

Sustainable Depolymerization of Marine PA6 Waste Using a Choline Chloride–Diethanolamine Deep Eutectic Solvent

P. Mercado-Martínez¹, K. Gutiérrez-Silva¹, M.C. Arango¹, O. Gil-Castell¹, Rosana Moriana-Torró¹, A. Cháfer^{1,*}

¹ Research Group in Materials Technology and Sustainability (MATS), Department of Chemical Engineering, School of Engineering, Universitat de València, Av. Universitat s/n, Burjassot, Valencia 46100, Spain

* amparo.chafer@uv.es

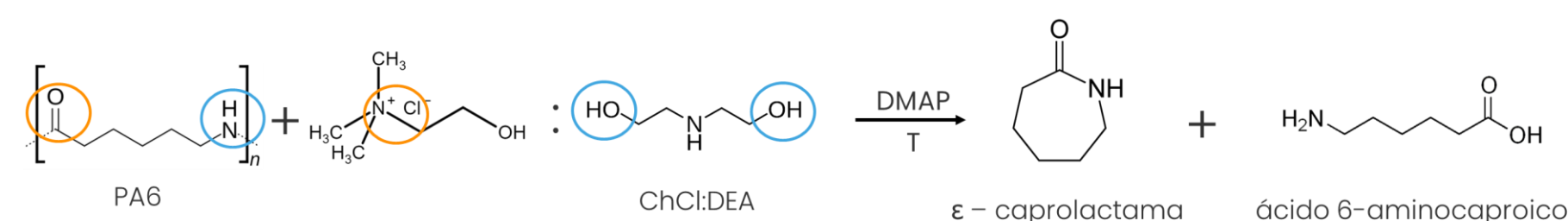
INTRODUCTION & AIM

- The accumulation of end-of-life polyamide 6 (PA6) fishing nets in marine environments poses a serious ecological and waste management challenge.
- Recent advances in chemical recycling through solvolysis have opened new avenues for recovering high-value monomers such as ϵ -caprolactam from polyamide waste streams, supporting circular economy principles.
- In this investigation, a deep eutectic solvent (DES) composed of choline chloride and diethanolamine (ChCl:DEA) at different molar ratios is employed as both reaction medium and nucleophilic agent for the depolymerization of PA6 sourced from marine waste.

- Using DES:
 - Advantages: Low-cost raw materials, easy synthesis, water stability, biocompatible, biodegradable, and non-toxic. DES
 - Physicochemical properties: Mostly polar; density higher and viscosity much greater than conventional solvents (temperature-dependent).

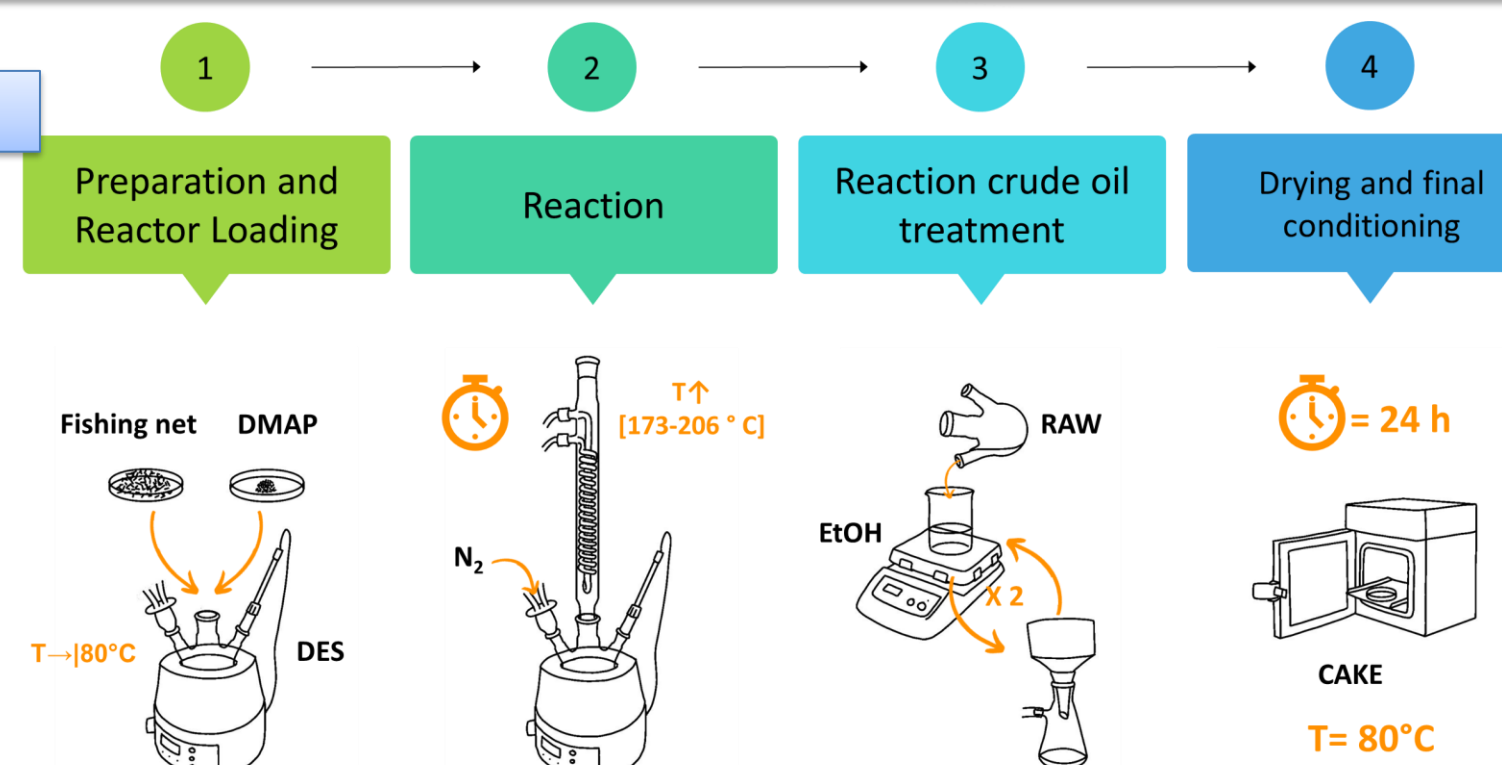
Main objective

To study the technical feasibility and optimize conditions for the depolymerization of PA6 using ChCl:DEA as a medium.



METHOD

Experimental procedure



Experimental design

- Dependent variable to maximize: Fishing net conversion X_{RED} (%)
- Independent variables: T (°C), RED/DES ratio (% w:w), ChCl:DEA ratio (mol:mol)
- Constant variables: Fishing net/catalyst ratio (RED/DMAP) 10% w:w, reaction time (t) 60 min.

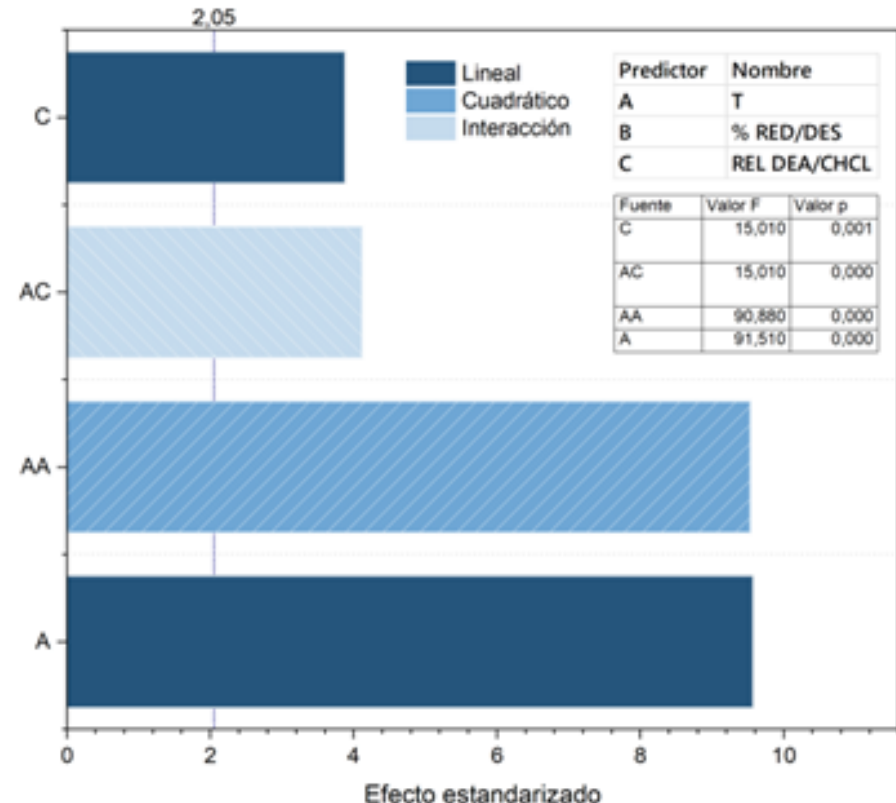
Composite Central Design (CCD)

Parameter	Variable (Unit)	Experimental levels				
		-2	-1	0	1	2
T	(°C)	173.18	180	190	200	206.82
RED/DES	(%)	6.64	8	10	12	13.36
ChCl:DEA	(mol:mol)	1:2.64	1:4	1:6	1:8	1:9.36

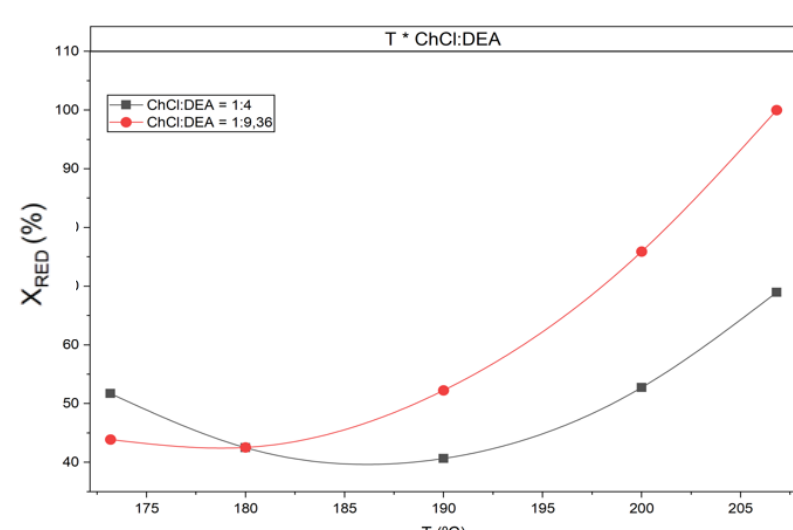
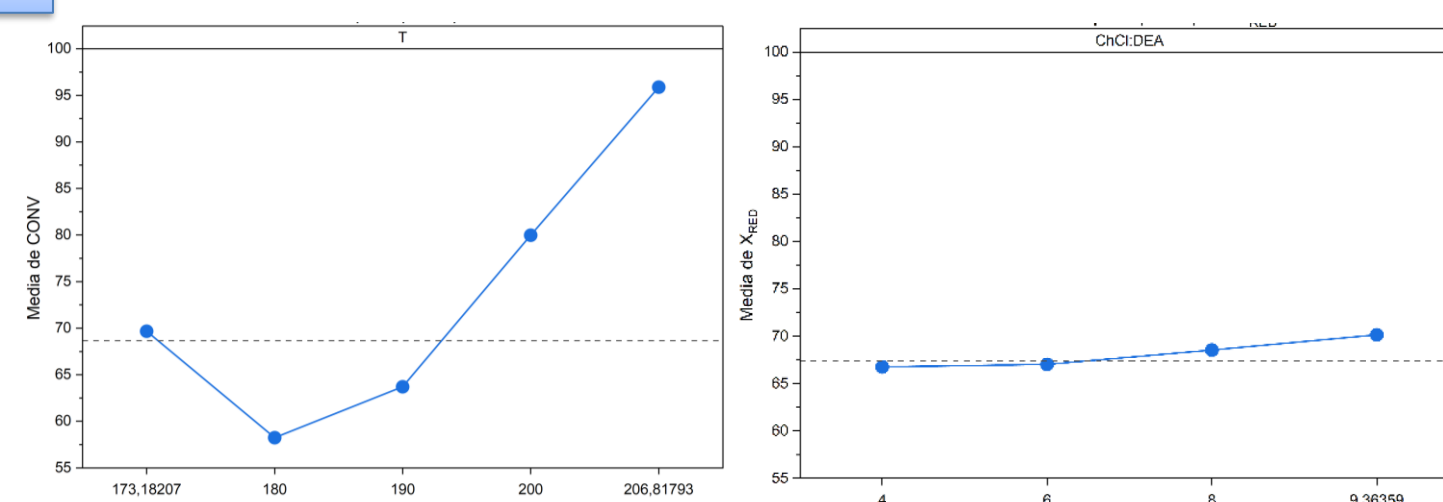
RESULTS & DISCUSSION

Statistical study of the experimental design

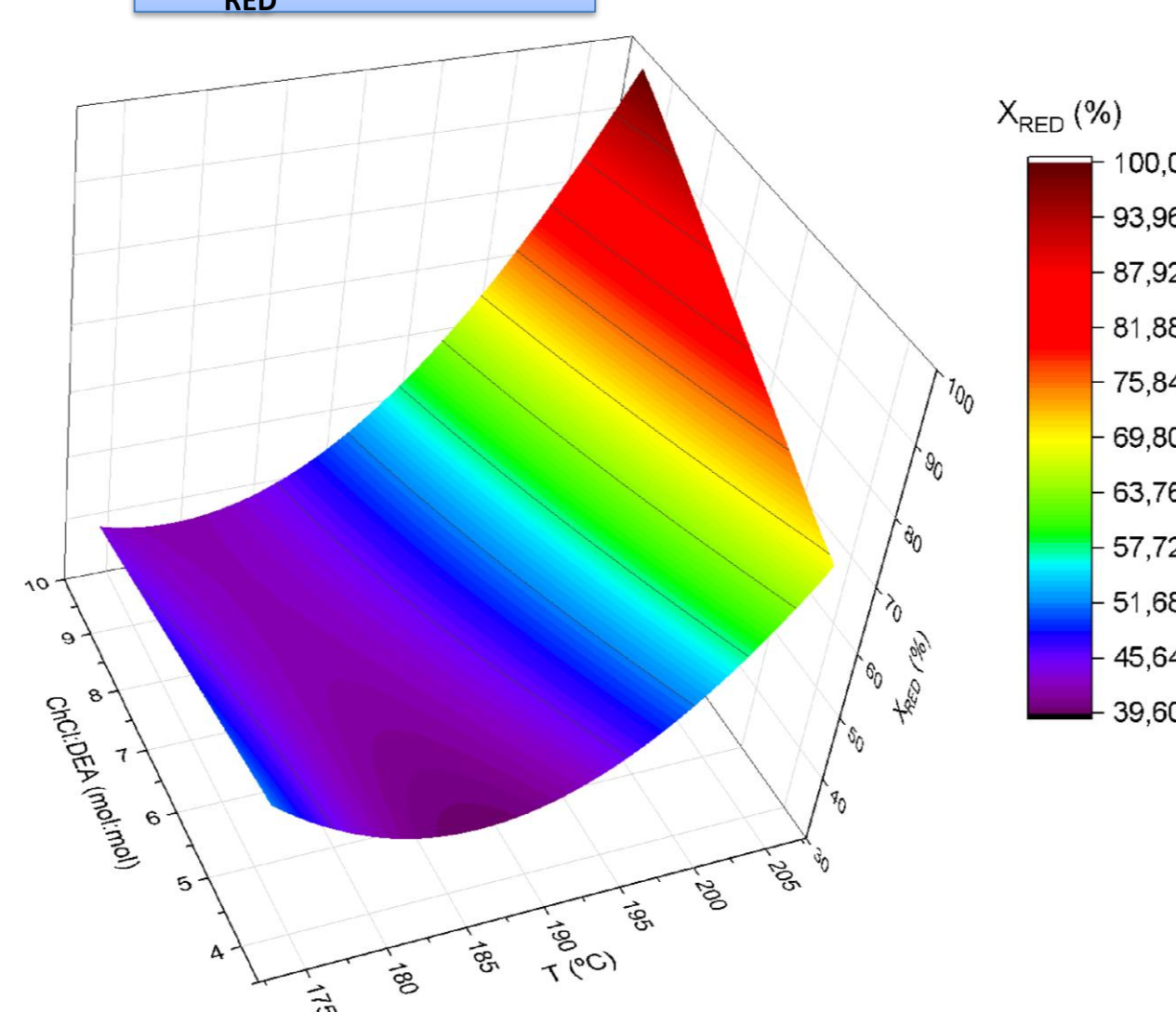
Statistical significant effects



Analysis of variance (Pareto Graph): individual effects, quadratic effects and key parameter interactions.



X_{RED} Maximization



T (°C)	ChCl:DEA (mol:mol)	X_{RED} (%)
206.82	1:9.36	99.99

CONCLUSION

The system composed of the DES ChCl:DEA with the DMAP catalyst is proposed as an efficient, reproducible, scalable and environmentally viable alternative for the chemical recycling of PA6 fishing nets, contributing to the circular economy with recovery of high value-added monomers.

REFERENCES

- Pasciucco, A., Rossi, L., & Hernández, M. Prevalence of polyamide 6 fishing nets in marine debris: Chemical recycling prospects from ocean-collected PA6 waste. *J. Cleaner Prod.* 213, 12345 (2025).
- Badia, J. D., Ballesteros-Garrido, R., Gamir-Cobacho, A., Gil-Castell, O. & Cháfer, A. Chemical recycling of post-consumer poly(ethylene terephthalate) (PET) driven by the protic ionic liquid 2-HEAA: Performance, kinetics and mechanism. *J. Environ. Chem. Eng.* 12, (2024).



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