

ELECTRONIC SUPPORTING INFORMATION (ESI)

**Sustainable valorization of real polyurethane mattress waste
via a novel multistage thermochemical approach**

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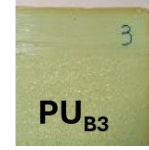
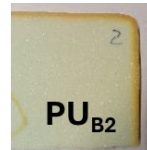
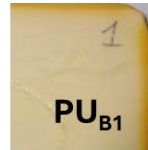
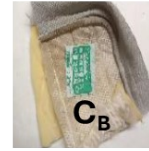
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Foam mattress based on polyurethane



Foam multilayer mattress based on polyurethane

Figure S1. Representative images of the structure of samples from discarded mattresses.

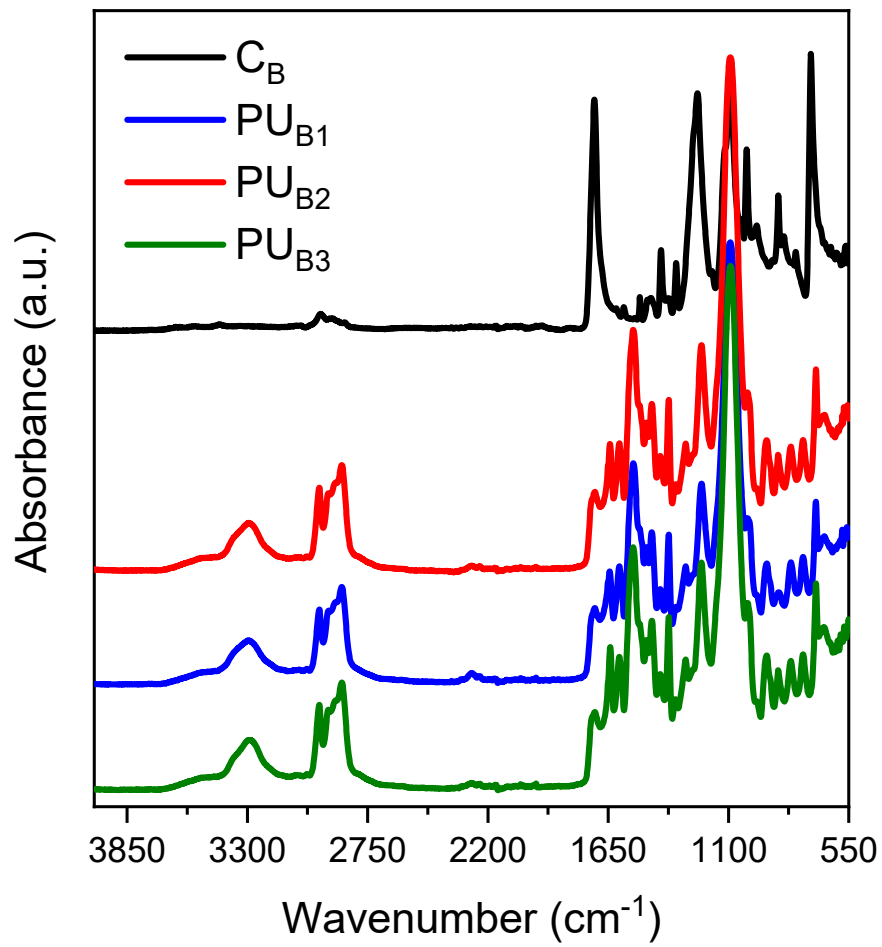


Figure S2. FTIR spectra employed for the identification of different parts of the multilayer polyurethane-based residual mattress samples.

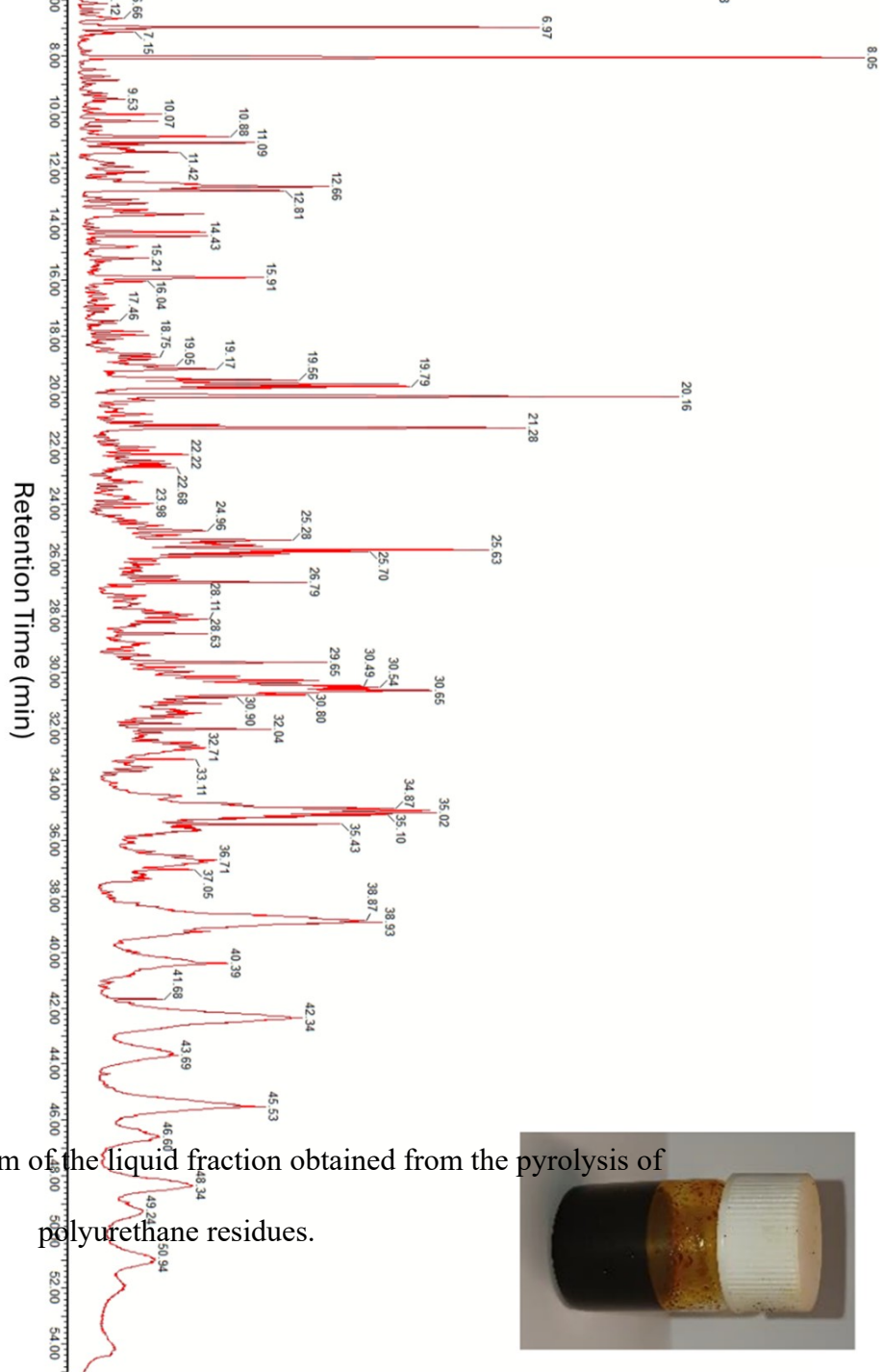
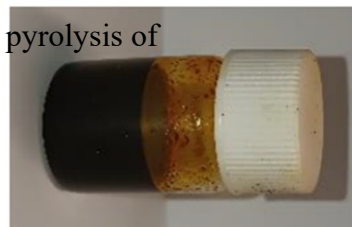


Figure S3. Chromatogram of the liquid fraction obtained from the pyrolysis of polyurethane residues.



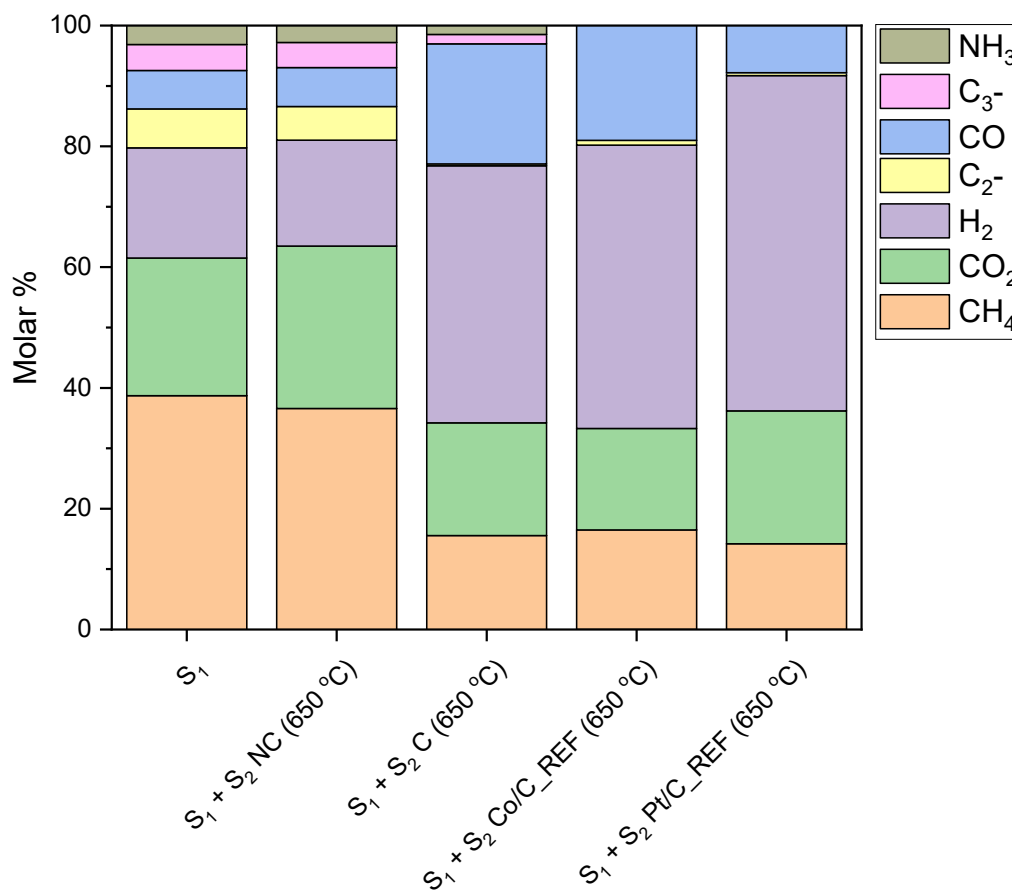


Figure S4. Catalytic performance results obtained in a two-step scheme (pyrolysis + catalytic transformation). S₁: Step 1; S₂: Step 2. NC refers to the reaction without catalyst (reference), whereas C corresponds to the reaction performed with the catalyst derived from residual fractions. Co/C corresponds to the data obtained using the reference catalyst with the same Co loading (0.5wt.%) supported on commercial carbon. Pt/C corresponds to the data obtained using the reference catalyst containing 0.5 wt.% Pt deposited on commercial carbon.

Table S1. Overview of literature on PU and waste mattress pyrolysis: conditions, products, and valorization pathways.

Feedstock/main goal	Ref.	Pyrolysis Conditions	Gas (key information)	Proposal and demonstration of the applicability		
				Gas	Liquid	Solid
Mattress						
Mattress/ Development of two models describing the pyrolysis and combustion degradation of PU wastes.	1	TG-IR and TG-MS, up to 900 °C	decomposition steps, mechanistic analysis	Outside the scope of this work	Outside the scope of this work	Outside the scope of this work
Waste mattress foam/Valorization of mattress foam waste via pyrolysis followed by thermal or catalytic cracking under inert atmosphere.	2	550 °C pyrolysis + 300-800 °C catalytic cracking (Dolomite, Olivine, HiFUEL®)	CH ₄ , H ₂ , CO	H ₂ -rich gas	Chemical feedstock precursor	Solid fuel
Whole mattress/	3	400-500 °C, 4.2-16.8 bar	CO, CO ₂ , CH ₄	Energy generation	Aromatic-rich compounds. Chemical	Solid fuel

Pressurized pyrolysis of real mattress waste composed of PU foams, fabrics, and textiles with diverse chemical composition.					feedstock precursor	
Polyurethane waste/Design and prepare low-cost, abundant catalysts and to investigate their effectiveness in the pyrolysis of polyurethane waste	4	350-450 °C (Kaolin/CuO)	Energy-rich gas mixture	Fuel gas	Recovery of amines and monomers	Outside the scope of this work
PU						
PU/Pyrolysis of various PUR investigated using TG-	5	TG-FTIR, up to 900 °C	decomposition steps, mechanistic	Outside the scope of this work	Outside the scope of this work	Outside the scope of this work

FTIR						
PU/ Pyrolysis behavior of seven PU with different hard/soft segment ratios studied under fast and slow pyrolysis conditions	6	up to 900 °C °C (fast and slow pyrolysis)	decomposition steps, mechanistic	Chemical feedstock recovery	Precursor-rich fractions	Outside the scope of this work
PU/Thermal degradation of PU studied using Reactive Molecular Dynamics	7	Reactive Molecular Dynamics, 300-3000 K	CO, CO ₂ , C ₂ H ₄ , H ₂ O, HCN, NH ₃ , CH ₂ O	Outside the scope of this work	Outside the scope of this work	Outside the scope of this work
This work: Development of a two-stage process for valorizing all fractions generated from pyrolysis of real PU mattress waste.		Step 1: 525 °C Step 2: Thermal catalysis	CH ₄ , NH ₃ , H ₂ , CO ₂ , and C ₂ -C ₃ hydrocarbons	H ₂ -rich gas, ammonia	Valorization through its use in the production of a new catalytic material employed in a second catalytic stage	

References

- 1 M. A. Garrido and R. Font, *J. Anal. Appl. Pyrolysis*, 2015, 113, 202–215.
- 2 A. Veses, O. Sanahuja-Parejo, I. Martínez, M. S. Callén, J. M. López, T. García and R. Murillo, *Waste Management*, 2021, 120, 415–423.
- 3 D. Serrano, A. Horvat, R. M. Mata, P. Costa and F. Paraleda, *Waste Management*, 2024, 181, 11–19.
- 4 H. A. Sani, M. Muhammad, A. Muhammad and T. A. Saleh, *Next Sustainability*, 2024, 3, 100024.
- 5 M. Zeller, D. Merz, L. Weigel, S. Tavakkol and D. Stapf, *J. Anal. Appl. Pyrolysis*, 2025, 188, 107048.
- 6 Y. Nishiyama, S. Kumagai, S. Motokucho, T. Kameda, Y. Saito, A. Watanabe, H. Nakatani and T. Yoshioka, *J. Anal. Appl. Pyrolysis*, 2020, 145, 104754.
- 7 Q. Chen, T. B. Y. Chen, W. J. Yang, I. M. De Cachinho Cordeiro and R. K. K. Yuen, *Compos. Part A Appl. Sci. Manuf.*, 2026, 207, 109854.