GCM Lab

GCM Lab **NEWSLETTER**

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ÉCOLE POLYTECHNIQUE MONTRÉAL

Université de Montréal

Hi,

I have the pleasure to inform you that since March 7, Mr. Nicolas Geoffroy has been the new business development manager for the GCM. I would also like to thank Ms Jacqueline Sanchez that fulfilled this position by interim after the departure of Mr. Jean-Sébastien Tassé.

Specialized in materials engineering, M. Geoffroy has acquired a vast experience in the metallurgy, chemistry and corrosion fields. He also developed in-depth knowledge of several analysis techniques used to obtain mechanical and chemical information on materials.

Whether you are interested in a physical or chemical analysis, a thin film deposit, an expert advice or the elaboration of a partnership agreement, M. Geoffroy will be glad to help you identify the resources needed and to coordinate you unique or complex project. Do not hesitate to contact him!

Sincerely,
Olivier Grenier, Central Facilities Director of the GCM

GCM Lab

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TEN QUESTIONS YOU HAVE ALWAYS BEEN AFRAID TO ASK ABOUT DIFFERENTIAL SCANNING CALORIMETRY (DSC)!

In collaboration with Sylvain Essiembre, research associate at the center for characterization and molecular synthesis of the University of Montreal

1. What is differential scanning calorimetry used for?

Differential scanning calorimetry (DSC) helps study the **thermal transitions** in a material to determine properties like the glass transition temperature (Tg), the crystallization temperature (Tc) or the melting point. This technique is often used on organic substances (plastics, drugs, adhesives, food products) but can also be very useful for inorganic metals (alloys, liquid crystals, etc…)

2. How is DSC used in the industry?

DSC is very popular for **quality control** applications since a precise measurement of the **thermal transitions** is an excellent way to determine product purity. Indeed, since thermal transitions are product specific, they vary according to chemical composition. Furthermore, DSC measurements can help identify unknown products, especially if the list of potential candidates is limited.

3. What is DSC used for in the polymer field?

On top of being useful to check the purity of a polymer, DSC can also check its degree of crystallinity. This property is very important since it directly affects several physical properties such as permeability, density and melting point. Furthermore, DSC can give information on the **degradation of a polymer**, generally shown by a lower melting point.

4. Can you give some examples of DSC applications in the pharmaceutical industry?

Pharmaceutical companies use DSC on a regular basis to study new molecules and antibodies, to develop new processes, to check the stability of proteins, etc… For example, for the commercialisation of a new amorphous drug, it is best to conduct the entire manufacturing process under the recrystallization temperature, which can be measured with DSC.

5. How can DSC be used for inorganic materials?

Although not as well-known in this field, DSC can be very useful to study alloys, liquid crystals and inorganic chemical compounds. For example, DSC can be used to analyse the formation of intermetallics in alloys or characterise mechanical transitions in shape memory metals. Obviously, DSC can also e used to characterize inorganic compounds such as sulphates, carbonates, chlorides, etc…

6. What are the advantages of DSC compared to other techniques?

DSC analysis are comparatively fast, inexpensive and do not require large volumes of samples. Also, since this technique has been around for half a century, a lot of literature is available to design tests and interpret the results. Thus DSC is perfect for routine tests or to rapidly diagnose industrial problems.

7. How does DSC work?

The basic principle behind DSC is quite simple: it is based on the measurement of the amount of energy required to heat a sample as function of temperature compared to a reference. This relationship is generally described as **enthalpy** (or heat flux) as a function of temperature. The instrument thus adjusts the amount of heat transmitted to the sample to maintain a temperature similar to that of the reference. A DSC analysis is generally done under inert atmosphere (nitrogen or argon) to avoid oxidation of the samples.

8. What do DSC results look like?

DSC results are generally presented as a graph showing the **heat flux versus temperature** (or time), as shown on ***Figure 1***. As the structure of the sample is changing during the heating process, so is the amount of heat required to maintain its temperature equal to that of the reference. Based on this, two types of phases changes can be distinguished: exothermic (where the sample liberates heat) and endothermic (where the sample absorbs heat) processes. For example, during an exothermic process such as crystallization, less heat is needed to increase the temperature of the sample since the material is generating heat on its own. However, during an endothermic phase change such as melting, more heat will be needed to keep the sample as the same temperature as the sample since it will also absorb energy.

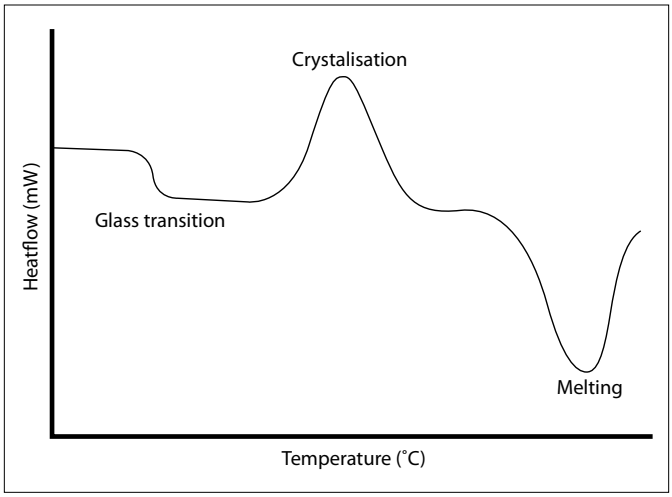

Figure 1 : Typical characteristics of a DSC curve.

Based on the above, it is easy to understand why an exothermic process such as crystallization is associated with a "hump" in a DSC curve (Figure 1), while an endothermic process is present as a "dip". Also, it is important to note that not all materials will experience phase changes as shown on Figure 1.

9. How can I determine the glass transition temperature (Tg) of my material since it takes place in a 10 degree range?

It is fairly common for glass transitions to occur in an interval of several degrees. Depending on the industry and the material, several methods can be used to precisely evaluate Tg such as linear regression or dilatometry. For most materials, it is important to double check commonly used method for correctness. A DSC specialist can thus be of precious help to suggest the best technique.

10. What are the typical operating parameters of a DSC analysis.

- Results : heat flux vs temperature
- Temperature range: -180°C to 500°C
- Heating range: 10°C / min to 20°C / min
- Mass of samples: 2 à 3 mg or more
- Cooling rate: de 10°C / min à 80°C / min

The GCM, in collaboration with the center for characterization and molecular synthesis of the University of Montreal, has five DSC instruments at its disposal and is able to perform a wide range of characterization procedures.