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Study the Thermal Properties of some Plastic Materials by TMA Q400 Machine

H.S. Bui
Université de Technologie, Ha noi, Viet Nam

Abstract:- Plastic materials are more and more important in our life. This article measure the thermal properties of some typical plastics materials by using the TMA Q400 machine. By comparison of their results and their chemical formulas will show their properties.

Keywords:- *TMA Q400, Non-Metallic Materials, Thermal Properties, The Glass Transition Temperature* T_g.

I. INTRODUCTION

The plastics industry is a new material industry capable of producing a wide range of products used in the life and replacing traditional materials such as iron, steel, glass, wood, crockery. , porcelain .... Because of the superiority of lightweight, beautiful form, physiological equivalence material, low price. So, plastic products have step by step penetrated into all areas of economy and life.

We try using the machine TMA Q400 of TA Instruments company to measure some thermal properties and plot the graph to show the relations between them and some conclusions for some selected plastic materials, so that we can find out some general features;

II. DESCRIPTION OF EXPERIMENTAL TESTS

The Thermomechanical Analysis (TMA Q400) have the general view is in the figure.1.

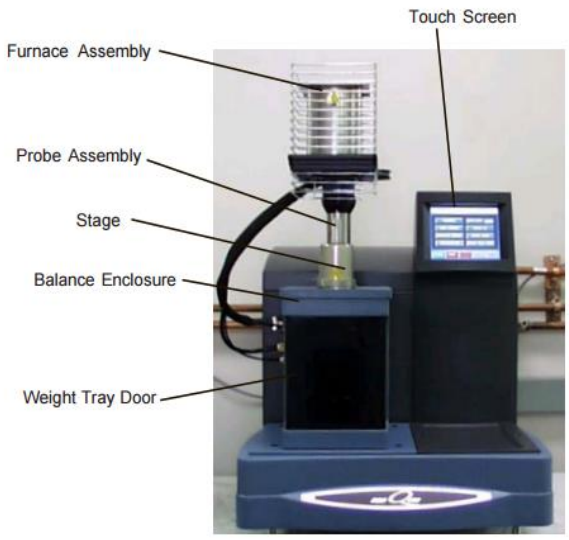

Fig 1:- The General View of TMA Q400

The Thermo-mechanical Analyzer (TMA) is an analytical instrument used to test the physical properties of many different materials. The TMA instrument works in conjunction with a controller and associated software to make up a thermal analysis system.

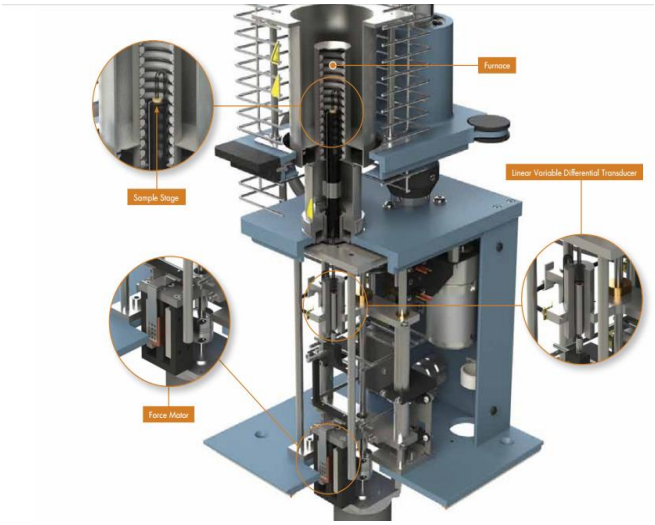

Fig 2:- The parts Inside the TMA Q400

All of your TMA experiments will have the following general outline. The majority of these steps are performed using the instrument control software.

- Calibrating the instrument
- Selecting, calibrating, and zeroing the probe
- Selecting the desired mode (standard or calibration) through the TA instrument control software
- Preparing and loading the sample
- Adjusting the thermocouple position and closing the furnace
- Creating or choosing the test procedure and entering sample and instrument information through the TA instrument control software
- Setting the purge gas flow rate
- Adding coolant to the furnace reservoir for subambient operation, if applicable
- Starting the experiment.

For each experiment, we have to prepare carefully:

A. Installing the stage on the TMA, check to make sure the furnace is raised and off to the side. Then follow these steps (refer to the figure here for illustration of the parts):

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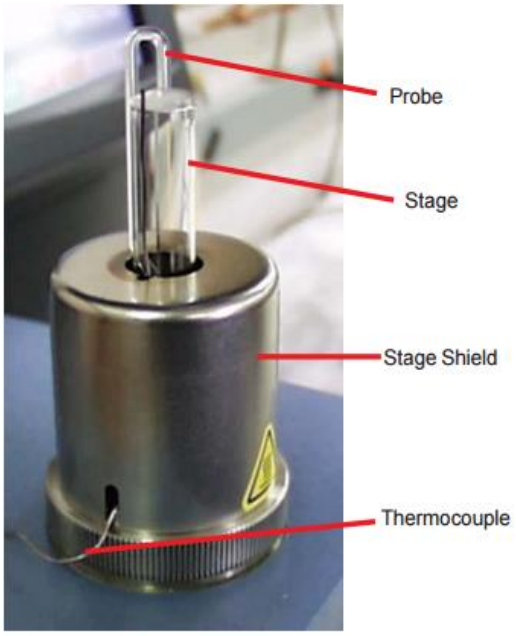

Fig 3:- Installing the Stage

B. Sample preparation and sample size are very important to achieving good results. Sample's dimensions: Height: 25mm, Diameter: 10mm. For film and fiber, the thickness of the sample is: 0.5 mm.

C. Cleaning: Dirt or sample residue left on the top of the stage may interfere with the next sample placed on the stage. To maintain proper experimental conditions, clean the stage carefully.

III. RESULTS AND DISCUSSIONS

All the materials have its different thermal properties. In fact, it will be demonstrated experimentally in a wide range of experiments as follows:

A. PPR Plastic

PPR is Polypropylene Type 3 (Type 3 polypropylene is a natural copolymer of propylene abbreviated as PPR.).

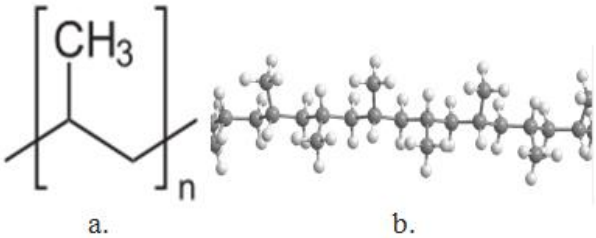

Fig 4:- Chemical Formula and Molecular Structure Simulation of PPR

The chemical formula is (C3H6)n as the figure 3a and the molecular structure simulation as the figure 4b.

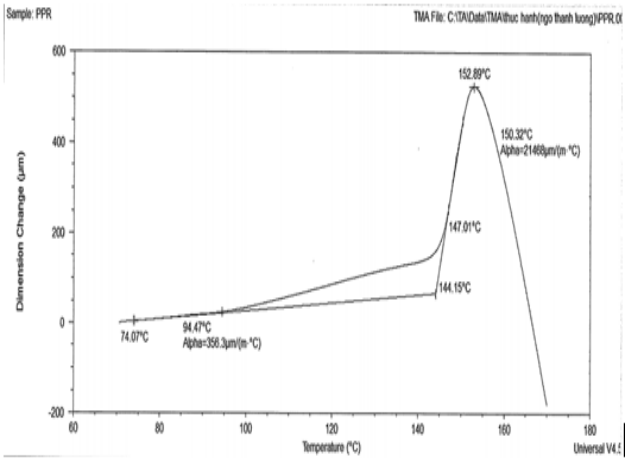

Fig 5:- Evaluation of the dimension with temperature of PPR

Original sample size is the height 2 mm. After measurement of its glass transition temperature and melting temperature, we have to fix the applicable force, and increase the temperature from 60 ºC to 170ºC at the rate of 5ºC / min, we obtain the result as shown above.

The horizontal axis is the axis of the temperature (ºC), the vertical axis is the axis of change in the size of the sample (µm). The graph expresses the relationship between size and temperature.

From the graph, we obtain the glass transition temperature (Tg) of PPR is 144,15ºC and the melting temperature is 152,89ºC.

B. Polyvinyl chloride

Polyvinyl chloride (C2H3Cl)n (abbreviated and commonly called PVC) is a thermoplastic made of vinyl chloride. Polyvinyl chloride is widely used in the construction, industry that the PVC is used by adding some plasticizers.

The chemical formula is (C2H3Cl)n as the figure 6a and the molecular structure simulation as the figure 6b.

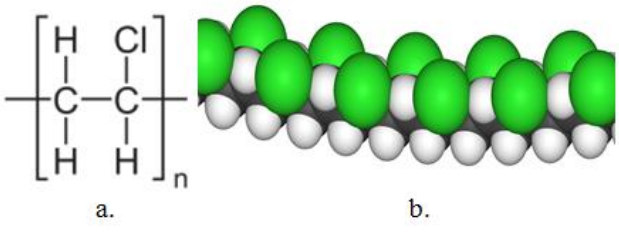

Fig 6:- chemical formula and molecular structure simulation of PVC

We use the same initial sample size 2mm such as PVC to do the experimental.

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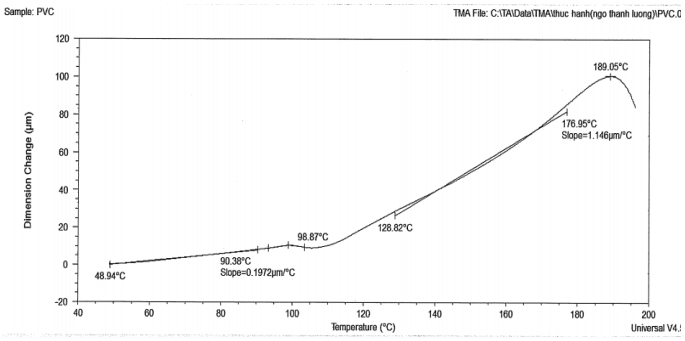

Fig 7:- Evaluation of the dimension with temperature of PVC

Measurement of glass transition temperature and melting temperature at the rate of 5ºC / min, from 45ºC to 200ºC., the results are as figure 7:

After the analysis of the experimental results, we obtained:

- The glass transition temperature Tg of PVC is 98.87ºC
- The melt temperature of PVC is 189.05 ºC.

C. Mica

Mica is a generic term for plate material. That is the one of minerals of the silicate. The chemical formula is AB2–3(X, Si)4O10(O, F, OH)2 (repeating unit).

For mica samples, we will measure the glass transition temperature, the melting temperature and the thermal expansion coefficient of the material. The initial sample size is near 2 mm. Then we raise the temperature from 40ºC to 180ºC at the rate of 5ºC / min and we follow the change in the size of the gain:

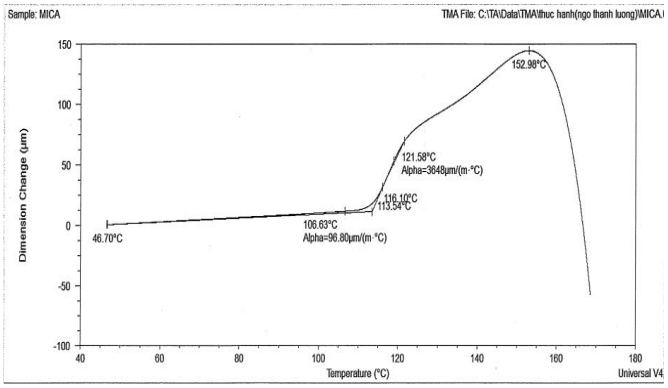

Fig 8:- Evaluation of the dimension with temperature of Mica

After analyzing the graph we obtain the result:

- The melt temperature of Mica is 152,98ºC.
- The glass transition temperature Tg of Mica is 113.54ºC.
- The lower heat transfer coefficient of Tg of Mica is 96.80 µm / (m. ºC).
- The high thermal expansion coefficient of Tg of Mica is 3648 µm / (m.ºC).

IV. CONCLUSION

The results of the experiments for almost type of typical plastics materials give some conclusions as follows:

- The thermal characteristics of plastics confirmed the easy ability to mold.
- The different metals have different thermal mechanics but the melt temperatures, the glass transition temperature of the similar characteristic material are almost the same.
- On the thermal aspect: We point out exactly the melt temperature, the glass transition temperature Tg, the lower heat transfer coefficient and the high thermal expansion coefficient. So that, we can use this parameters to serve research and exchange the results with
- On the mechanical aspect: The results will help us having the exact informations and coefficient for mechanical manufacture and getting the perfect products.

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