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Chemical recycling of rigid polyurethane foams modified with rebiopolyols

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INTRODUCTION

Global production of polyurethane materials in 2023 was about 22 million tons. It is estimated that in the case of polyurethane foam materials, post-production waste can account for up to 15% of the total weight of the plastic produced. In many countries, this waste ends up in landfills, which is a growing problem due to its significant volume-to-weight ratio. Alternative, more environmentally beneficial uses of polyurethane waste are therefore being sought, in line with a circular economy. Rebiopolyols were obtained by a glycolysis reaction of rigid polyurethane foams made from biopolyols synthesized from rapeseed oil. The foams obtained with rebiopolyols were then chemically recycled using a glycolysis reaction with various liquifying agents. The grade II rebiopolyols obtained in this process were characterized and compared to grade I rebiopolyols.

RESULTS AND DISCUSSION

Tab. 1. The biopolyol used in the synthesis of the foams and the I and II grade rebiopolyols tested.

Type	Symbol	Characteristics
Biopolyol	EPO_DEG	biopolyol synthesized from rapeseed oil
Grade I rebiopolyol	R/EPO_DEG/DEG	obtained by glycolysis of polyurethane biofoam derived from EPO_DEG, with diethylene glycol
	R/EPO_DEG/EG	obtained by glycolysis of polyurethane biofoam derived from EPO_DEG, with ethylene glycol
	R/EPO_DEG/PG	obtained by glycolysis of polyurethane biofoam derived from EPO_DEG, with propylene glycol
Grade II rebiopolyol	RR_DEG	obtained by glycolysis of polyurethane biofoam obtained from R/EPO_DEG/DEG, with diethylene glycol
	RR_EG	obtained by glycolysis of polyurethane biofoam obtained from R/EPO_DEG/EG, with ethylene glycol
	RR_PG	obtained by glycolysis of polyurethane biofoam obtained from R/EPO_DEG/PG, with propylene glycol

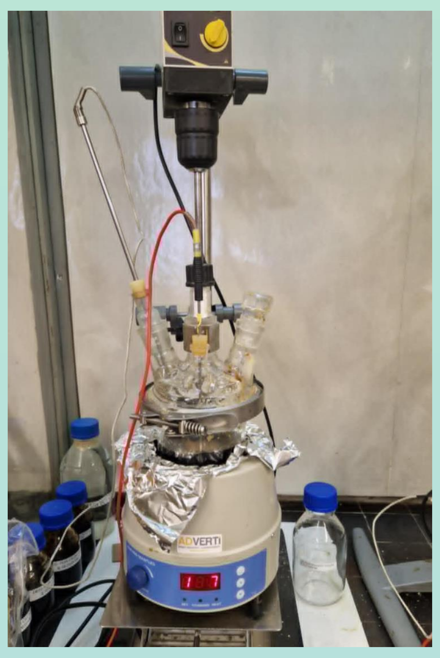

Fig. 1. Apparatus for PUR foam glycolysis reaction.

Fig. 2. Grade I rebiopolyol.

Sample

Sample

Sample

Fig. 3. Grade II rebiopolyol.

Sample

Sample

Sample

Tab. 2. The number-average (M_n) and weight-average (M_w) molecular weight, dispersivity (D), and unreacted liquifying agent content (%G) of the obtained I grade rebiopolyols.

Sample symbol	M_n [g/mol]	M_w [g/mol]	D	%G
R/EPO_DEG/DEG	468	863	1.85	12.5
R/EPO_DEG/EG	359	655	1.83	13.3
R/EPO_DEG/PG	419	664	1.58	10.0

Tab. 3. The number-average (M_n) and weight-average (M_w) molecular weight, dispersivity (D), and unreacted liquifying agent content (%G) of the obtained II grade rebiopolyols.

Sample symbol	M_n [g/mol]	M_w [g/mol]	D	%G
RR_DEG	609	1106	1.82	7.25
RR_EG	370	578	1.57	6.92
RR_PG	406	593	1.46	4.86

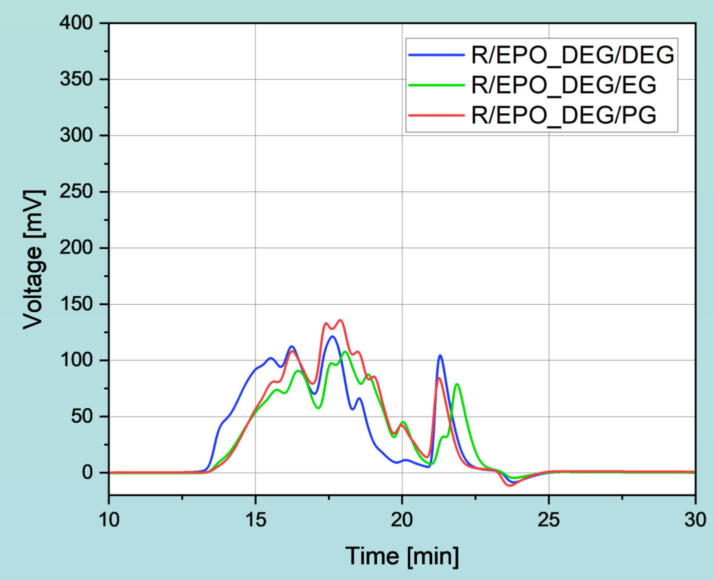

Fig. 4. GPC chromatogram of the obtained I grade rebiopolyols.

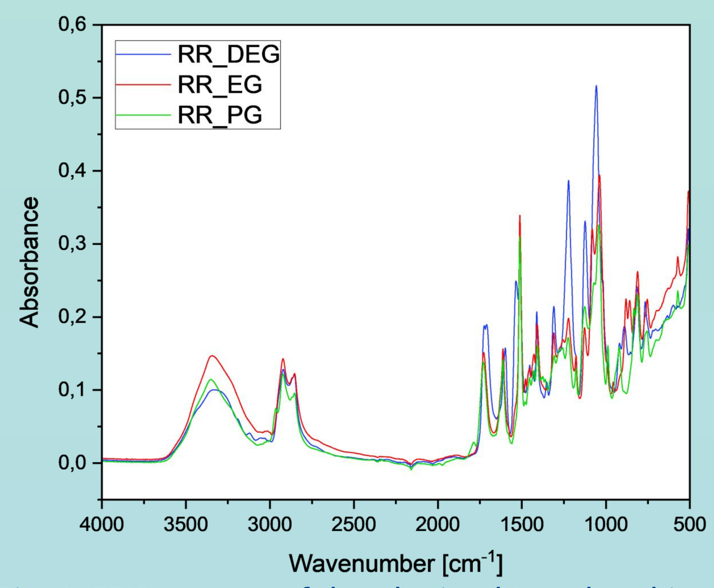

Fig. 6. FTIR spectra of the obtained I grade rebiopolyols.

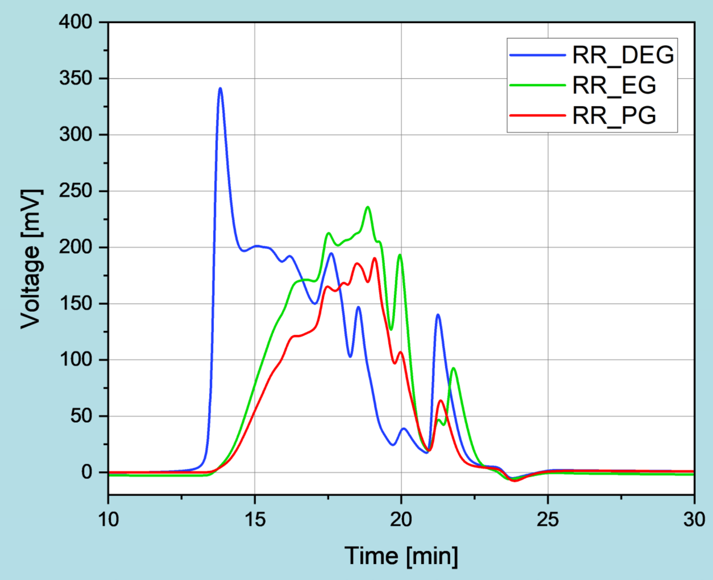

Fig. 5. GPC chromatogram of the obtained II grade rebiopolyols.

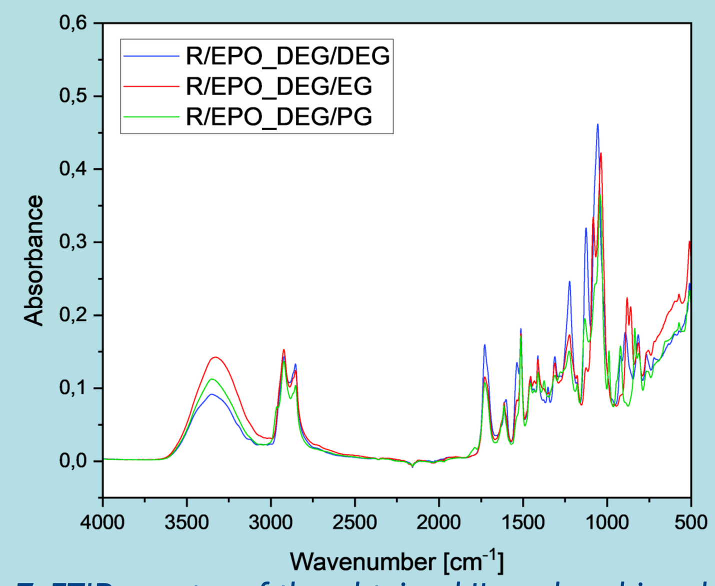

Fig. 7. FTIR spectra of the obtained II grade rebiopolyols.

Tab. 4. Properties and functionalities of I grade rebiopolyols.

Sample symbol	Hydroxyl value [mgKOH/g]	Acid value [mgKOH/g]	Density [g/cm³]	Viscosity [mPa·s]	Functionality
R/EPO_DEG/DEG	421±4	4.72±0.08	1.13	8069	1.1
R/EPO_DEG/EG	717±2	4.97±0.30	1.11	976	1.4
R/EPO_DEG/PG	575±13	5.88±0.24	1.11	1843	1.9

Tab. 5. Properties and functionalities of II grade rebiopolyols.

Sample symbol	Hydroxyl value [mgKOH/g]	Acid value [mgKOH/g]	Density [g/cm³]	Viscosity [mPa·s]	Functionality
RR_DEG	409±14	4.24±0.64	1.18	564052	4.4
RR_EG	680±12	4.11±0.34	1.17	9756	4.5
RR_PG	572±8	4.02±0.10	1.13	15301	4.2

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SUMMARY

In the process of obtaining first- and second-stage rebiopolyols, the type of glycol used in the glycolysis reaction of PUR biofoam affects the properties of the product. The recycling of polyurethane foams carried out in two cycles is in line with the principles concerning the European Green Deal and the circular economy.

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„Chemolysis possibility analysis for polyurethane bio-materials synthesized from bio-polyols of various chemical structures and analysis of influence of resultant bio-recyclates on expansion process and properties of new bio-polyurethanes"
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