

# Secondary Transition in Polymers

**Keywords:** DMA, Temperature Sweep, Viscoelastic Properties, Secondary Transition, Polymers

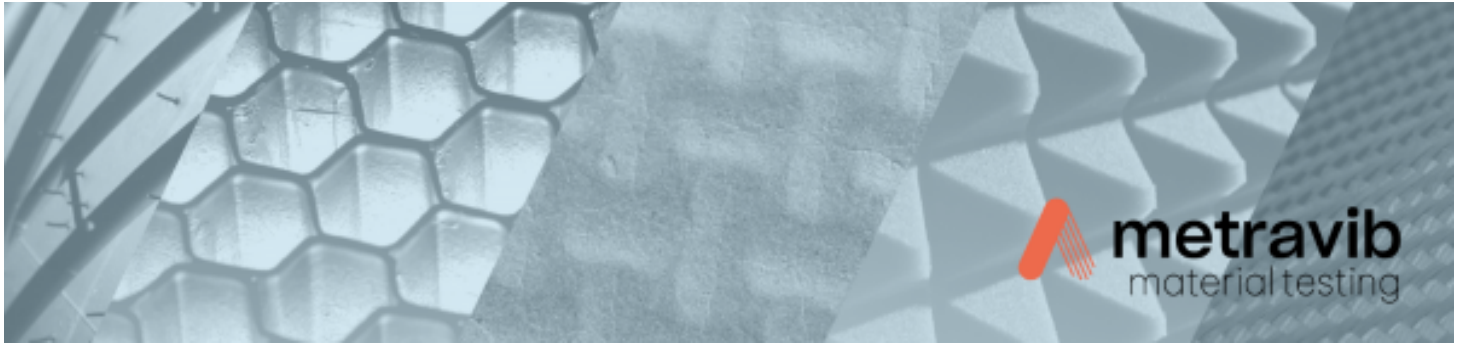


Figure 1. Metravib DMA+300

## Introduction

Dynamic Mechanical Analysis (DMA) is one of the most efficiently interesting and powerful characterisation techniques for glass transition temperature. The glass transition temperature is often accompanied by secondary transitions, often denoted as  $\alpha$ ,  $\beta$  and  $\gamma$  transitions, in crystalline polymers. These secondary transitions are often linked to the mechanical properties [1]. In other words, these secondary transitions have an effect on the mechanical properties of the polymers, i.e., impact strength and other end-use properties. From an applicative aspect, these transitions can be studied by DMA in order to optimize the vibration damping effect or the impact resistance of polymer-based materials. This study of identification of secondary transitions on POM (Polyoxymethylene) was performed with the help of METRAVIB's DMA+300 series.





## Materials & methods

The material used for this study was POM. POM is characterized by its high strength, hardness and rigidity, commonly used in industrial applications, such as mechanical gears, insulators, valve bodies etc. The dimensions (h x b x t mm) of the specimen used for this study were 16 x 4.1 x 1.6 mm, respectively. The specimens were studied in tension mode Figure (2). The dynamic displacement of  $1e-5$  m was applied on the specimen at 5Hz.

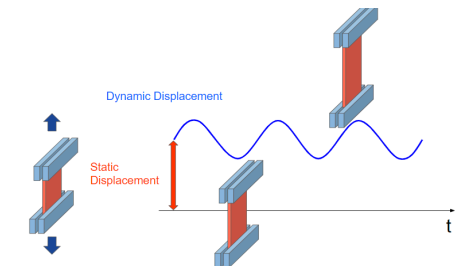


Figure 2. Schematic diagram of Tension test mode

Dynamic Displacement (m)	1e-5
Frequency (Hz)	5
Temperature (°C)	-70 to 160
Rate (°C/min)	2
DMA	DMA+300
Test Mode	Tension

Table 1. Test parameters

Since, the goal of this study was to identify the primary and secondary transitions, a temperature sweep ( $-70^{\circ}\text{C}$  to  $160^{\circ}\text{C}$ ) was performed at 5 Hz. The cold source used to go to  $-70^{\circ}\text{C}$  was Metravib’s Air Chiller System (Liquid nitrogen free). The parameters used for the test are mentioned in Table 1.

## Results

Figure 3 shows the results obtained for the temperature sweep at 5 Hz to identify the primary and secondary transitions. The results are presented in terms of storage modulus ( $E'$ ) and loss factor ( $\tan \delta$ ) as a function of temperature. The decrease of  $E'$  indicates the molecular dynamic rearrangements of elastomer chains between the glassy state (localized molecular movement) and the rubber-like state (high amplitude movement).

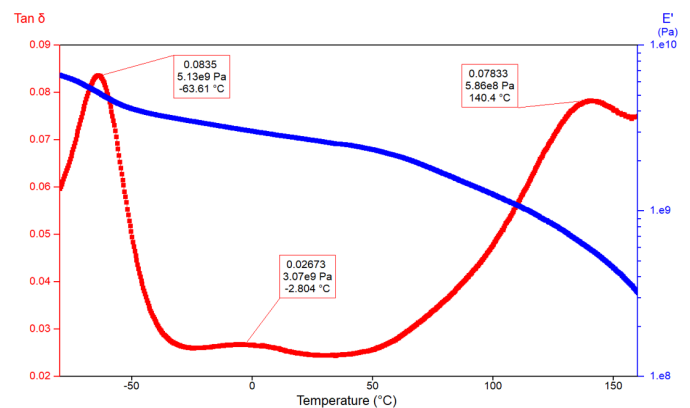


Figure 3.  $E'$  and  $\tan \delta$  as a function of temperature at 5 Hz.





Whereas, the primary transition was accompanied by the secondary transitions. These secondary transitions in polymers are complex, having an amorphous and crystalline contribution. At lower temperatures, crystalline mechanisms occur and have lower activation energy, whereas, at higher temperatures, an amorphous mechanism takes place [2].

The secondary transitions occurring are often assigned to lattice vibrations or motions of side chains or side groups. Along with lattice vibrations, secondary relaxations are sometimes assigned to local-mode relaxations too, involving short segments of polymer chains (between 2 and 5 carbon atoms in length) [3].

## Conclusions

This study shows the ability of Metravib's DMA+300 along with Metravib's Air Chiller to identify the secondary transitions in polymers. The temperature sweep performed from  $-70^{\circ}\text{C}$  to  $160^{\circ}\text{C}$  at 5 Hz has allowed us to identify the primary transition accompanied by the secondary transitions in the polymers.

## References

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