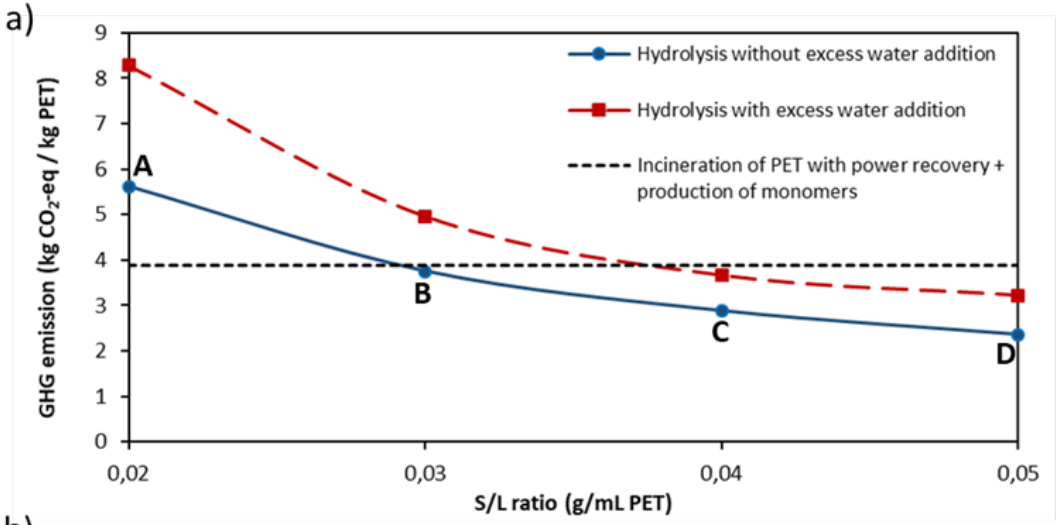


- ✓ Hydrolysis under mild conditions
- ✓ No catalyst
- ✓ Removal of colorants
- ✓ Recovery of polyolefins
- ✓ Pure PET monomers

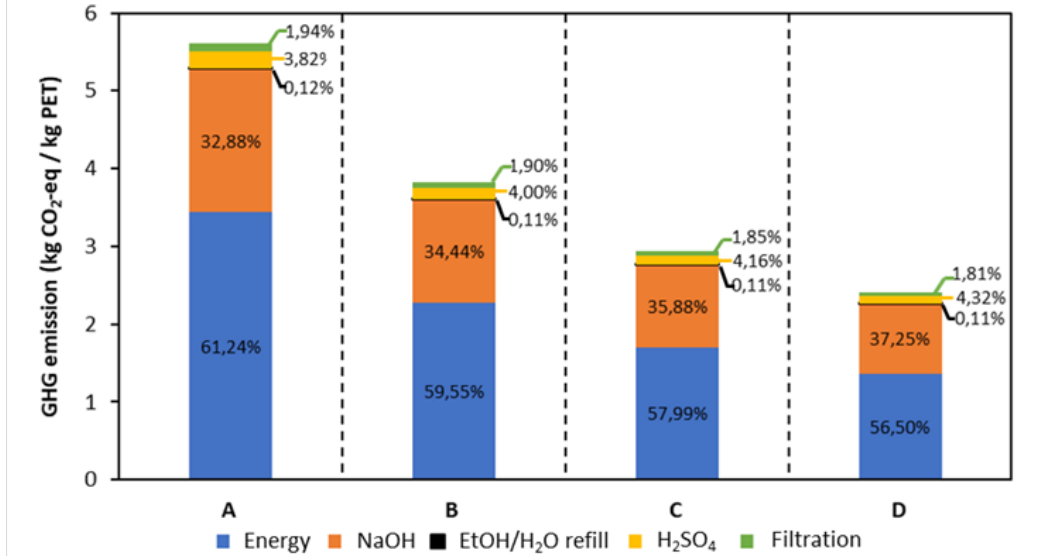
Life cycle assessment

❖Delamination of PET plastic waste via selective depolymerization

a)



b)



- Increasing the solid/liquid (S/L) ratio
- Avoiding excess water addition during monomer purification

Lower energy consumption during purification

Lower carbon emissions

Conclusions

I. Recycling of PET trays is limited

II. Alkaline hydrolysis is a promising route

III. Hydrolysis yield of multilayer PET trays should be increased

IV. Thickness and crystallinity play an important role on the hydrolysis rate

V. S/L ratio and monomer purification have effect on the LCA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Towards closed-loop recycling of multilayer and coloured PET plastic waste by alkaline hydrolysis†

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THANK YOU FOR YOUR ATTENTION