XIII Congresso Nazionale AICIng
II Congresso Nazionale Divisione di Chimica per le Tecnologie - SCI
25-28 giugno 2023 – Politecnico di Milano

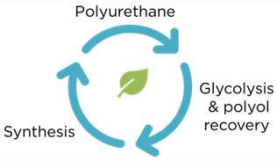
CHEMICAL RECYCLING OF ELASTOMERIC AND VISCOELASTIC POLYURETHANES

Alberto Bottari, Ada Truscello, Lucia Rita Rubino, Fatima Margani, Maurizio Stefano Galimberti
Politecnico di Milano, Department of Chemistry, Materials and Chemical Engineering "G. Natta", Via Mancinelli 7, 20131 Milano, Italy.
alberto.bottari@polimi.it

Objectives

1. Development of a **feasible protocol** for the chemical recycling of PUs through **glycolysis** in order to recover the polyether **polyol**
2. **Characterization** of the glycolysis products from the **chemical recycling** *via* ^{1}H-NMR
3. Preparation of PU tile **using the products obtained from the depolymerization** replacing the virgin starting material

Results and Discussion



Polyurethanes (PUs) are a very versatile class of polymers with widespread applications. Their worldwide demand is estimated to be **24 million tons** by 2024 [1]. PUs can be elastomeric, thermoplastic, or viscoelastic (such as the material of "memory foam" mattresses and pillows). At the end of their life, **PUs are mainly landfilled.**[2]
Nowadays, **PUs recycling** is still under investigation to achieve further development to arrive at industrial applications.

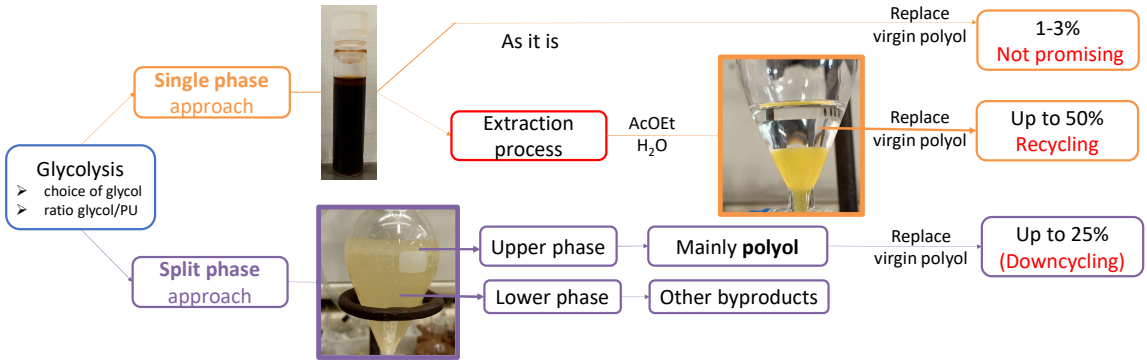
Starting from end of life PUs

- Glycolysis
- Characterization
- Reformulation

Result: new PUs with similar mechanical properties

A double approach for glycolysis

Polyols and isocyanates are present in a **wide variety** of shapes and sizes. As a result, a unique process of recycling cannot be suggested, but it must be adapted to the polymer. The process could be **single** or **split** phase and the difference between the two approaches is the number of phases obtained after the depolymerization reaction [3]

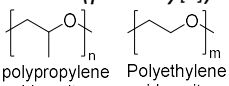


Parameters for glycolysis

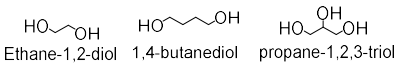
1 *Ratio glycol:PU*

0.5:1 → 5:1

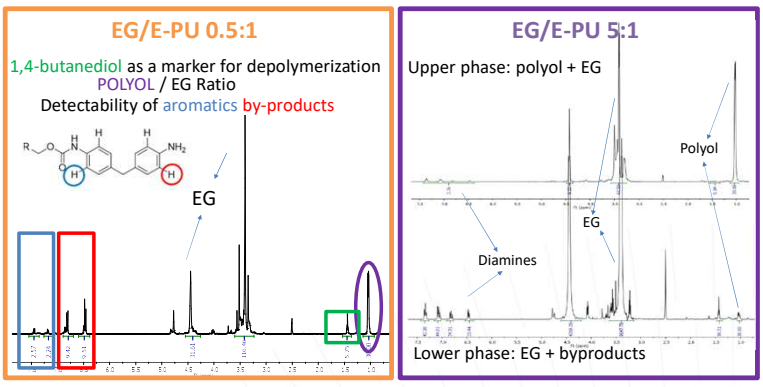
2 *Polyether polyol building units (polarity[4])*



3 *Type of glycol*



Characterization



^{1}H-NMR analysis is used to monitor the **reaction advancement**, the presence of the reaction **products**, the **quantities of byproducts** and **glycol** in the different phases. Results were confirmed by FT-IR and the OH number analysis.
On the recycled tiles, **tensile tests** were performed showing **properties comparable to starting materials.**

Conclusions

1. A **complete cycle,** from the PU synthesis to the reformulation with recovered polyol were performed through **glycolysis**.
2. A new method of characterization of the glycolysis products was used. **^{1}H-NMR allowed to obtain information about reaction proceeding** and **presence of polyol, byproduct and glycol.**
3. At the end of the cycle, the **synthesis** with **partially recycled building blocks** ware performed; the obtained materials were characterized by tensile tests, achieving very promising results, comparable to starting materials.

References and acknowledgements

[1] https://www.statista.com/statistics/747004/polyurethane-demand-worldwide/
[2] Kemona, A., & Piotrowska, M. (2020). Polyurethane recycling and disposal: Methods and prospects. Polymers, 12(8), 1752.
[3] Simón, D., et al. "Recycling of polyurethanes from laboratory to industry, a journey towards the sustainability." *Waste Management* 76 (2018): 147-171.
[4] Molero, C., A. De Lucas, and J. F. Rodríguez. "Purification by liquid extraction of recovered polyols." Solvent extraction and ion exchange 24.5 (2006): 719-730.

Thanks to ECOTRON project (Horizon UE) and Pozzi Arosio s.a.s.