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Electret Stability Related to Spherulites in Polypropylene

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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 = 30 µm
- 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 in ~1 sec.
- Corona charged to ~500 V
- Isothermal and humidity stability experiments

Results
Isothermal experiments at 90°C and 120°C along with a humidity experiment at 50°C with 90% relative humidity have 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 of the size of the spherulites. This could be, as here presented, by thermal methods or it could be by nucleation agents.

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 control the spherulites size are planed

Spherulites size
Depending on the cooling method, spherulites of different size, concentration and ratio between spherulites and non-spherulites area 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.

<table>
<thead>
<tr>
<th>Spherulite Area [µm²]</th>
<th>Slowly Cooled</th>
<th>Medium Cooled</th>
<th>Fast Cooled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean spherulite area</td>
<td>40000 cm⁻¹</td>
<td>44500 cm⁻¹</td>
<td>NA</td>
</tr>
</tbody>
</table>

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 thought to be related to the different sizes of the spherulites.

Fig. 6. Spherulites

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