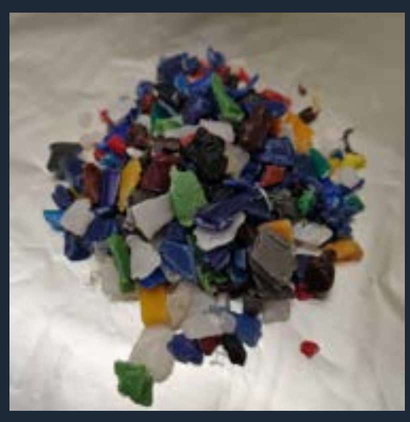
Veridis

*When knowing your plastic composition really matters*

# MADSCAN: A new thermal analysis system for characterisation of recycled polymers

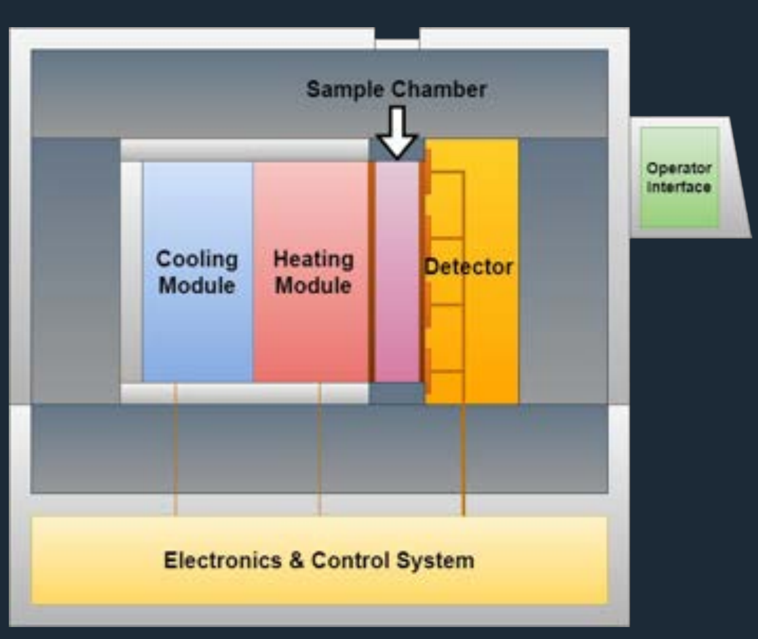
## Up to 1000 flakes/granules analysed with <u>one</u> MADSCAN T-30 scan

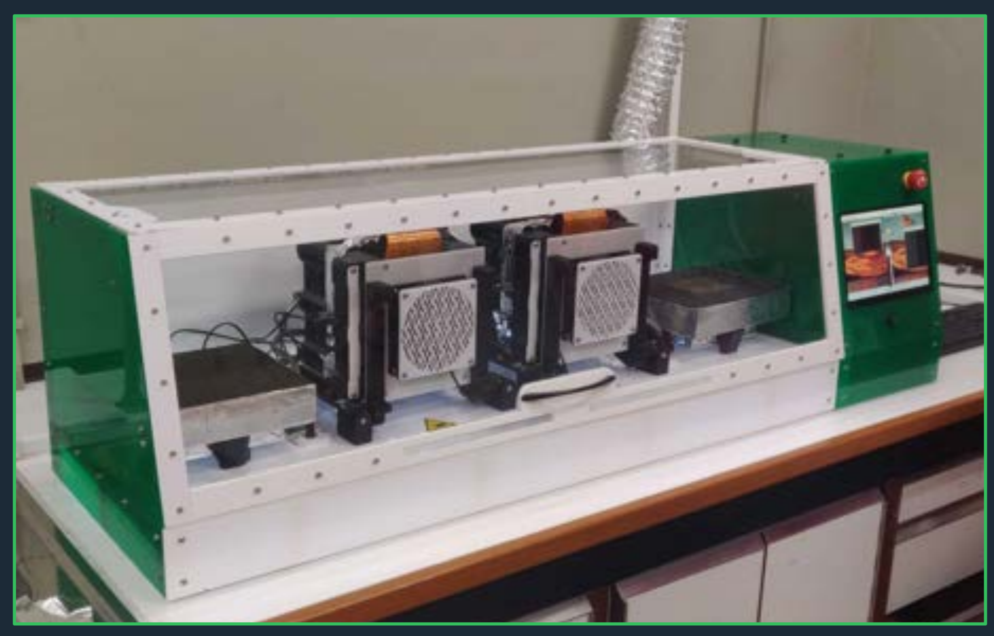


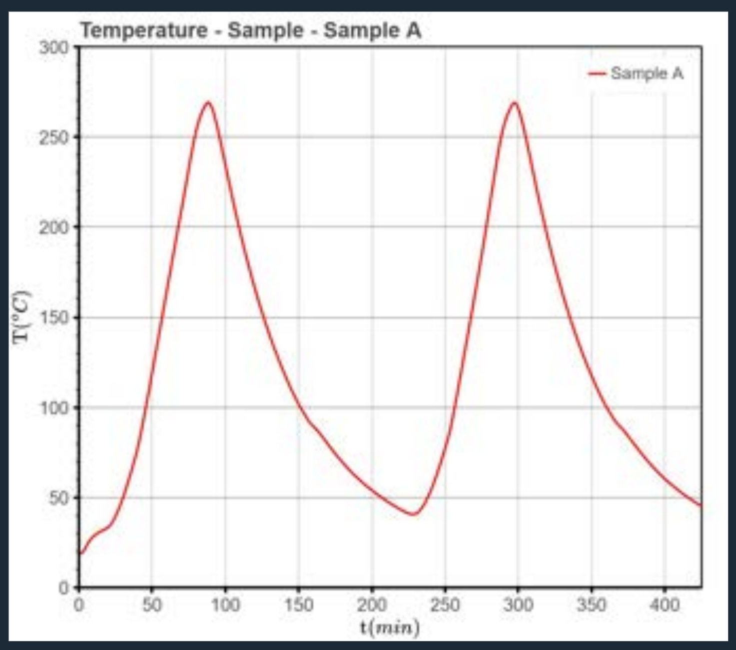





## The MADSCAN System - *automating complex material measurements*






**Sample size:**

- 1-2 grammes - MADSCAN T-2 (2021)
- 20-30 grammes - MADSCAN T-30 (Q2-2023)
- 50 grammes - MADSCAN T-50 (Q3-2024)
- 50 grammes - MADSCAN S-50 (Q4-2025)

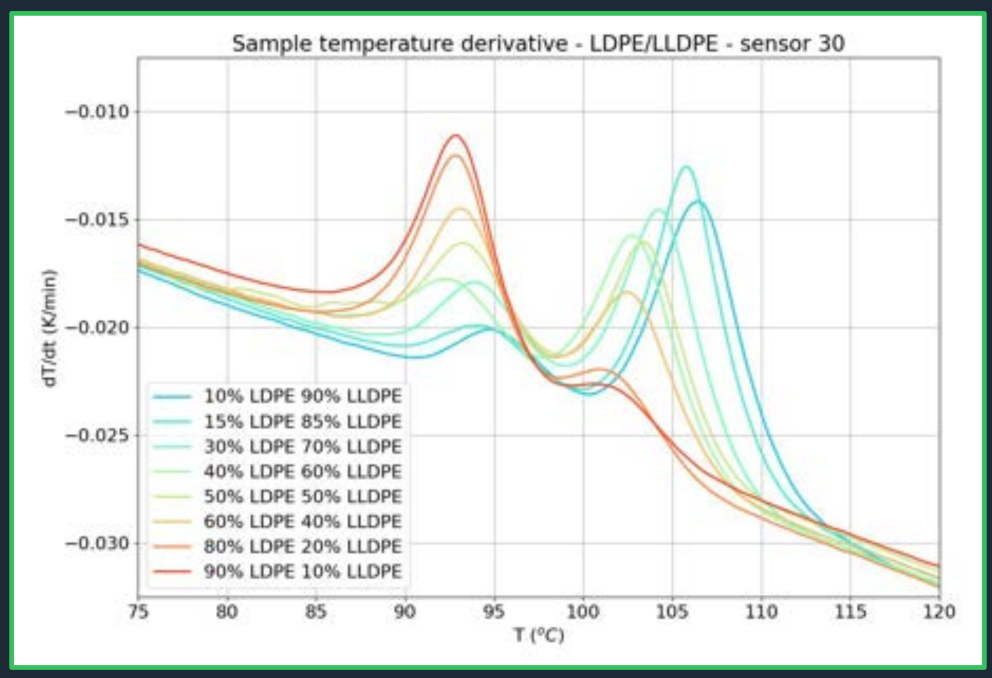
**MADSCAN T-30:**

- Temperature range: RT - 330 °C
- Sample types: flake, compound, powder
- Detection limit: <1 % of mass
- Heating rate: 5 °C / min.
- Measuring: Enthalpy, heating rate

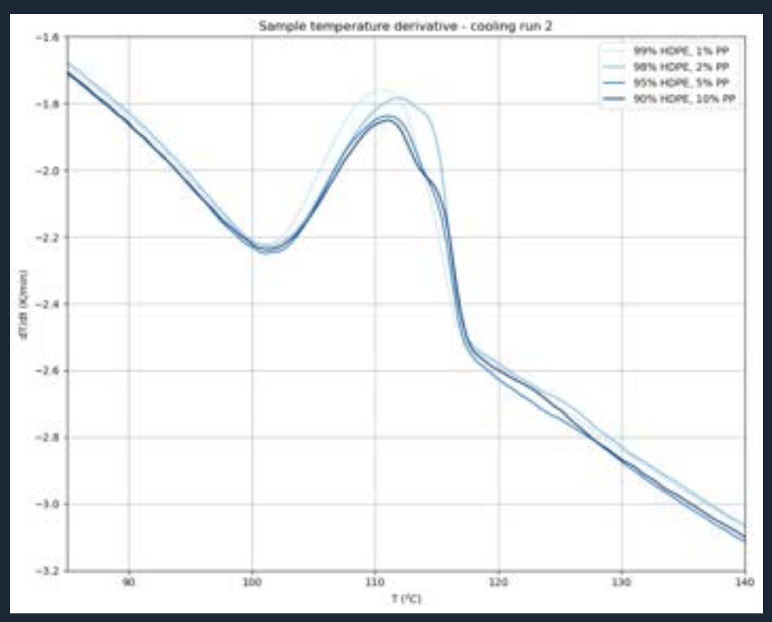
**Measurement protocol:**

- Sampling (e.g. according to CEN/TS 16010)
- Load sample in system
- Run measurement in linear heating or full power mode
- Signal processing & analytics

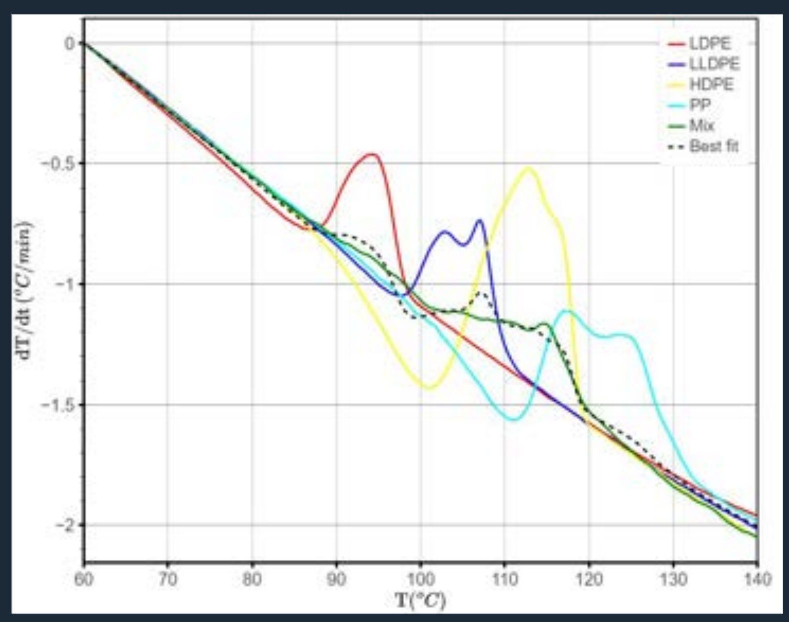
## Measurement results




Series of MADSCAN measurements for binary virgin polymer flake mixes. In this sample, the variation in the cooling rate is zoomed in to define the polymer fractions by means of the crystallization curves. This shows that the LDPE/LLDPE fractions can be clearly distinguished from each other.



Measurement series to determine the limit of detection in the binary HDPE/PP polyolefin flake mixture. Typically in blends the co-crystallisation of HDPE and PP makes the estimation of small fractions extremely difficult.




Measurement analysis of mixed plastic polyolefin waste, here our analytical methods can clearly elucidate the different fractions from the signal.

## Applications

**Plastic Waste Sorting**

- Output quality control
- Advanced Process Control
- Process Optimisation
- Insight & Reporting

**Mechanical Recycling**

- Input Verification
- Output quality control
- Advanced Process Control
- Process Optimisation

**Chemical Recycling**

- Input Verification
- Advanced Process Control
- Process Optimisation

**Plastic Material Processing**

- Input Verification
- Additive optimisation
- Output quality control
- Process Research

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# Polymer quantification with MADSCAN

Tycho Aronds & Floris Gerritsen

## Introduction

Currently a lot of recycled plastics are unusable since their composition is hard to determine and are therefore discarded in landfills or burned.[1] Current conventional analysis methods measure only really small amounts (<0.1 g) of plastic at a time. This sample size is not representative enough for big amounts of recycled plastics where local variety of polymers can differ a lot, as represented in figure 1.[2] Veridis has developed a thermal analysis method for the analysis of polymers called the MADSCAN (Massive DSC Analysis), which solves this problem by increasing sample sizes up to 500 g. The current setup is to 30 g. The objective of this research is to build a suitable database using the MADSCAN technology that can be used for quantification of unknown polymer samples using fit-analysis.[3]

Figure 1: Example of recycled plastics consisting of locally different polymers.[4]

## Methods

The main technique used in this research is the MADSCAN. A database is built by measuring virgin HDPE, LDPE, LLDPE, PET, PP (see figure 3, 4 and 5) and a combination of these polymers in 10% increments. The plastic granules are mixed and molten down into a slab that can fit into the sample chamber with the help of a sample preparation tool. The current setup has two usable cores. Each sample is heated from 50 °C to 350 °C with a rate of 5 °C/min and cooled down passively for 2 cycles. For each measurement the environmental data, power input and temperature sensor data (64 sensors) is logged. Thermal behaviour of polymers is closely tied to polymer structure and can therefore be used for analysis.

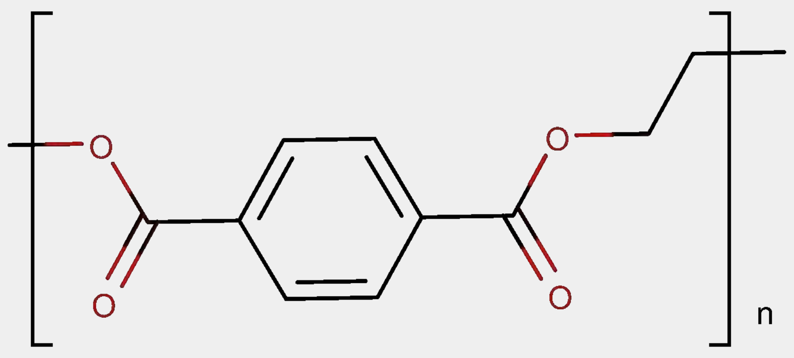

Figure 3: molecular structure of PET

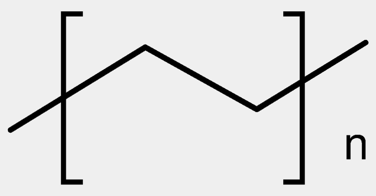

Figure 4: molecular structure of PE

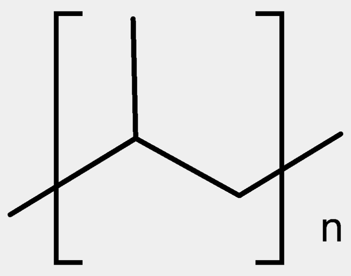

Figure 5: molecular structure of PP

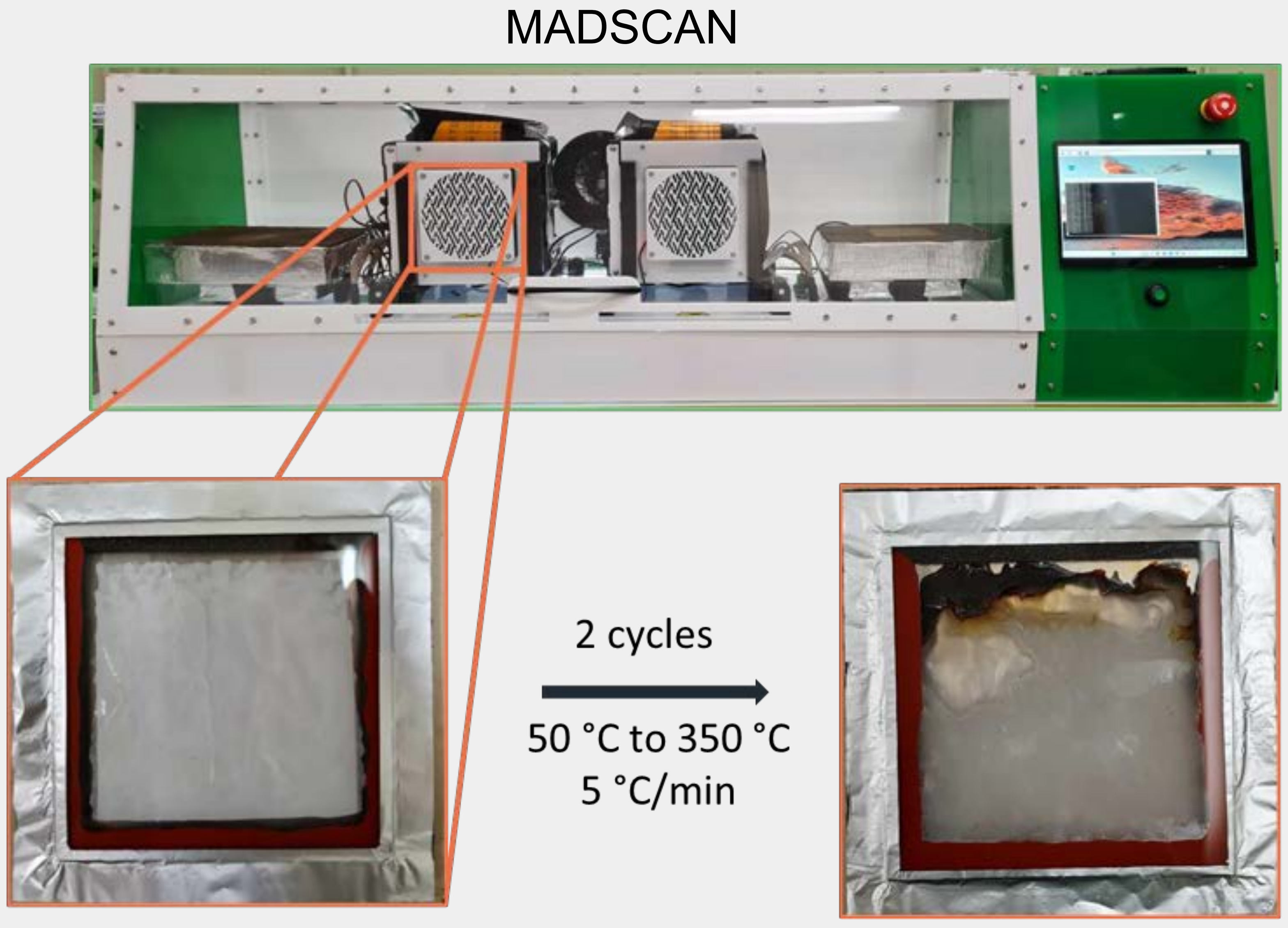


Figure 2: Overview of the MADSCAN machine and examples of the samples before and after measurement.

## Results

In figure 6 the temperature derivative zoomed in on the crystallization points of the database samples with LDPE and LLDPE of a single sensor can be seen. The peaks at ~93 °C corresponds to the amount of LDPE in the sample and the peaks ~105 °C corresponds to the amount of LLDPE in the sample. This data is used to compare the unknown samples to with the use of fit-analysis.

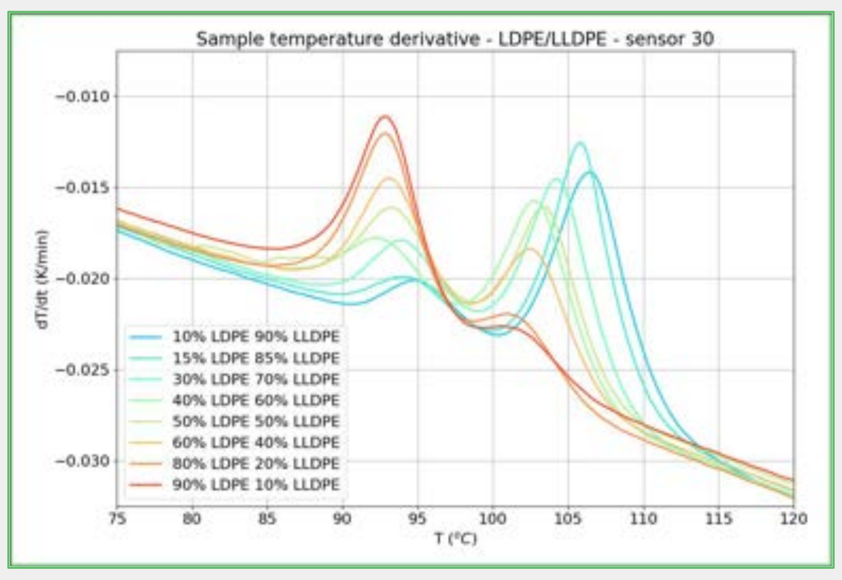


Figure 6: Temperature derivative of LDPE/LLDPE series, zoomed in on the crystallization temperatures.

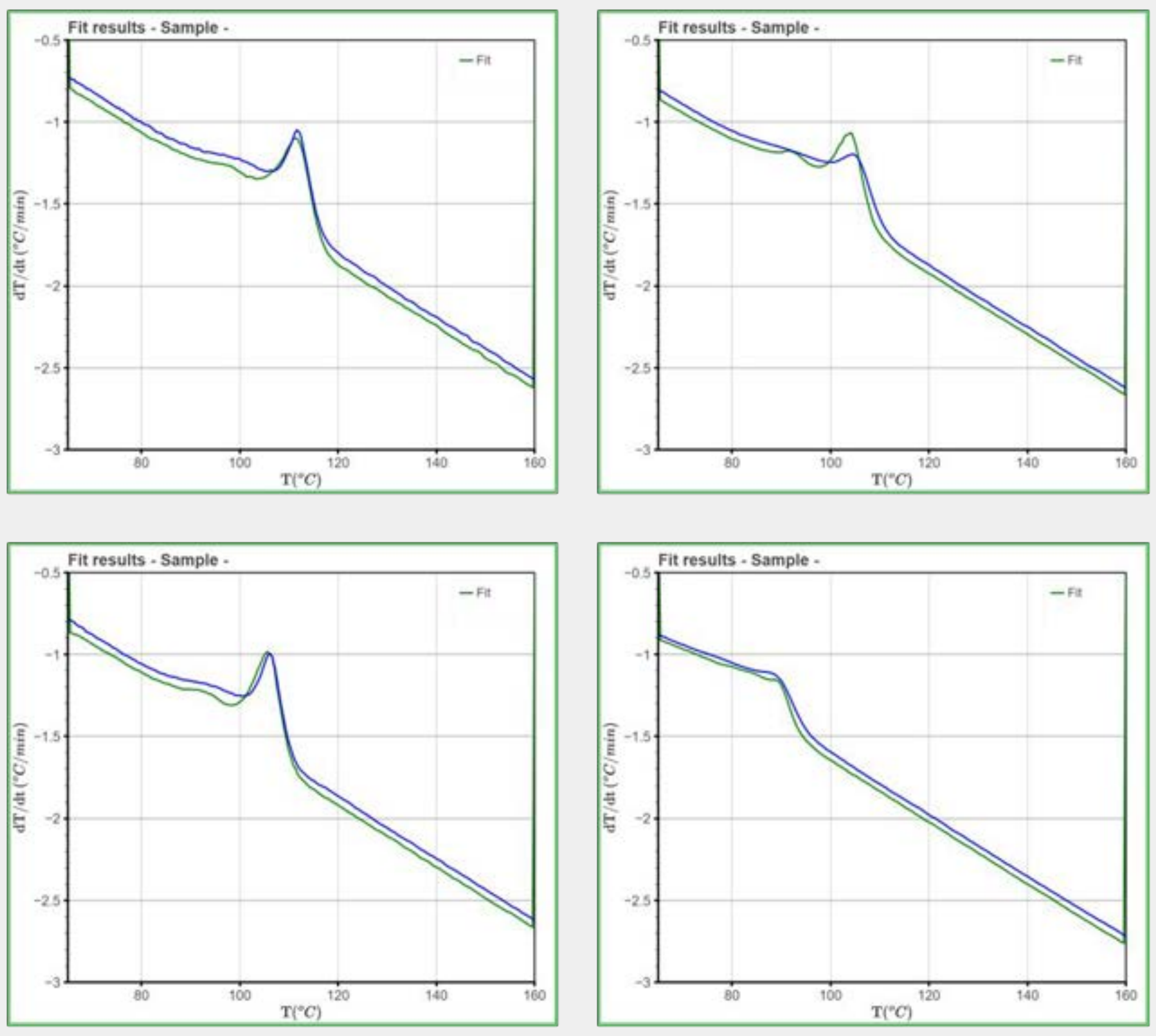


Figure 7: Example of fit-analysis with an unknown sample on four different sensors with the use of the LDPE/LLDPE database samples

Fit-analysis is used to interpolate the unknown sample in the database. In figure 7 four sensors are shown were fit-analysis is applied. The data of the unknown sample (in blue) is compared to each database sample (in green) to see what data shows the most similar behaviour. In Table 1 the results of average sensor data is shown. Using the fit-analysis it is determined that the unknown sample consists of 68% LLDPE and 32% LDPE with a margin error of about 10%. This error will decrease once the database is expanded, and more analysis is done.

Table 1: Results of fit-analysis

| **Type** | LLDPE | LDPE |
|---|---|---|
| **Percentages** | 68 ± 10* wt% | 32 ± 10* wt% |

## Conclusion

The unknown sample was estimated to consist for 68% out of LLDPE and 32% out of LDPE with an error margin of 10%. The project has been successful in laying the foundation of the database but is by no means done. More database samples and more development on the MADSCAN are needed to give a more accurate and precise quantitative analysis on unknown polymer samples.

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