Quantitative comparison conventional and microwave-assisted heating in ZnO-catalysed glycolysis of virgin PET

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Introduction

Polyethylene terephthalate (PET) is widely used in textiles and packaging [1], but its increasing production and limited recyclability [2] pose significant environmental and economic challenges. Therefore, improving PET recycling through efficient valorization routes, such as selective depolymerization, is essential for sustainable resource management.

Glycolysis is an effective depolymerization route, producing bis(2-hydroxyethyl) terephthalate (BHET) as a high-purity monomer that can be repolymerized into PET with properties comparable to virgin material [4]. Glycolysis is a mature alternative through which the value-added product BHET can be obtained; however, it has a series of limitations, such as the reaction rate.

The focus of this study is the use of microwave irradiation to overcome the limitations associated with the conventional approach. Microwave-assisted heating is faster and more selective than conventional methods, with lower energy losses [3,5]. By coupling selective microwave heating with an efficient ZnO catalyst, the process achieves rapid energy transfer, enhanced kinetics, and high conversion. This study provides a quantitative comparison between conventional and microwave-assisted glycolysis, focusing on reaction efficiency, operating severity, and catalyst and solvent requirements.

OBJECTIVE: To compare reaction time, yield and operating conditions between conventional and microwave-assisted PET glycolysis

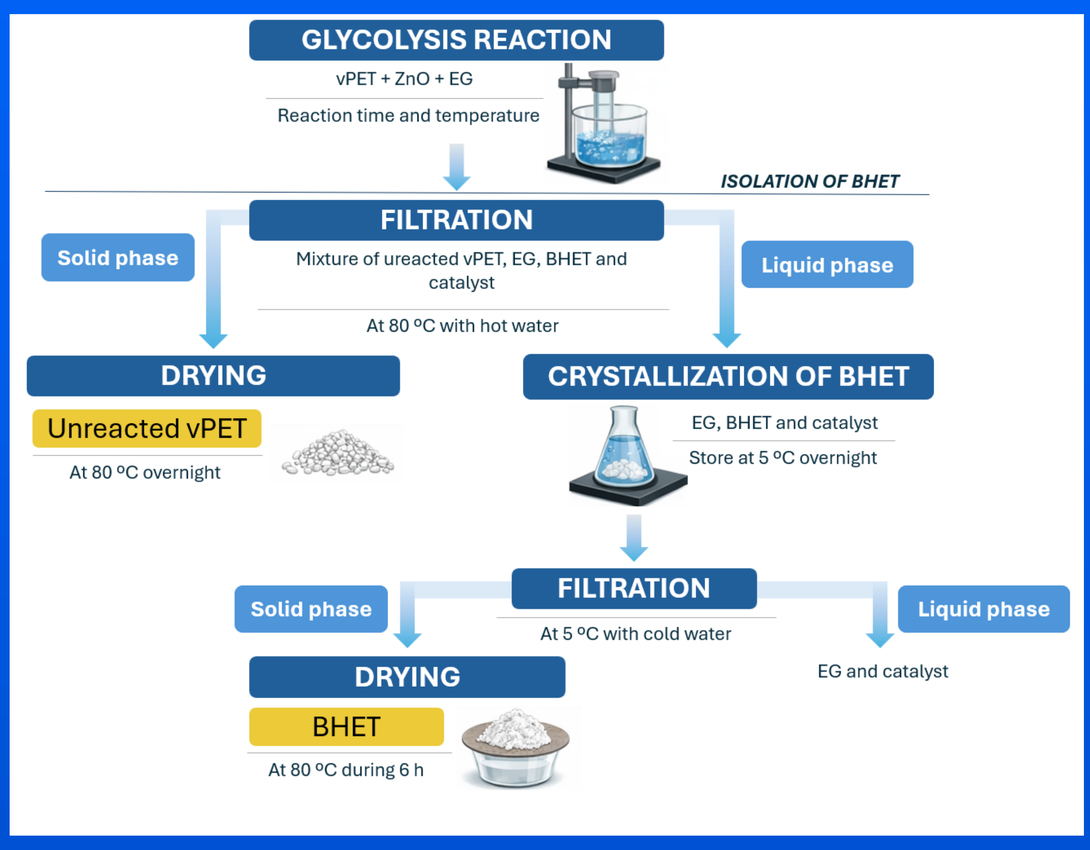

Figure 1: Flowchart of the methodology for PET glycolysis and BHET isolation.

Results & Discussion

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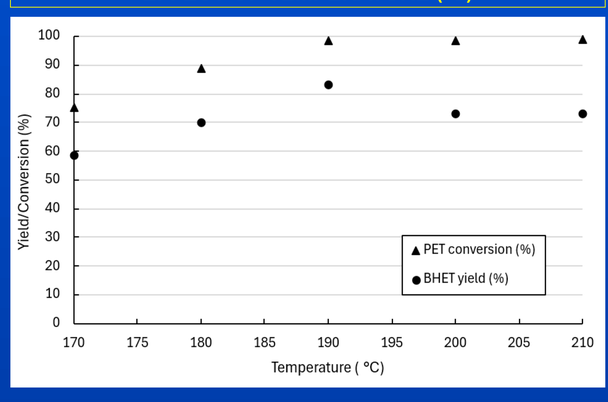
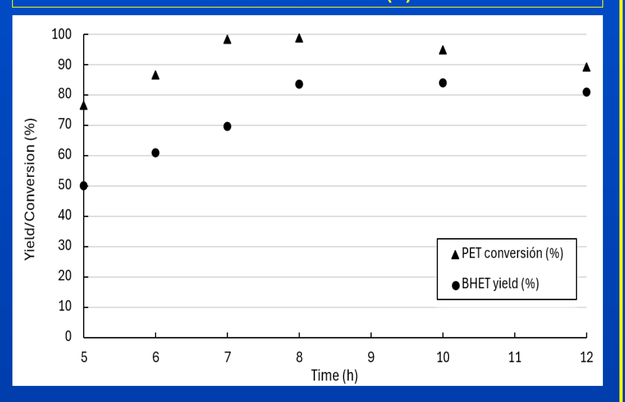
GLYCOLYSIS UNDER CONVENTIONAL HEATING

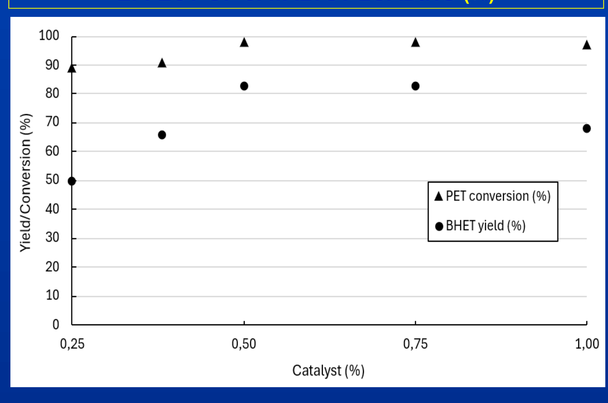
EFFECT OF TEMPERATURE (ºC)



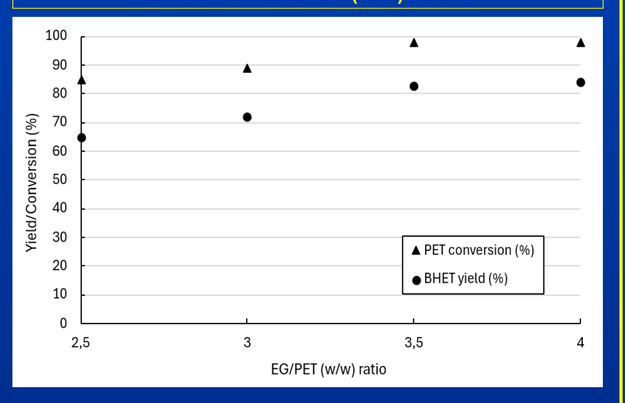
EFFECT OF TIME (h)



EFFECT OF CATALYST LOADING (%)

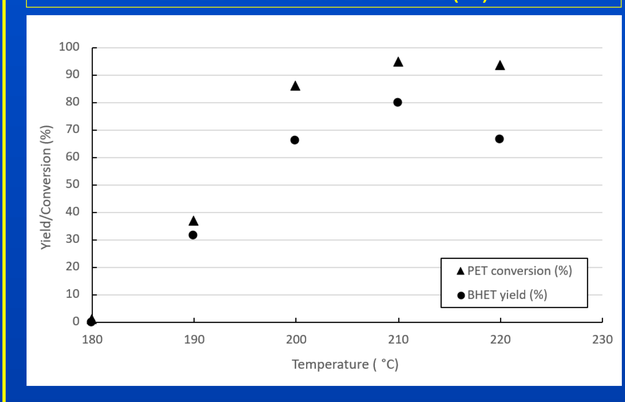


EFFECT OF EG/PET (w/w) RATIO

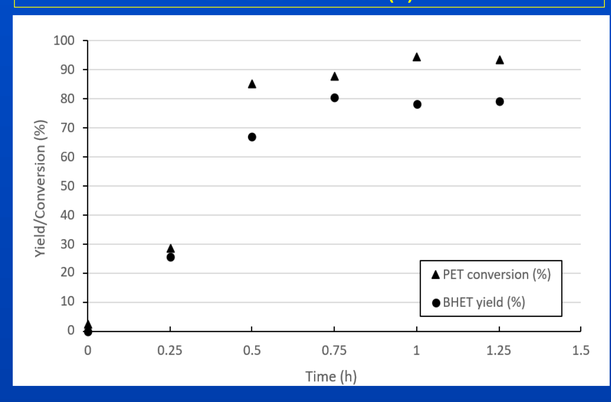


MW-ASSISTED GLYCOLYSIS

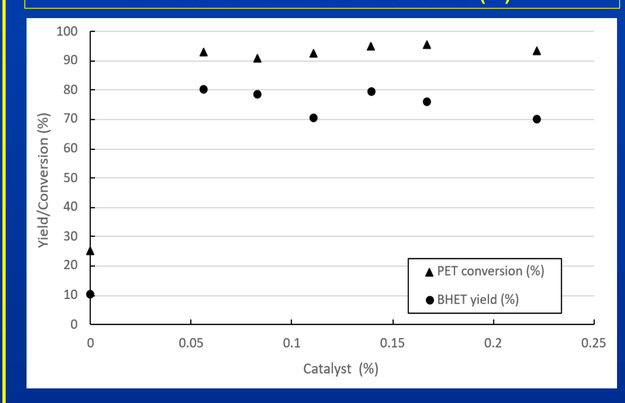
EFFECT OF TEMPERATURE (ºC)



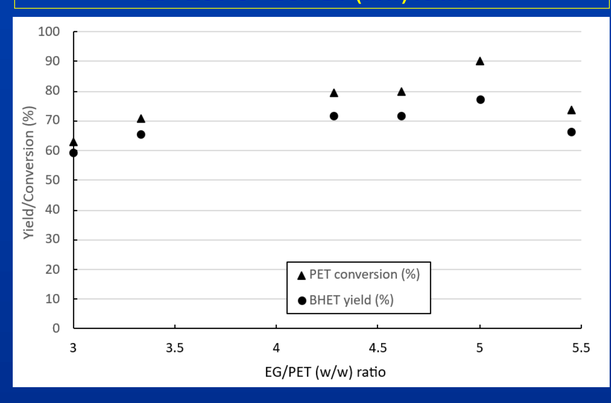
EFFECT OF TIME (h)



EFFECT OF CATALYST LOADING (%)



EFFECT OF EG/PET (w/w) RATIO



Optimal parameters	Convetional heating	Microwave-assisted
Reaction temperature	190 ºC	210 ºC
Reaction time	8 h	1 h
Catalyst concentration	0.5 % w/w	0.14 % w/w
EG/PET ratio	3.5 w/w	5 w/w
PET conversion	~ 95%	
BHET yield	> 80%	

Microwave heating achieves similar conversion in significantly shorter times and lower catalyst loading

Conclusions

- Microwave irradiation has been shown to **reduce the reaction time** by approximately 90%, even when lowering the amount of catalyst used, which confirms its robust performance.
- Future research should extend this methodology to **post-consumer PET** and assess the activity of **alternative catalyst systems**. In addition, further work is required to evaluate the scalability of microwave-assisted glycolysis and the long-term reusability of ZnO over multiple reaction cycles.

References

Complete references can be found here:

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