

REMOVING SOLVENT TRACES TO ACHIEVE FOOD QUALITY POLYMERS

FROM DISSOLUTION RECYCLING

Introduction

Plastic waste management remains one of the most critical challenges in the transition toward a circular economy. Solvent-based recycling has potential to remove contaminants while preserving the polymer's original structure. This makes it particularly attractive for applications that require high purity, such as the production of food-grade polymers. However, the use of organic solvents in dissolution recycling introduces potential health concerns if residual solvent remains in the final material. In this work, thermogravimetric analysis (TGA) is used to evaluate the drying behaviour of polystyrene in two different solutions under varying heating rates and initial solvent content.

Materials and methods

Materials: Polystyrene (Ineos Styrolution, PS 168N/L), o-xylene (OX) from Thermo Fisher Scientific, dimethyl adipate (DMA) from Sigma-Aldrich.

Methods:

The solutions were made in glass vials with a magnetic stirrer, 10 wt% of PS was dissolved in solvent.

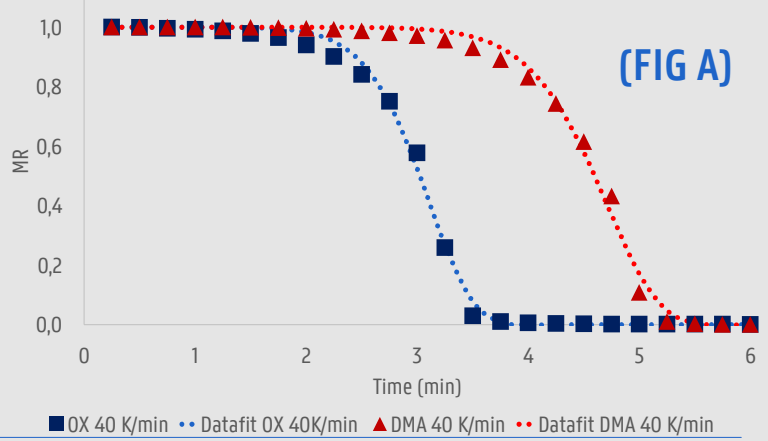
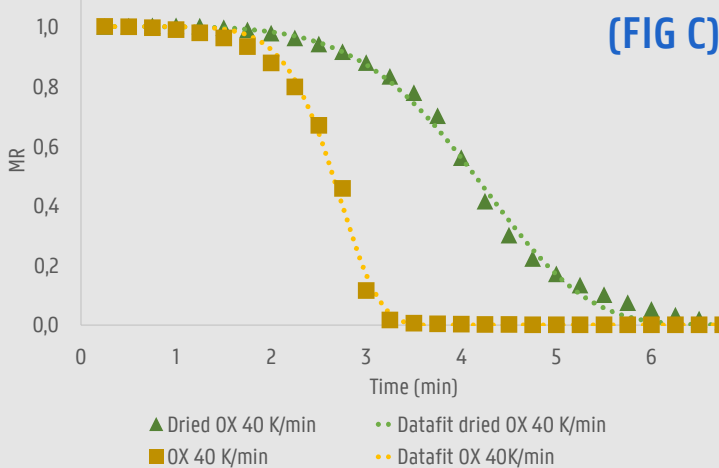
The dried o-xylene solution was made by dissolving 10 wt% of PS and then letting the vial open at 100°C for 24 hours.

The TGA is TG 209 F3 Tarsus from NETZSCH. The initial temperature was 30°C with different heating rates and sample masses.

R studio was used to fit the Page model to the experimental drying data. Page model consist of: $MR = \exp(-k \cdot t^n)$, with k the drying rate constant and n an empirical exponent. All data had a resulting R² of 0,996 or higher.

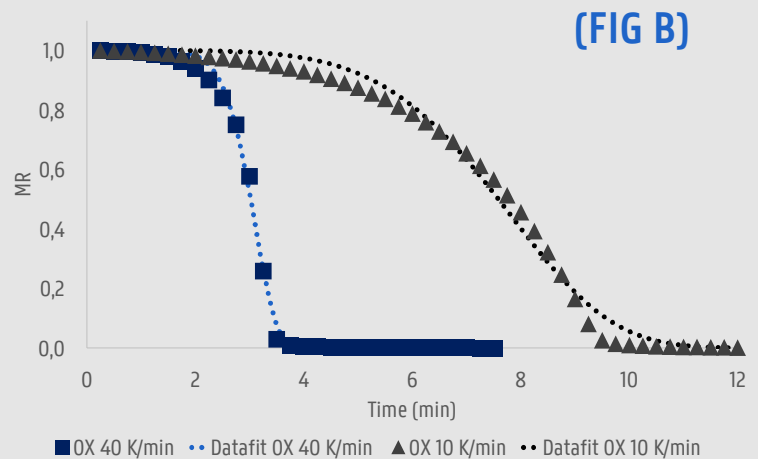
Influence of heating rate (FIG B)

Increasing the heating rate from 10 to 40 K/min compresses the drying it into a shorter time interval, resulting in a higher Page exponent n and a larger k. The 10 K/min gives a $k = 1,98 \cdot 10^{-5}$ and $n = 5,16$; the 40 K/min gives $k = 3,69 \cdot 10^{-5}$ and $n = 8,89$. But the increase in heating rate shifts the solvent loss to higher temperatures.



Influence of solvent (FIG A)

Drying at 40K/min leads to the following values for o-xylene: $k = 3,69 \cdot 10^{-5}$ and $n = 8,89$, compared to dimethyl adipate: $k = 2,82 \cdot 10^{-8}$ and $n = 11,15$. The markedly lower boiling point of o-xylene compared to dimethyl adipate (145 and 227°C) results in earlier and more intense solvent evaporation and leading to a much larger effective Page drying constant. In contrast, the higher boiling point of dimethyl adipate shifts solvent removal to higher temperatures, producing delayed mass loss that is captured by a smaller effective k and a larger Page exponent n.



Influence of initial solvent content (FIG C)

The wetter sample exhibits a significantly higher Page model exponent n, indicating a more complex drying behaviour. The k value are not comparable since moisture ranges differ too greatly. The dryer sample dries later and then higher temperature than the wetter sample.

The wetter sample: $k = 3,97 \cdot 10^{-4}$ and $n = 7,65$; the dryer sample: $k = 5,48 \cdot 10^{-4}$ and $n = 5,02$. The drying rate is set at 40 K/min.

Conclusion

- The Page model provides an excellent empirical fit
- Changing the solvent from o-xylene to dimethyl adipate shifts the evaporation to higher temperature (reflected by the higher n and lower k values)
- Lower initial solvent dries at later time and higher temperature
- Increasing the heating rate shifts the solvent evaporation to higher temperature while compressing into a shorter time interval.

Contact

Viktor.Buysse@ugent.be
www.lcpe.ugent.be

Universiteit Gent

@ugent

Ghent University