Dynamic Mechanical Analysis with the DMA SDTA861

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Dynamic Mechanical Analysis (DMA) is used to determine the mechanical properties of viscoelastic materials by subjecting them to cyclic loading as a function of temperature, time and frequency.

The SDTA861 is characterised by a wide frequency range of 0.001 Hz to 1000 Hz, a temperature range of -150 °C to 500 °C and a force range of 0.01 to 12 N.

Different loads are possible. The mode chosen depends not only on the problem but also on the type of sample:

Shear: The advantage of this measurement mode is that samples can be measured from viscous to very hard. It is suitable for elastomers, thermoplastics and thermosets.

Tension: This type of loading is suitable for films, fibres and thin rods.

Compression: This type of measurement allows conclusions to be drawn about soft materials such as elastomers.

3-point bending: This mode is particularly suitable for very rigid samples such as composites, even below the glass transition temperature.

Single cantilever bending: This geometry is suitable for samples that expand or contract during measurement, such as thermoplastics.

Dual cantilever bending: This mode is particularly suitable for samples that tend to flex excessively under high pre-stress.

Applications

The DMA can be used for a wide range of applications in virtually all sectors of industry.

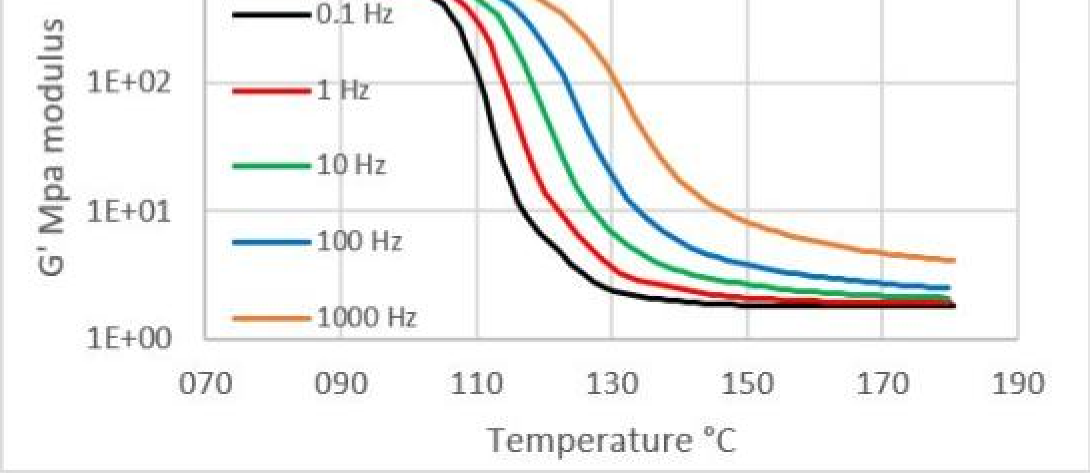
The table below shows that the DMA is mainly used for measuring glass transition temperature, rocess optimisation

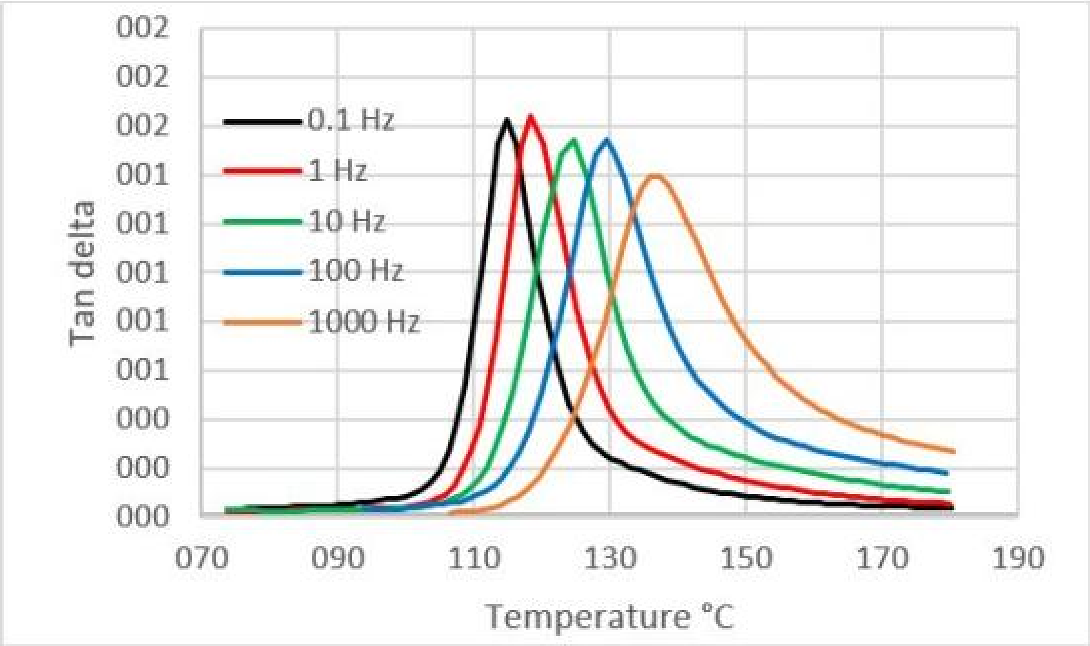
Industry	DMA application
Automotive and aerospace (composites)	Cross-linking, glass transition, modulus, damping
Chemicals	Glass transition, crystallisation, melting, modulus
Greases and oils	Glass transition, crystallisation, modulus
Paints and varnishes	Curing reaction
Rubbers (elastomers)	Vulcanisation, glass transition, melting, mechanical properties, effect of fillers, viscoelastic behaviour
Plastics (thermosets, prepregs, film coatings, adhesives, thermoplastics, packaging and cables)	Curing reactions, cross-linking, cold crystallisation, glass transition, secondary relaxations, viscoelastic behaviour, material defects, effects of loading
Ceramics	Physical nature of transitions, modulus
Food products	Glass transition, gelation
Pharmaceuticals	Glass transition

Examples illustrating the various application areas of the DMA SDTA861

Modulus and delta tangent measurement of an epoxy resin cured at different frequencies

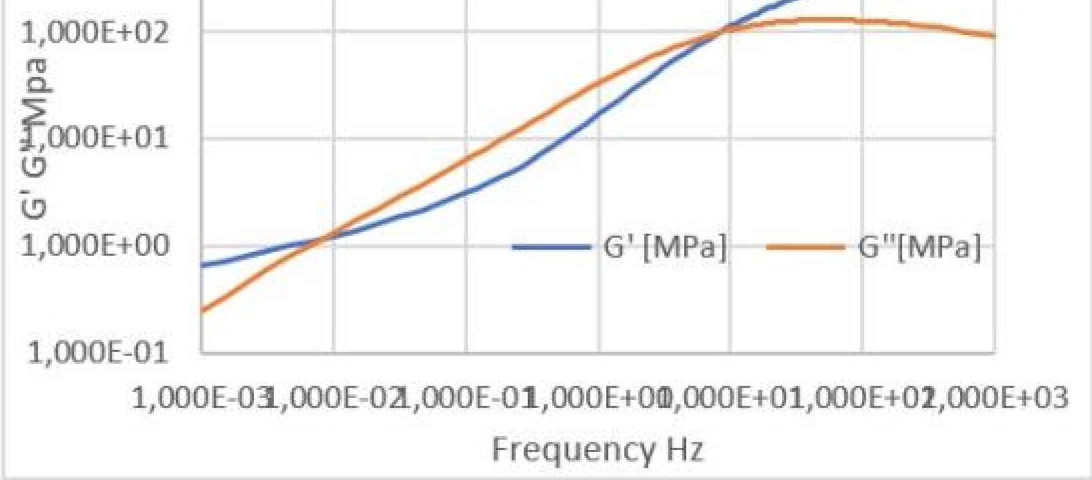
The modulus and glass transition temperature of an epoxy resin or composite material can be measured as a function of temperature by the DMA. The delta tangent moves to higher temperatures as the frequency increases. The decrease in modulus during the glass transition is accompanied by a peak in the delta tangent.

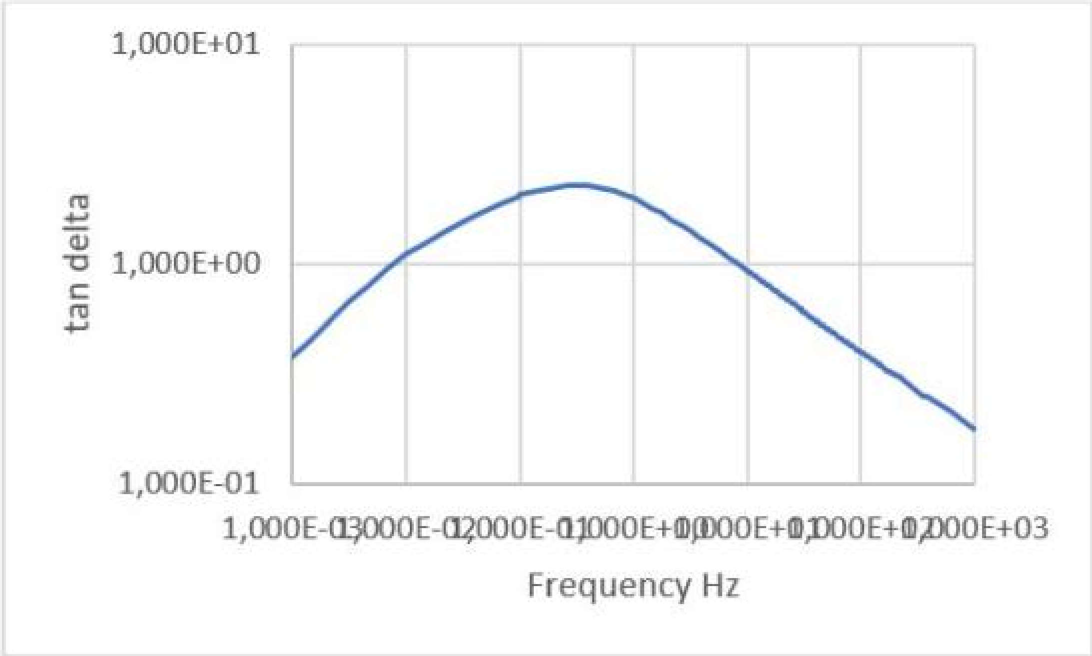




Frequency scan of an elastomer

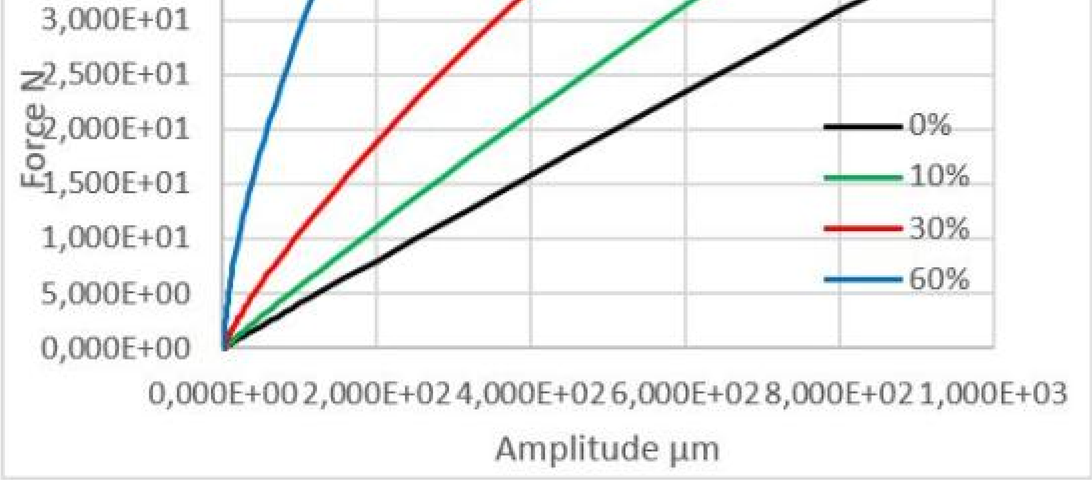
In practice, materials are loaded over a wide frequency range, with the properties changing with frequency. In this case, the modulus increases and the loss factor reaches a maximum of 0.32 Hz.

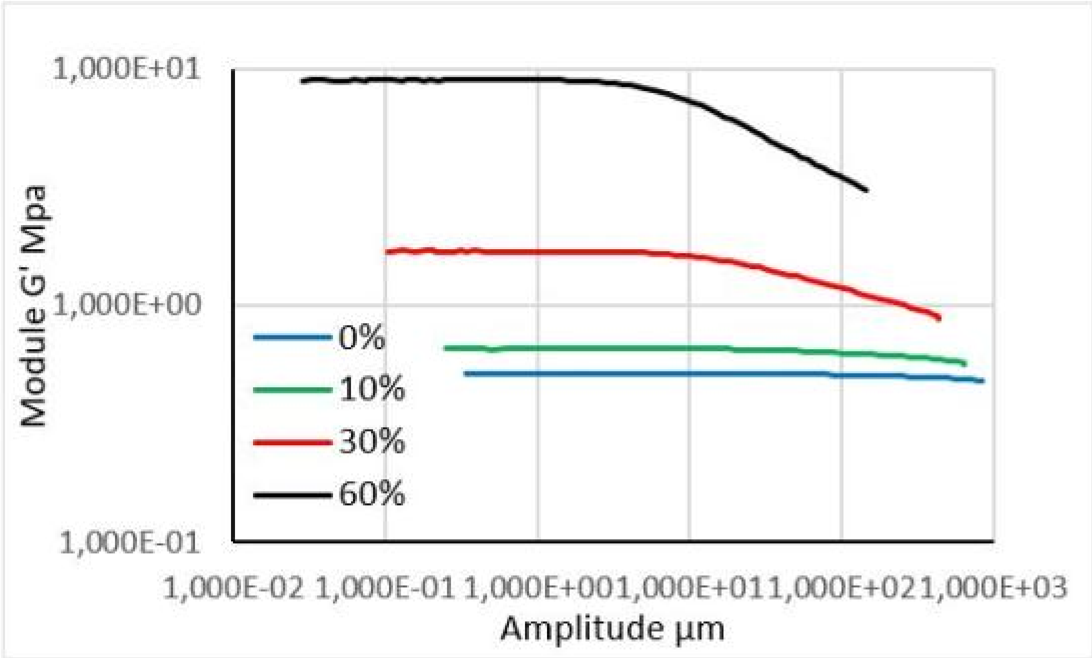




Displacement amplitude scan of a rubber

The modulus of filled polymers increases with the loading rate but decreases with increasing strain amplitude.



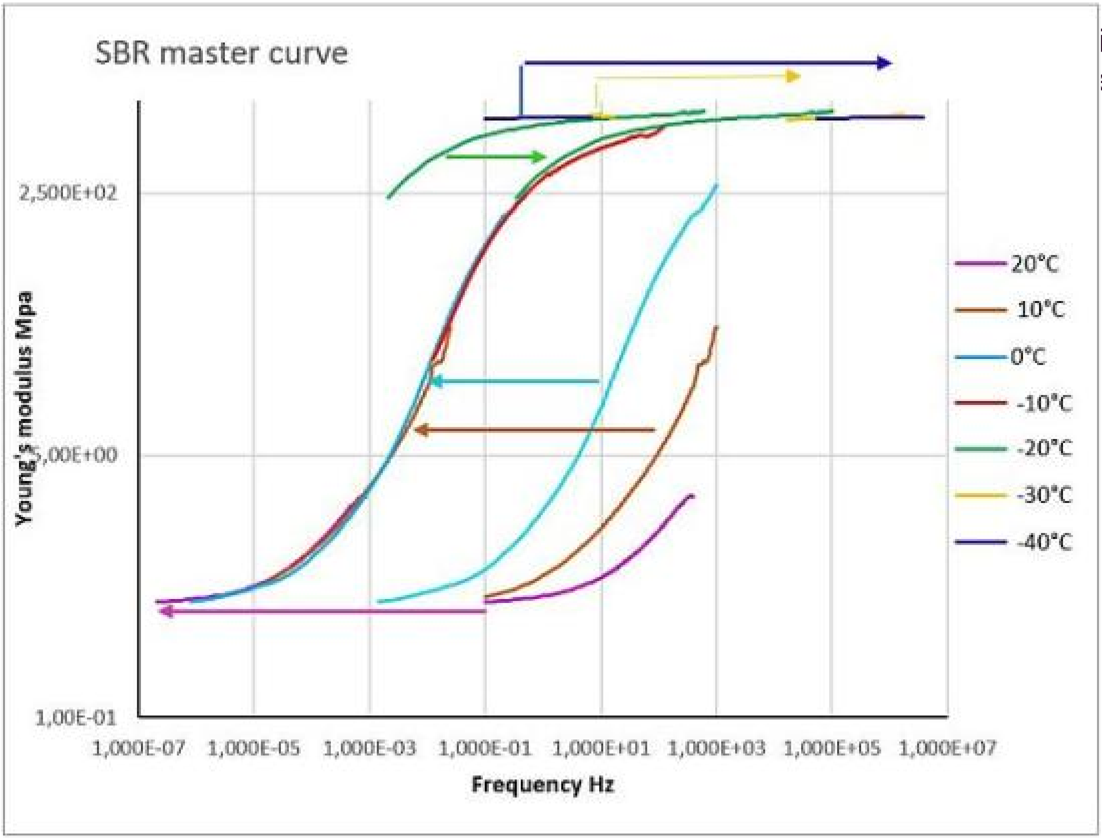


Master curve technique

Measuring the viscoelastic properties of materials at high frequencies is necessary in many industrial applications such as tyre performance and safety prediction, noise and vibration reduction in mechanical engineering, acoustic design of vehicles and industrial processing machines.

Viscoelastic behaviour is frequency and temperature dependent. There is an equivalence between frequency and temperature related behaviour during transition processes. This equivalence is called TTS (Time-Temperature Superposition) and forms the theoretical basis for the master curve technique which allows the prediction of polymer behaviour outside the range accessible during a test. This is because:

- High frequencies are equivalent to low temperatures. The sample is in a glassy state and therefore has a high modulus.
- Low frequencies are equivalent to high temperatures. The sample is in a rubbery state and therefore has a low modulus.



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More information on the Mettler Toledo DMA SDTA861 in our Sirris Test Labs.

The DMA SDTA861 is one of the 4 pieces of equipment in our new thermal analysis chain. This chain also includes a Flash DSC 2+, a TMA SDTA2+ and a DSC.

Time-Temperature Superposition using DMA , Webinar Mettler Toledo 2017

Thermal analysis excellence – Brochure DMA/SDTA861 , Mettler Toledo

Analyse mécanique dynamique , Webinaire Mettler Toledo 2012

Master Curve Construction – Exploiting the TTS Principle , Mettler Toledo Thermal analysis , June, 27 2018

Authors