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Electret Stability Related to Spherulites in Polypropylene

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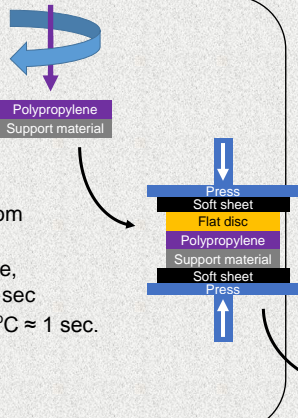
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Motivation

Polypropylene is used as a model system for investigating the discharge mechanisms in polymer electret materials. The goal is to get an understanding of how to enhance the temperature and humidity stability for polypropylene and to be able to transfer this knowledge to other electret polymers. Polypropylene is chosen as a model system due to the limited charge lifetime compared to other much more stable electrets. This makes it possible to see improvements in the performance of polypropylene much faster than other more stable electret polymers.

Sample preparation

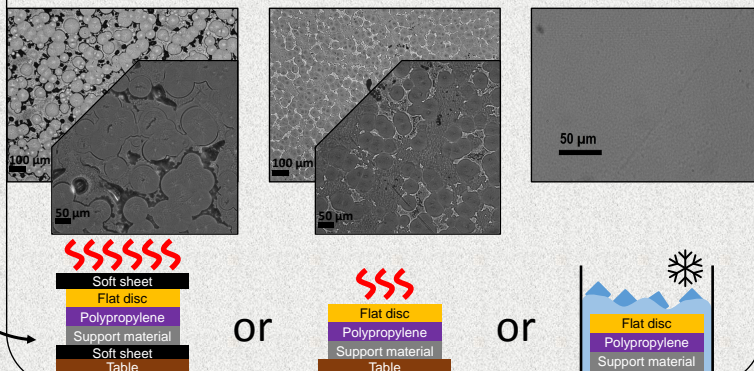
- Spin coated polypropylene layer
- Levelled in a press at 10 bar and 180°C, polypropylene thickness $\approx 30 \mu\text{m}$
- Three cooling treatments:
 - Slow cooling – Cooled from 180°C to room temperature in 5 min.
 - Medium cooling – Placed on marble table, from 180°C to room temperature in ≈ 10 sec
 - Fast cooling – Ice bath, from 180°C to 0°C ≈ 1 sec.
- Corona charged to -500 V
- Isothermal and humidity stability experiments



Spherulites size

Depending on the cooling method, spherulites of different size, concentration and ratio between spherulites and non-spherulites area are formed. This has been confirmed for the samples that has been slowly and medium cooled. It is believed that the spherulites in the samples that has been cooled fast are too small, if any, to be seen in optical microscopy AFM or SEM techniques.

	Slowly cooled	Medium Cooled	Fast Cooled
Concentration	40,000 cm^{-1}	44,500 cm^{-1}	NA
Mean spherulite area	1,800 μm^2	600 μm^2	<1 μm^2
Mean spherulite/non-spherulites ratio	62 %	26 %	NA



Results

Isothermal experiments at 90°C and 120°C along with a humidity experiment at 50°C with 90% relative humidity has been conducted. Each data point is an average from five different measuring points from five different samples, a total of 25 measurements per data point. In general there is a tendency that the faster the samples have been cooled, from its melting state to its solid, the more stable the charges become, both in respect to temperature and humidity. (Fig. 1-3)

Fig. 4 shows the normalised voltage after 25 hr. from the three experiments, seen in Fig. 1 to 3, vs. the spherulites area. The graph in Fig. 4 indicate that there are some charge stability to gain by controlling the size of the spherulites. This could be, as here presented, by thermal methods or it could be by nucleation agents.

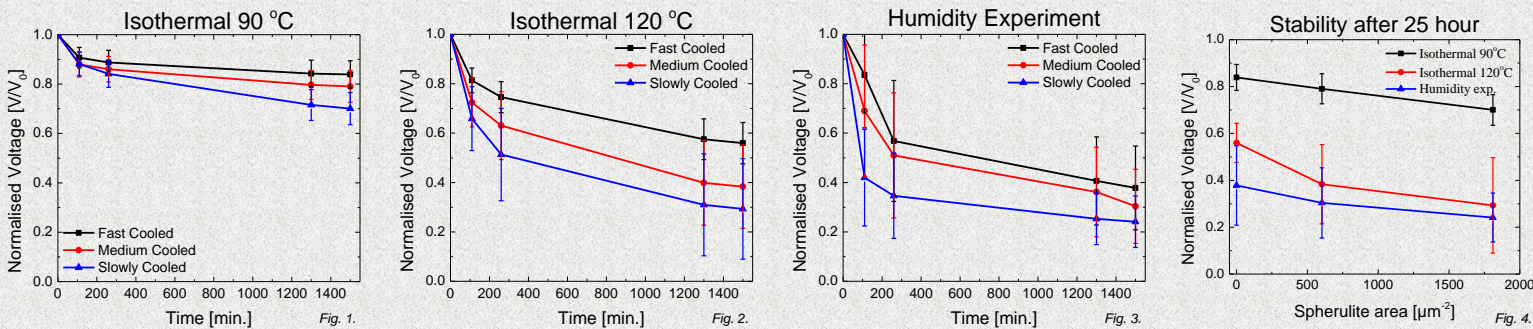
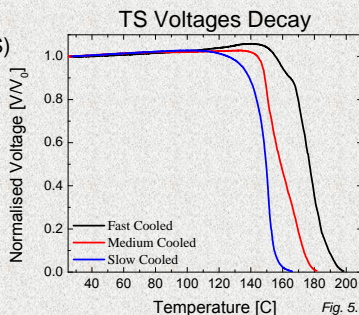


Fig. 5 shows thermal stimulated (TS) voltage decay. As seen the charge release happens at higher temperature for the fast cooled samples then the slowly cooled samples. The effect it thought to be related to the different sizes of the spherulites.



Conclusion

Smaller spherulites give more stable electrets

- Fast cooling enhances charge stability
- Fast cooling push charge release towards higher temperature
- Polypropylene is a promising model system for electret polymers
- Further investigating of how the spherulites, if any, looks in the fast cooled samples are needed.
- Further investigating of how to controls the spherulites size are planned



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