

APPLICATION SHEET

Thermoplastics – DSC 214 *Polyma*

Fast Cooling Rates for a Lower Degree of Crystallinity of Polymers

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Introduction

PTFE, well-known under its brand-name Teflon® given by the company DuPont, is a semi-crystalline thermoplastic polymer. Its melting temperature is high in comparison to other thermoplastics and its coefficient of friction low compared to any solids. These two properties among others make it of interest in applications such as non-stick coatings for frying pans.

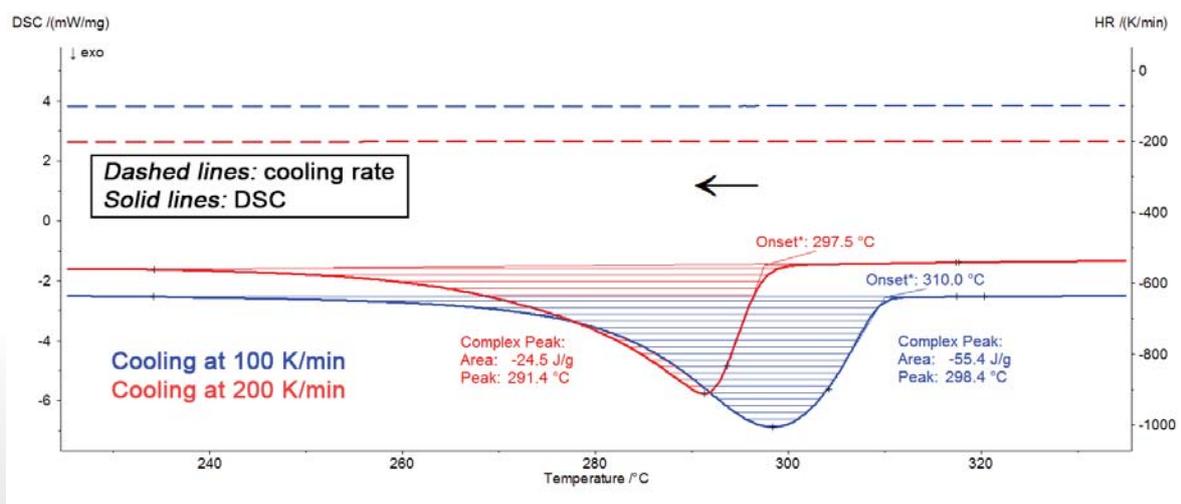
Test Conditions

A 5.08-mg PTFE sample was weighed into a *Concavus* pan. The NETZSCH DSC 214 *Polyma* was used to heat the polymer three times at 100 K/min to above the melting temperature. Between the heating runs, the same sample was cooled at 100 K/min and 200 K/min, respectively. The cooling steps and also the consecutive heating runs were investigated.

Test Results

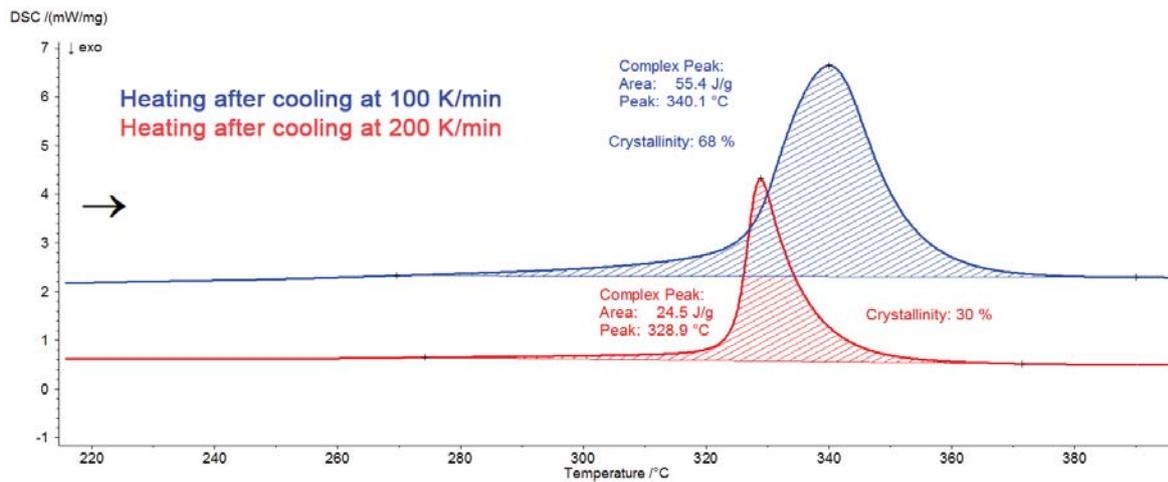
The cooling segments are shown in figure 1. The cooling rates (dashed lines) of 100 K/min and 200 K/min are perfectly linear during the test, so that the crystallization peaks can be evaluated. The crystallization start, defined as the onset of this peak, occurs later (at a lower temperature) with an increased cooling rate. A difference of more than 10°C in the crystallization onset temperatures was detected between the cooling run at 100 K/min and the one at 200 K/min.

The cooling rate influences not only the start of crystallization, but also the crystallization enthalpy given by the peak area. The faster PTFE is cooled, the less time it has to crystallize. This leads to a lower enthalpy (55.4 J/g during cooling at 100 K/min versus 24.5 J/g during cooling at 200 K/min).



1 DSC curve of PTFE during controlled linear cooling at 100 K/min and 200 K/min

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" DSC curves of PTFE during heating at 100 K/min and after cooling at 100 K/min and 200 K/min

The results of the two heating steps at a constant rate of 100 K/min after cooling at 100 and 200 K/min are depicted in figure 2.

Here, similar conclusions can be drawn. The peak area is lower for the heating run which follows the faster cooling run. This can be attributed to the lower crystallinity of the polymer after cooling at 200 K/min in comparison to its state after having cooled at 100 K/min. The degree of crystallinity can be calculated very easily in the NETZSCH

Proteus[®] software. By applying this software, the cooling at 100 K/min is found to result in a crystallinity degree of 68%, whereas the same sample is only 30% crystalline after cooling at 200 K/min.

Furthermore, the lower the cooling rate of the preceding segment, the higher the temperature of the melting peak, because the crystallites formed during cooling are bigger in this case.