The Chemical Recycling of Unsaturated Polyesters

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Introduction

Unsaturated Polyester Resins (UPR) are thermosets made by crosslinking Polyester resins with a monomer, most often styrene. This creates a very stable network with **high thermal and chemical stability**. This stability makes it very useful for varying kinds of purposes, but this also makes it **harder to re-use or recycle**. For this reason, an accessible method for the degradation of UPR into **Low-Mass UPR** (LMUPR) needs to be developed and is why this research will be looking into the degradation of UPR under mild conditions using a mechanochemical method.

Figure 1: Different uses across different industries for Unsaturated Polyester Resin

Figure 2: Buchi Rotavapor® R-300

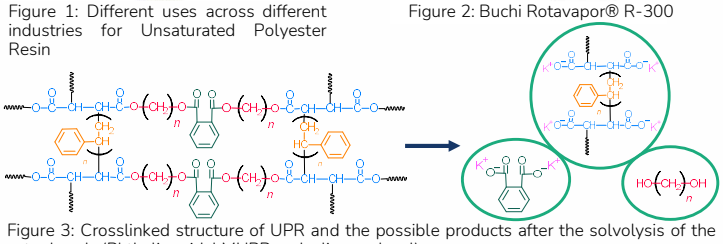

Figure 3: Crosslinked structure of UPR and the possible products after the solvolysis of the ester bonds (Phthalic acid, LMUPR and a linear glycol).

The solvolysis reactions were performed in a **rotary evaporator** with **glass milling balls**. The rotation from the rotary evaporator moves the glass beads around in the connected flask, which provides **energy transfer** to the UPR to improve the degradation.[1] The rotation also provides a continuous refreshment of the **surface area** of the UPR.

Methodology

To determine the optimal conditions for the mechanochemical degradation, a **Design of Experiment** was set-up. The factors that were investigated were: *Time*, *temperature*, *solvent to UPR ratio* and the *rotational speed* of the rotary evaporator. **Ethylene glycol** (EG) was used as the solvent and KOH as the catalyst.

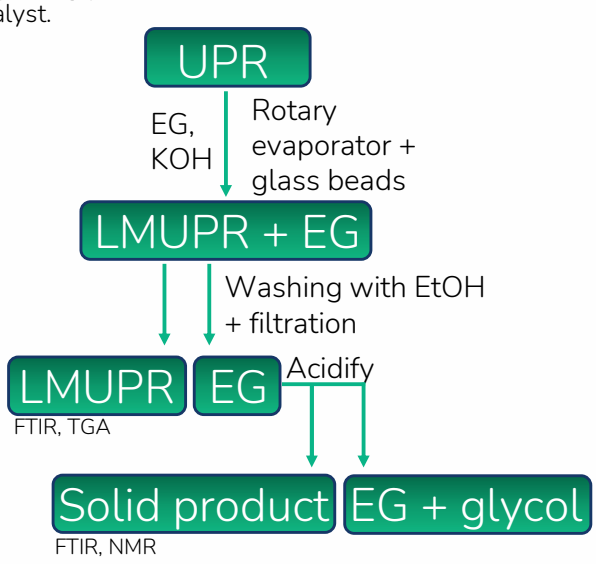

Figure 4: Schematic of the reaction steps and all reaction products

Results

For the Design of Experiment, it seemed that a **higher temperature** seems to have the best effect on the degradation of UPR. The residual weight of the UPR after the reaction is consistently lower when a **higher temperature** is used, so more UPR has degraded whenever a higher temperature was used during the reaction.

DoE nr.	1	2	3	4	5	6	7	8	9
Temperature (°C)	50	70	90	50	70	90	50	70	90
Time (min)	60	60	60	120	120	120	180	180	180
Solvent/UPR (mL/g)	10	25	40	25	40	10	40	10	25
RPM	10	30	50	50	10	30	30	50	10

Figure 5: Reaction Parameters from the Design of Experiments

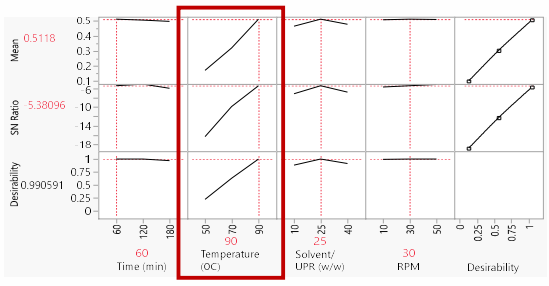

Figure 6: Graph of UPR residue and parameter effects

As for the TGA results, the same observation can be made. **Reactions 6** and **9** have the **most residue** left after heating to 600 °C, which is an indication for the amount of **carboxylate groups** that have formed during the reaction. Further analyses need to be performed to properly determine the effect of all factors tested during the Design of Experiment.

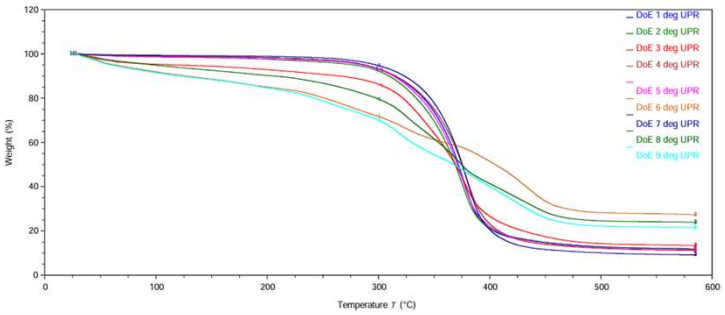

Figure 7: Thermograph showing residual UPR after each reaction. TGA ramped to 600 °C at 20 °C/min.

Conclusion

The results from the Design of Experiment indicate that the **temperature** is the **most influential** parameter during the solvolysis of UPR. Based on these findings, the next phase will focus on the detailed characterisation of the solvolysis products, as well as investigating different catalysts that might improve the solvolysis.

References

1. Wang, W., Peng, Y. (2022). Mechanochemical organic synthesis in a rotary evaporator beyond conventional application: Proof-of-concept reactions. Synthetic Communications, 53, 625-639

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