

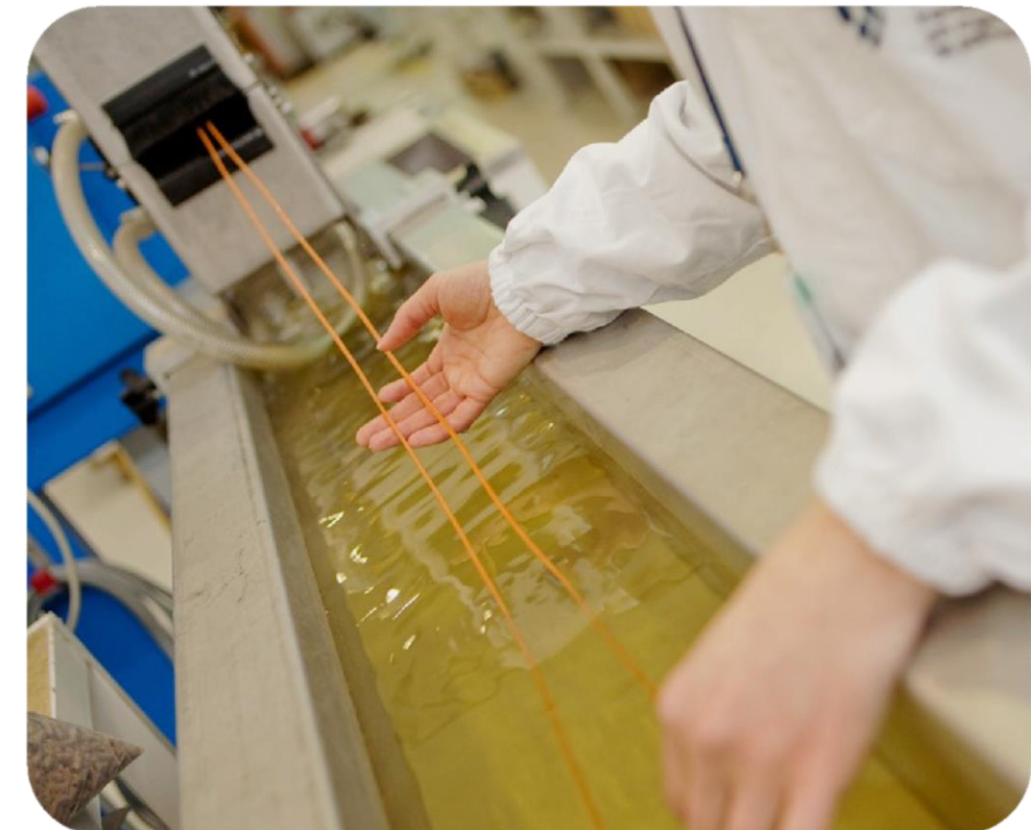
# **EFFECT OF EPOXY-BASED CHAIN EXTENDER ON THE MECHANICAL PROPERTIES OF R-PET FOR FOOD CONTACT**

Gustavo Kampa Santana

# About us



Inside



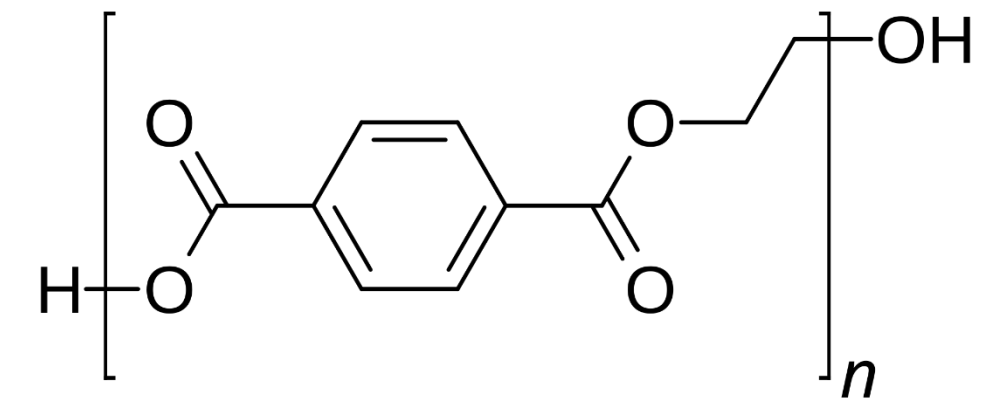
Extrusion, Compounding and Advanced Materials area  
(ECMA)

Images from Piep's database

Polymer Connect 2024

# About PET

- 24 million tons (2022);
- Semi-crystalline;
- High melting temperatures (240-270 °C);
- Excellent mechanical properties;
- PET packaging for food contact.



*Polyethylene terephthalate – (C<sub>10</sub>H<sub>8</sub>O<sub>4</sub>)<sub>n</sub>*



PET bottles: [parker.com/us/en/divisions/bioscience-and-water-filtration-division/industries/food-and-beverage.html](https://parker.com/us/en/divisions/bioscience-and-water-filtration-division/industries/food-and-beverage.html)  
Polyethylene terephthalate: By Schippmeister - Own work, CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=82979191>



# Plastics issues

- Plastic packaging: essential, but we must be aware!

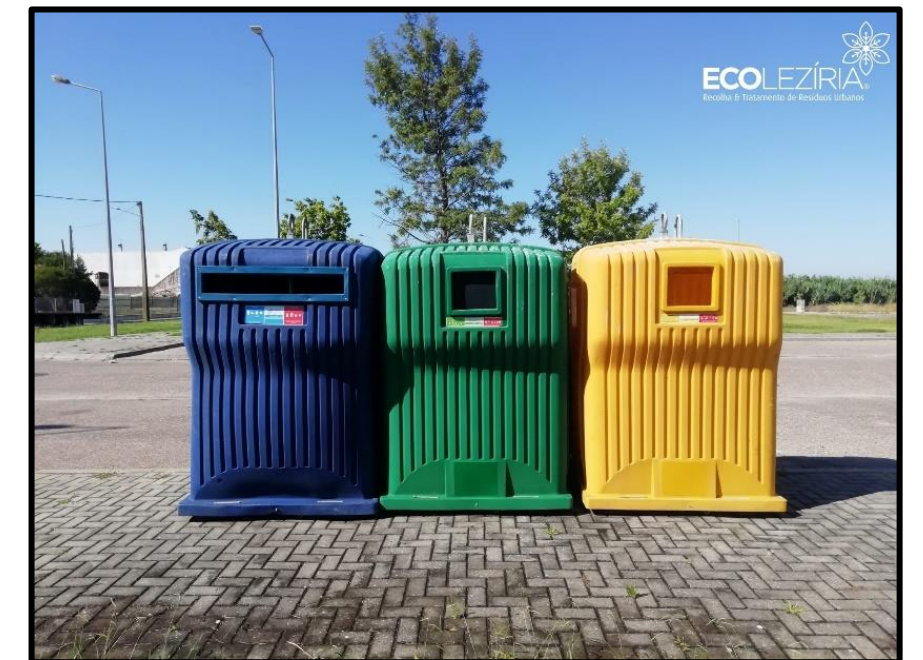


Nonrenewable resource



Non-biodegradability

Inadequate disposals



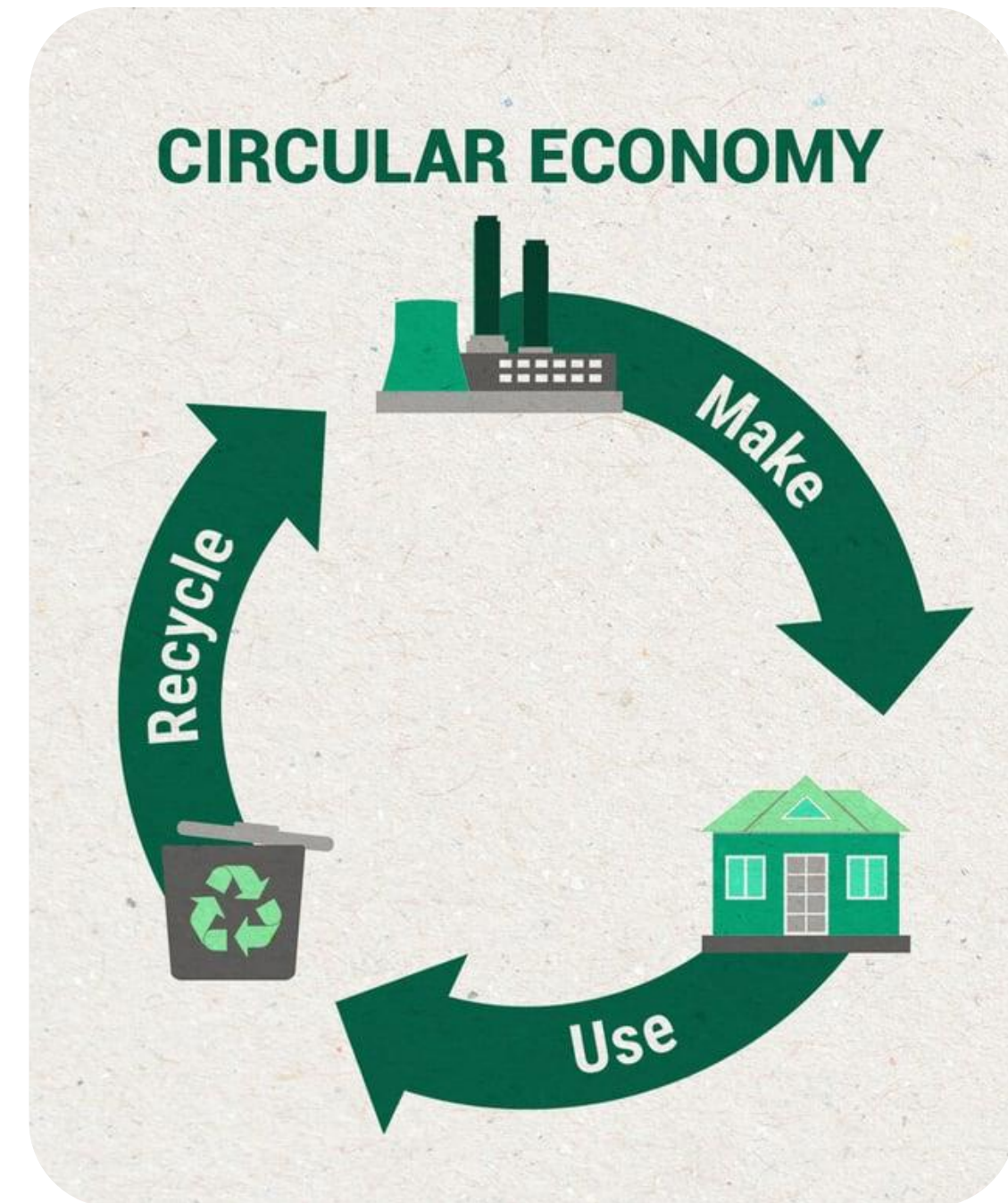
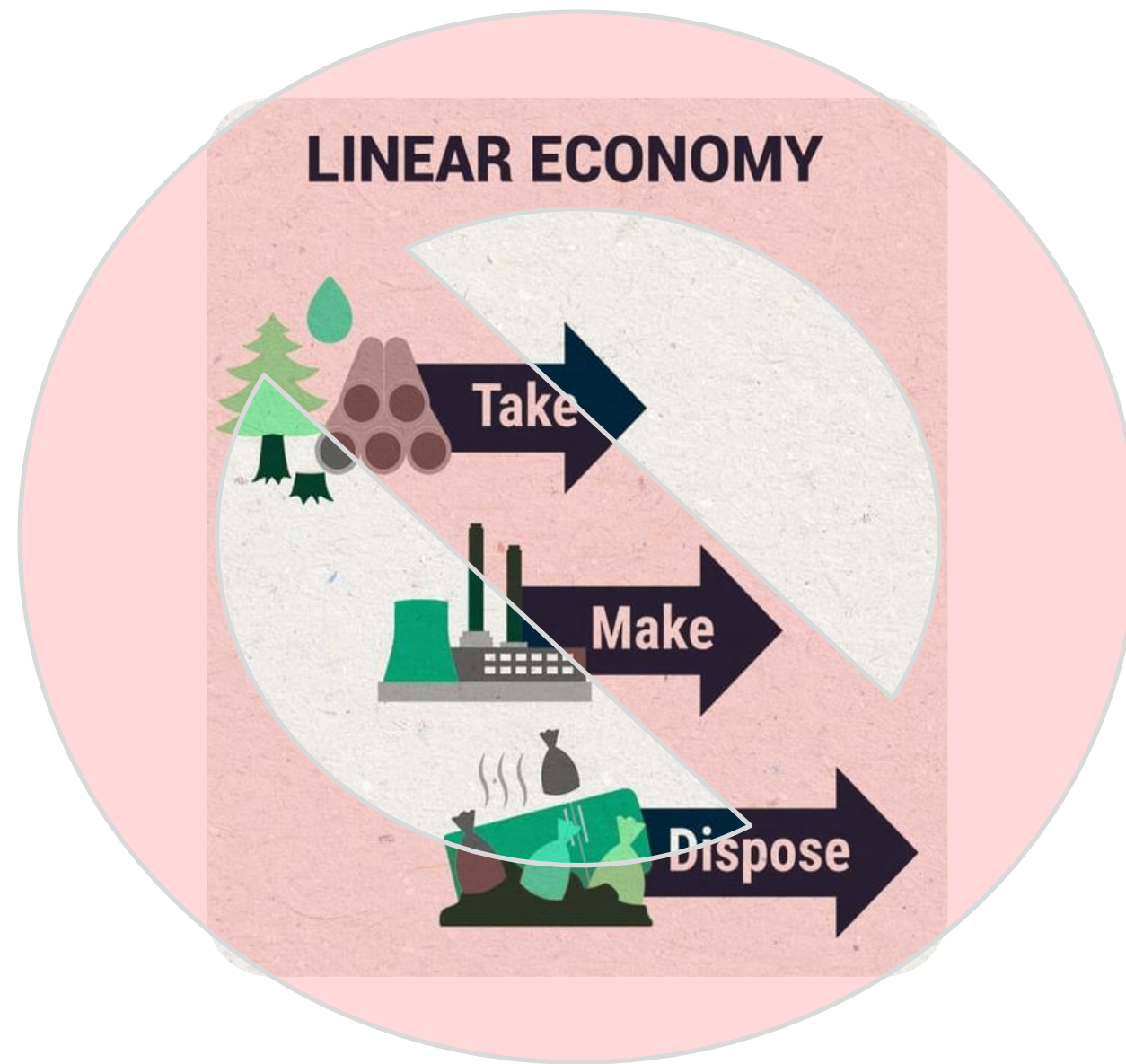
Waste management care

Single-use plastics

*Ecopontos*: <https://correiodoribatejo.pt/ecoleziria-investe-mais-de-370-mil-euros-em-novos-ecopontos/Lixão> ("garbage dump"); <https://amazonia.fiocruz.br/scdp/blog/story-in-italian/what-are-plastic-waste.php>  
Oil platform: <https://paginaglobal.blogspot.com/2015/03/industria-do-petroleo-e-gas-timorense-e.html>



# Plastics issues



# Abstract

Plastic food packaging is an essential part of products. However, plastics in general, were produced for many years based on a linear economy model. The main objective of this research is to replace virgin polyethylene terephthalate (PET) in bottles in the food sector with 100% thermomechanically recycled PET (R-PET) to promote a circular economy. Since R-PET does not have the same tensile and impact resistance as its virgin counterpart, the incorporation of an epoxy-based chain extender additives (CEs) was studied.

# Intrinsic viscosity (IV)

Sample - Description	IV (dl/g)	Note
Virgin PET ( <i>Plastiverd Flow</i> )	0,76	Current bottle material
R-PET ( <i>Worpet</i> ) - "Original"	0,75	
R-PET ( <i>Worpet</i> ) - Reprocessed	0,70	Compared to the "original", 1 additional thermal cycle
0.10% CE1	0,72	
0.20% CE1	0.75	
0.50% CE1	0,80	
1.00% CE1	To be realized	
0.10% CE2		
0.20% CE2		
0.50% CE2		
1.00% CE2		



Decreased IV justifies the use of chain extenders!

Chain extenders (CEs)

CE1 = ADR 4400

CE2 = ADR 4468

ASTM D4603-18

Polymer Connect 2024



# Materials and methods



R-PET Worpel (WORLDPET)

Pre-drying: 160 °C (3-4 h)

Joncryl ADR grades (BASF):

- CE1: 4400
- CE2: 4468



Coperion ZSK 26 (L/D ratio 40)  
Co-rotating twin screw extruder  
Processing: 240 °C; 180 rpm



Samples:

- 100% R-PET (reprocessed)
- R-PET + CE1 (0.10 - 1.00%)
- R-PET + CE2 (0.10 - 1.00%)

Images: Author's own work (PIEP)

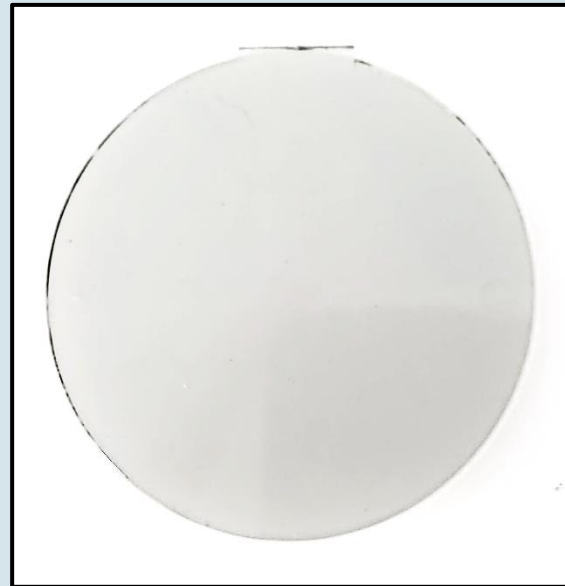
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# Materials and methods

Impact resistance (falling dart)

ISO 6603-2:2023



Diameter: 60 mm

Thickness: 2 mm

Tensile strength

ISO 527-2:2012



Length: 59 mm

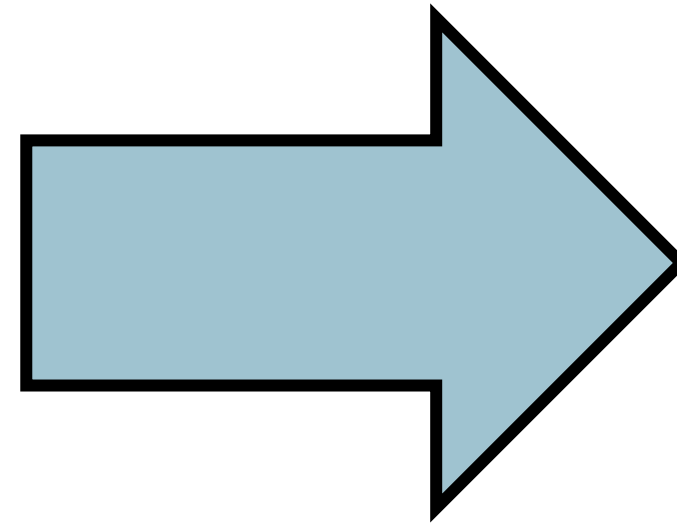
Thickness: 2 mm



Mechanical Testing Laboratory: <https://mirarge.com/en/mitec-altypi-2/mechanical-testing-laboratory/>

test specimens: Author's own work (PIEP)

# Preliminary Results

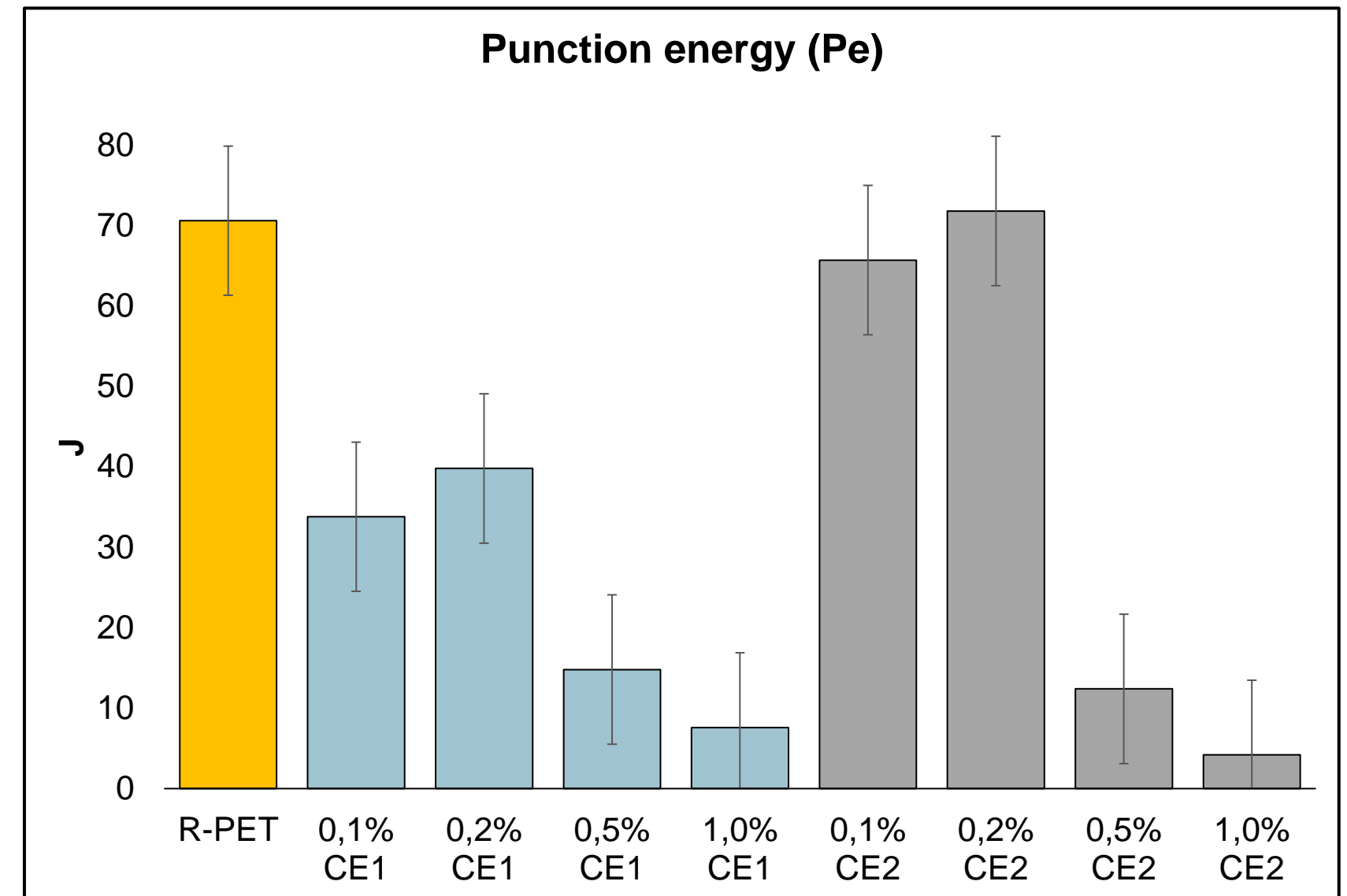
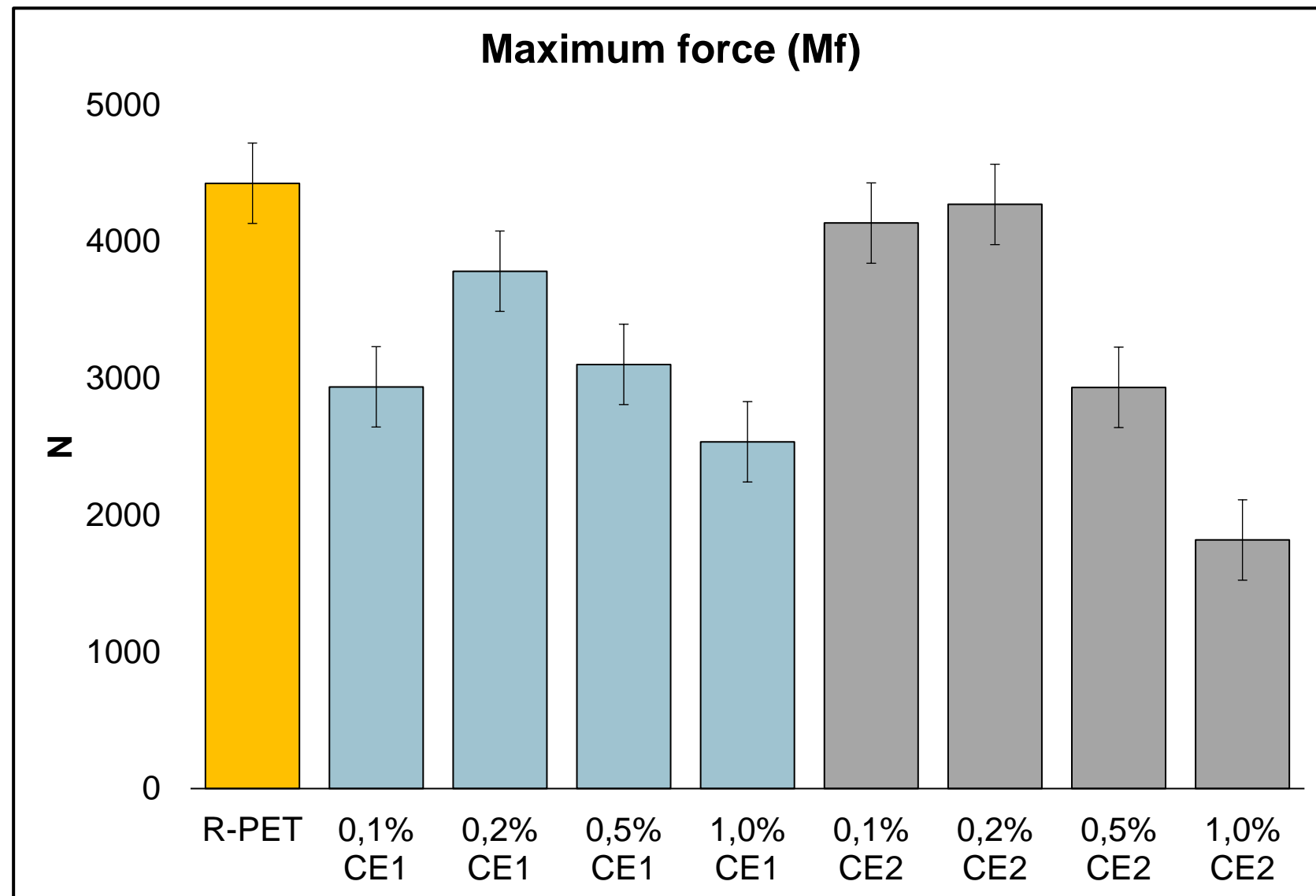


Images: Author's own work (PIEP)

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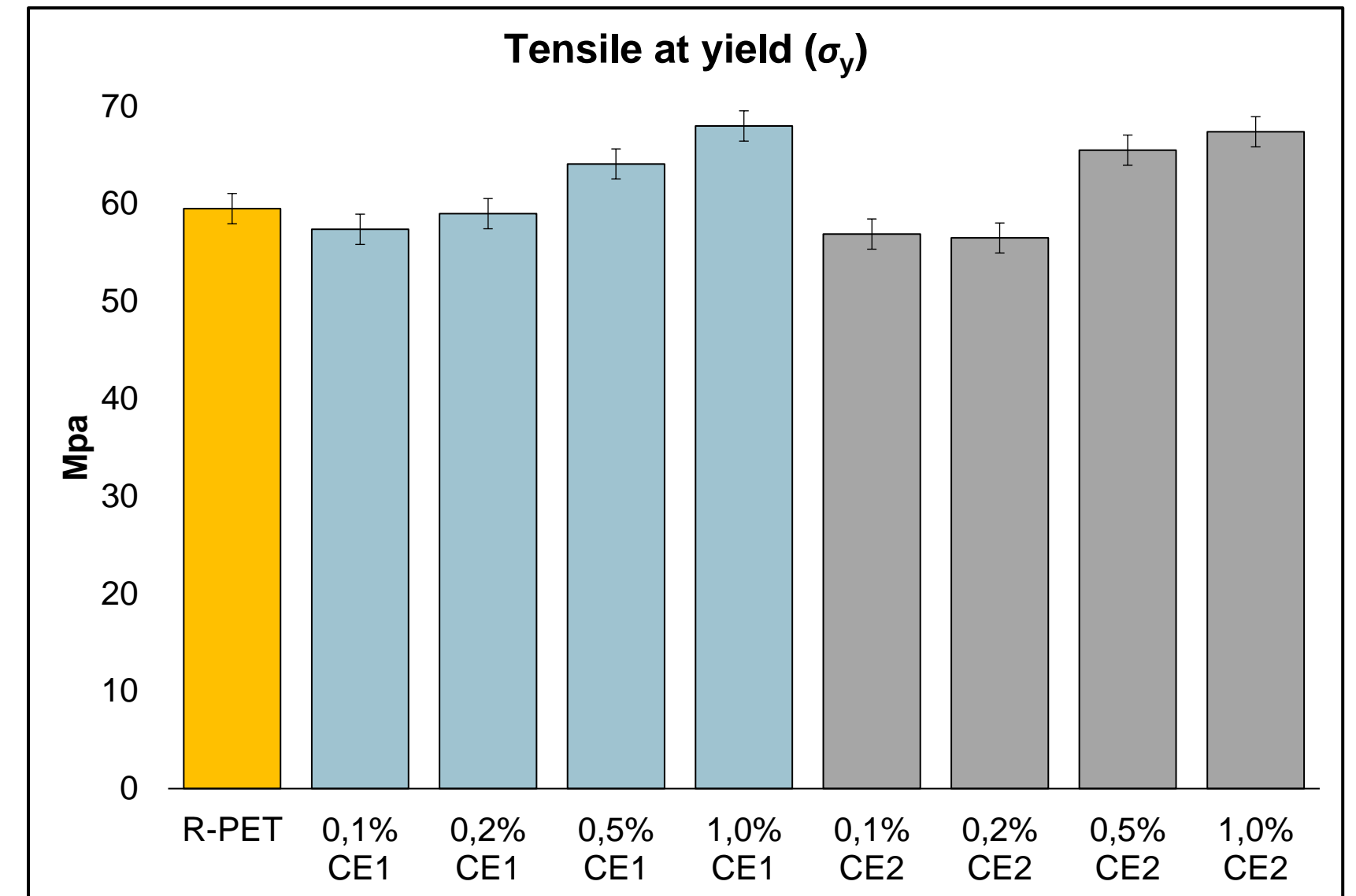
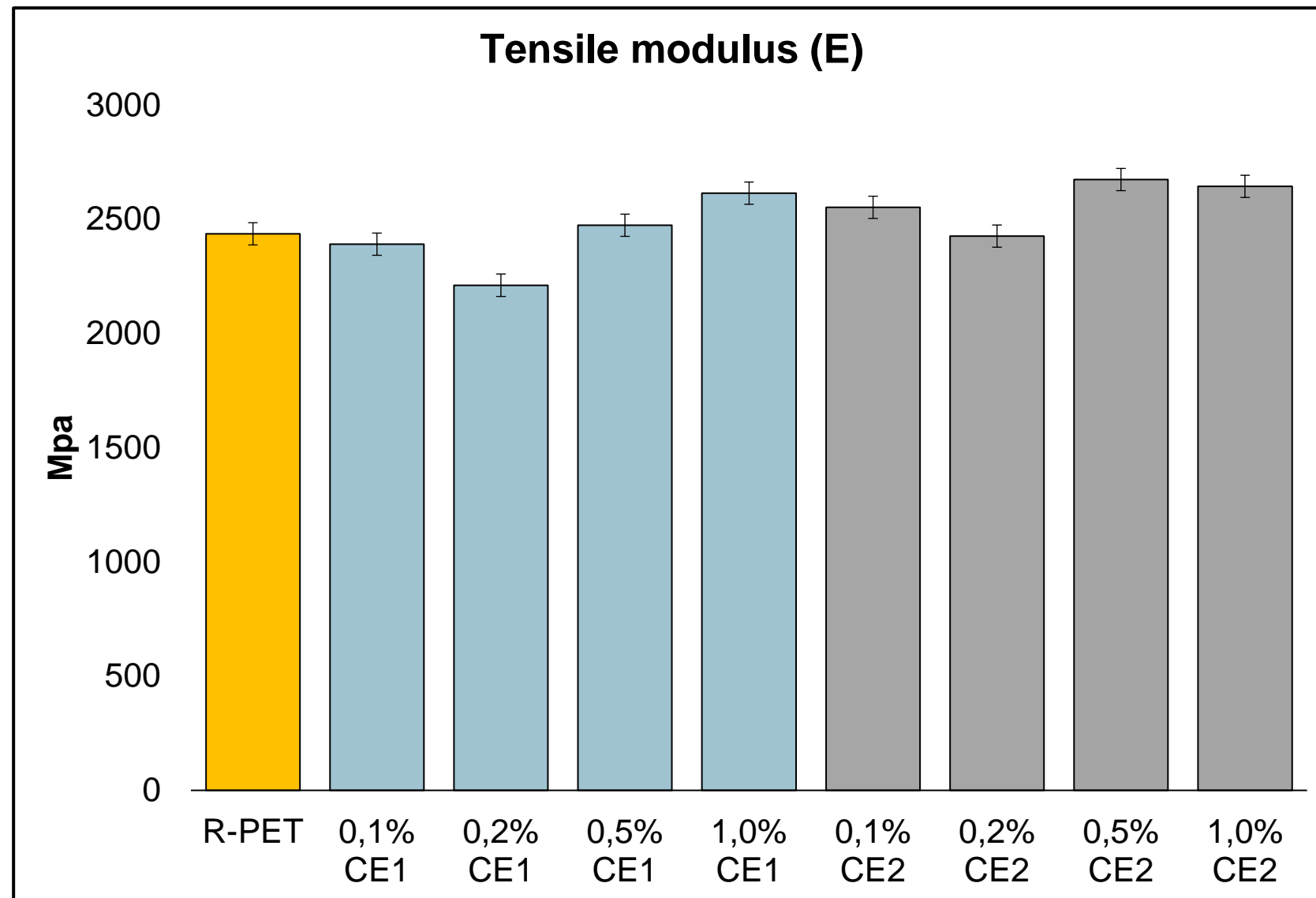
# Impact resistance



Maximum and excess concentrations

EC2 performance

# Tensile strength

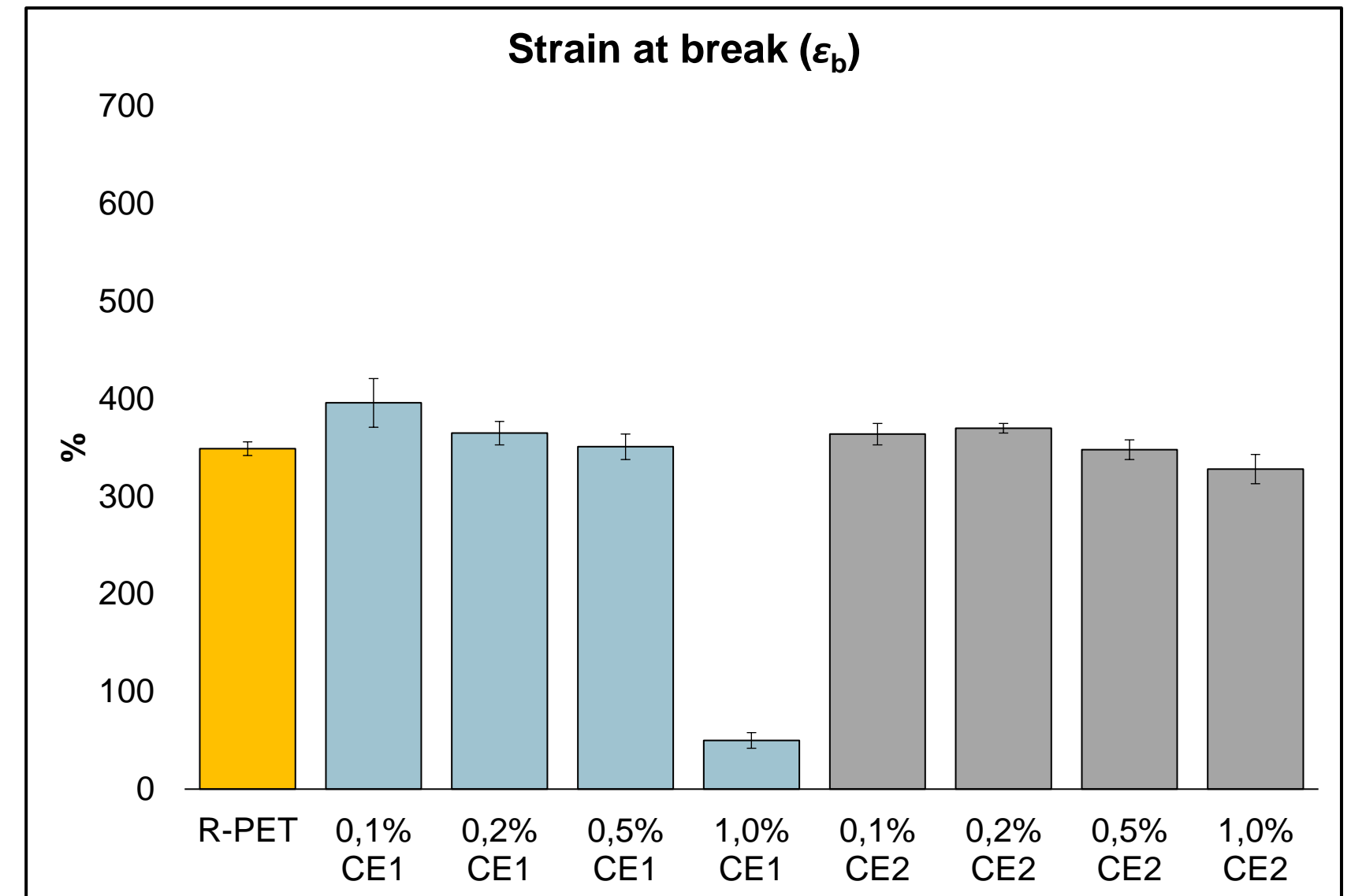
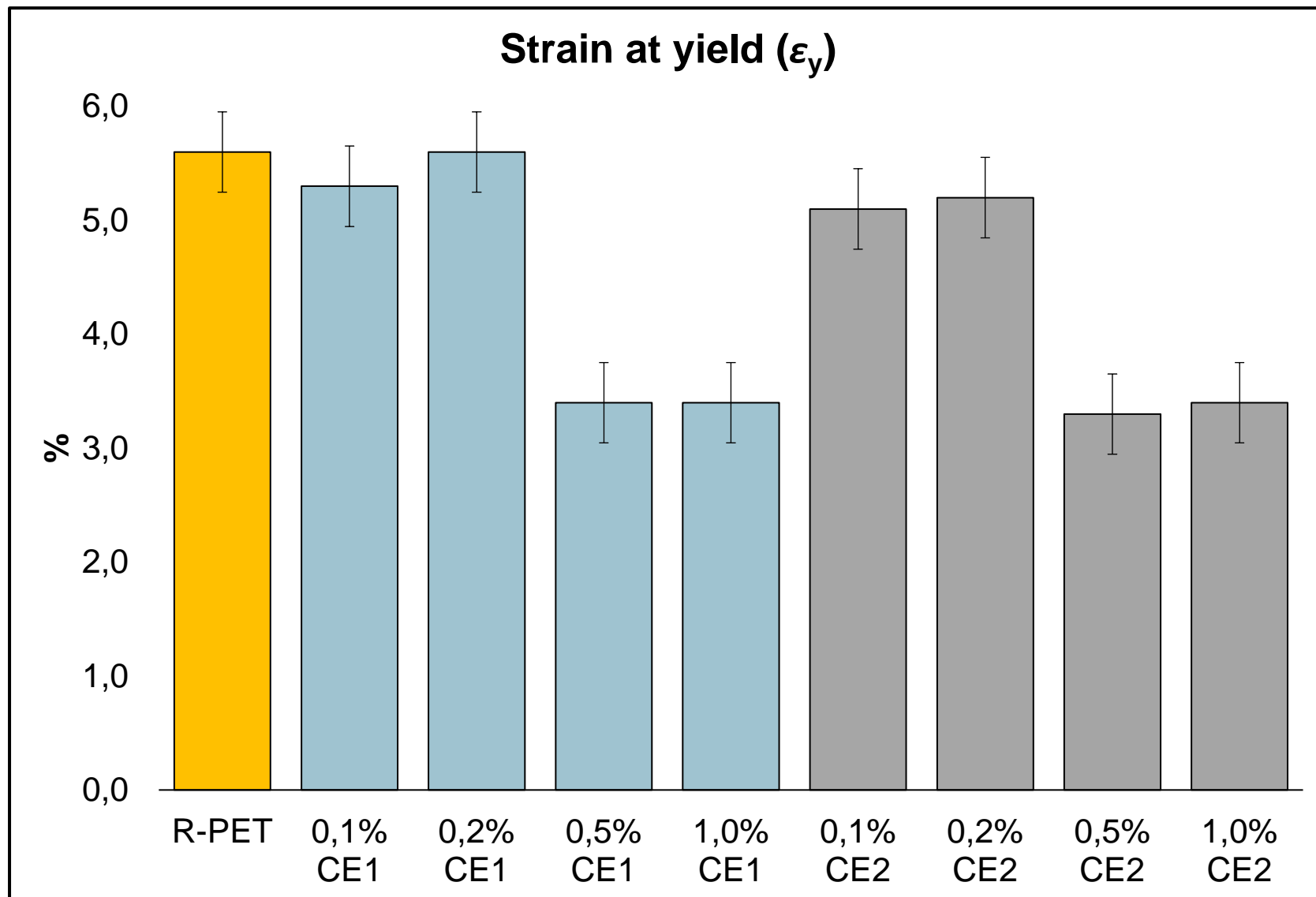


E with no significant discrepancies

High concentrations and stiffness



# Tensile strength



At 0.1 and 0.2% materials have greater resilience

High yield stress translated into more fragile behavior

# Conclusions

- Low incorporations: better overall performance;
- Most promising chain extender: ADR 4468 (CE2);
- Satisfactory R-PET after new thermal cycle;
- The potential to exploit chain extenders is still vast.



IA image: <https://lexica.art/prompt/a463fc6a-44e1-4a9c-9534-4dfac6860235>



# Next steps

- Complete IV tests;
- Use other additives in the most promising compositions (0.10 and 0.20%);
- Verify the branching effect of CE2;
- Obtain bottles and evaluate mechanical and processing properties.



IA image: <https://lexica.art/prompt/8a91cbc0-c24c-44b9-ae27-43d0f36531c4>

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OCTOBER 23-25, 2024 | ATHENS, GREECE

# Questions?

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# Thank you!

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