A Low-cost, Student-built Differential Thermal Analysis (DTA) Apparatus for Measuring Glass Transition

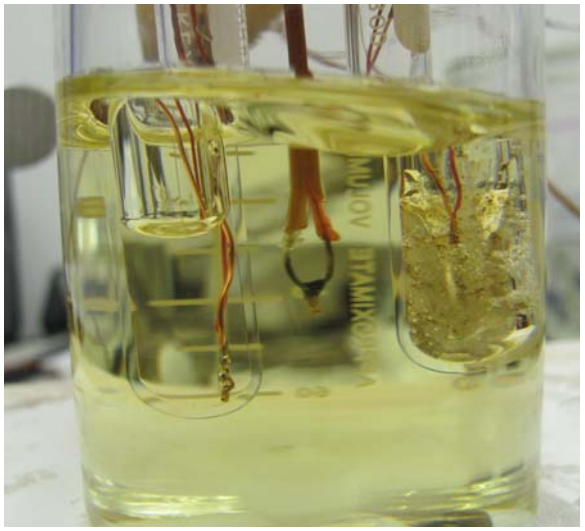
William R. Heffner,

Int. Materials Inst. for New Functionality In Glass
Lehigh University, Bethlehem, PA

wrh304@lehigh.edu

Tyler Schott & Adam Kohn

Lehigh University, Bethlehem, PA



A student outreach activity of IMI-NFG

http://www.lehigh.edu/imi/

AAPT Winter 2011 Meeting 10 min (1/12/11)

Background and Overview:

Part of a much larger collection of low-cost, hands-on experiments designed to engage students in glass and material science.
From making the candy glass to measuring properties like density, refractive index, crystallization dynamics and thermal analysis.
Full collection available on our website (see below).

Topic of today's talk:

Home-built DTA (Differential Thermal Analysis) Apparatus
for quantitative exploration of thermal transitions
in crystalline and glassy materials.

Common Materials with Low Temperature Transitions

Stearic Acid - as a crystal melt "standard" (T_{melt} ~ 70 C)
Sugar Glass - for "glass transition" (T_g)
- our favorite glass that students can make themselves
Polyethylene Terephthalate (PET)
- common plastic material with both T_g and $T_{crystallization}$

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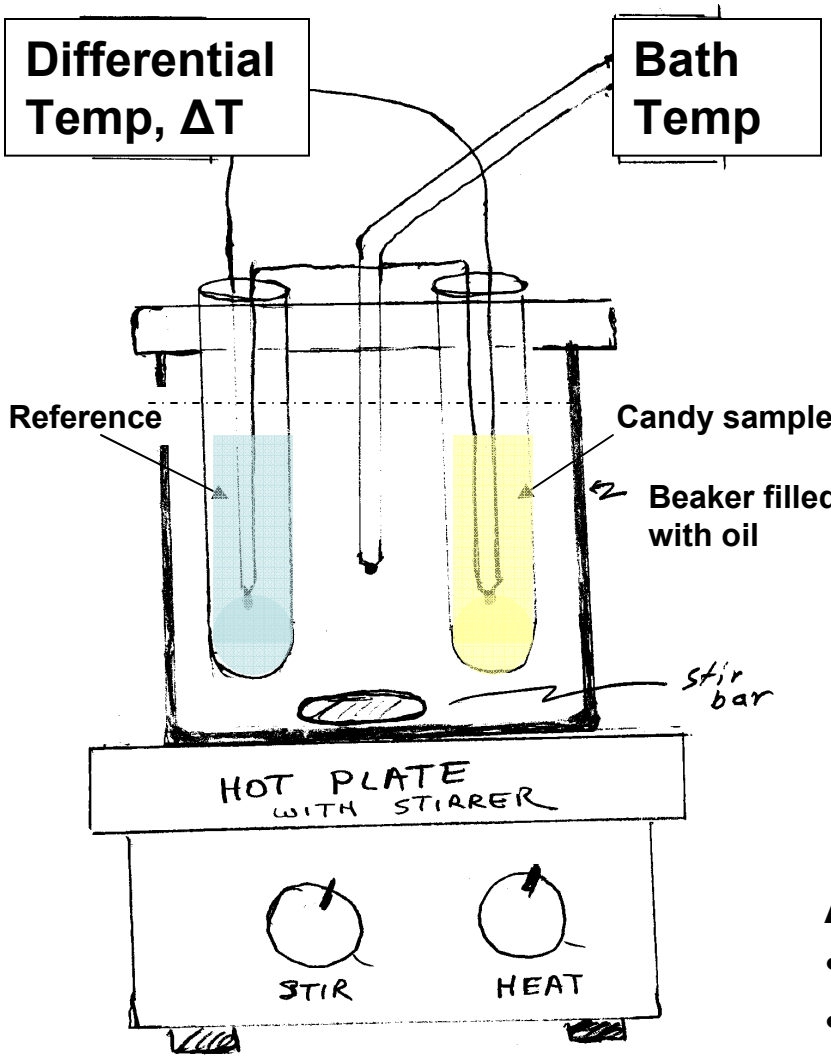
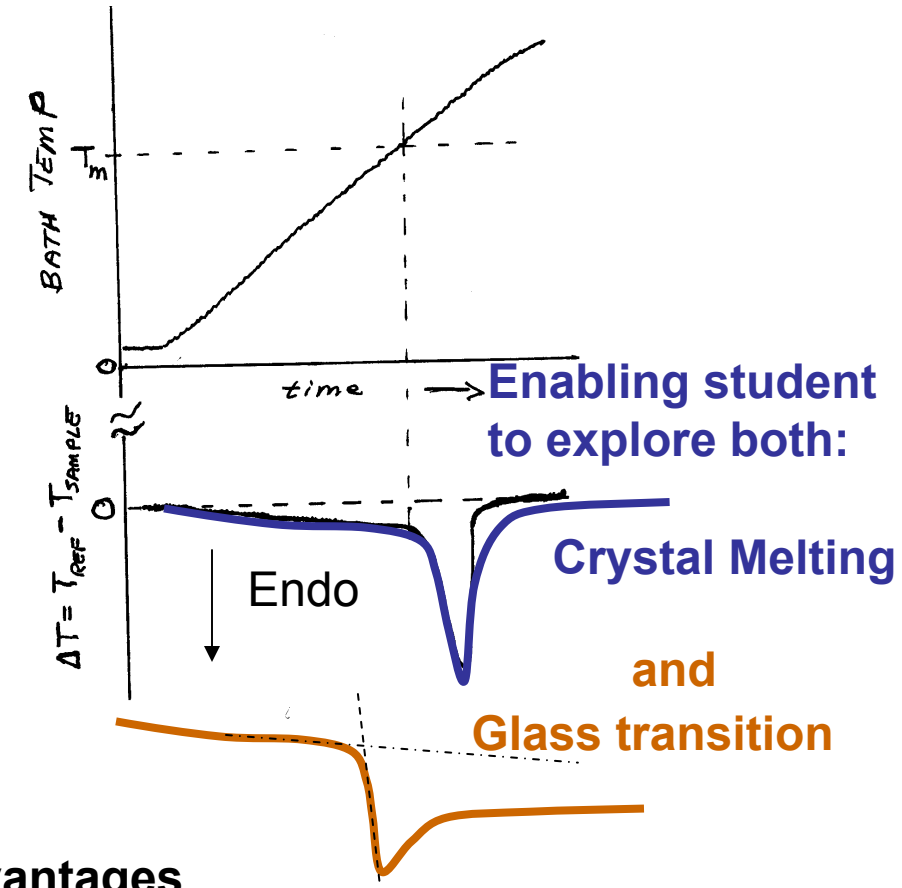
Overview of the Home-built DTA

Getting a handle on Glass Transition





Advantages

- **Low Cost**
- **Student Assembled**
- **Can see (and poke) what's happening**

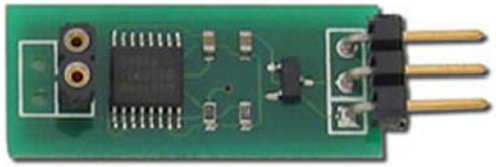
DIY Data Collected Using Basic Stamp Microcontroller

MoBo mother board ($70)

Power Daughterboard ($15)

The **Basic Stamp** is a microcontroller platform from Parallax Inc. popular among educators for its ease of use, capability, strong support and focus on education.

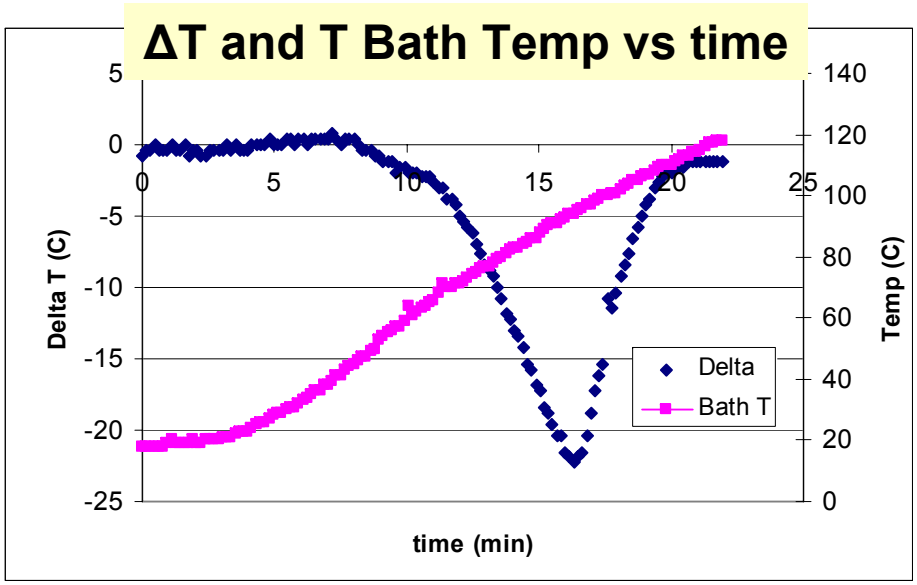
Poster presented at AAPT
Details and DTA software code available on IMI website,



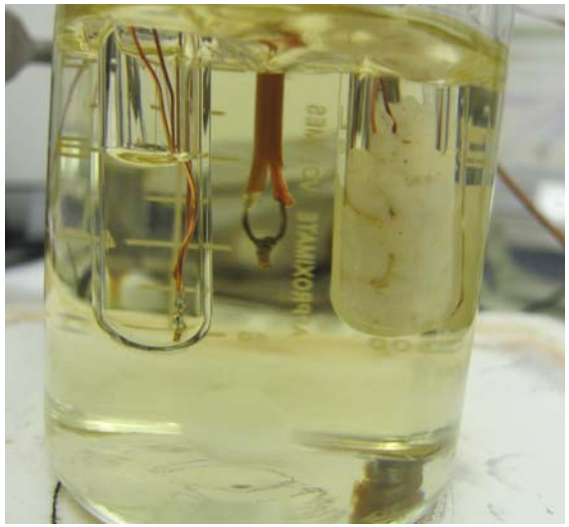
DS2760 Thermocouple Kit ($35)

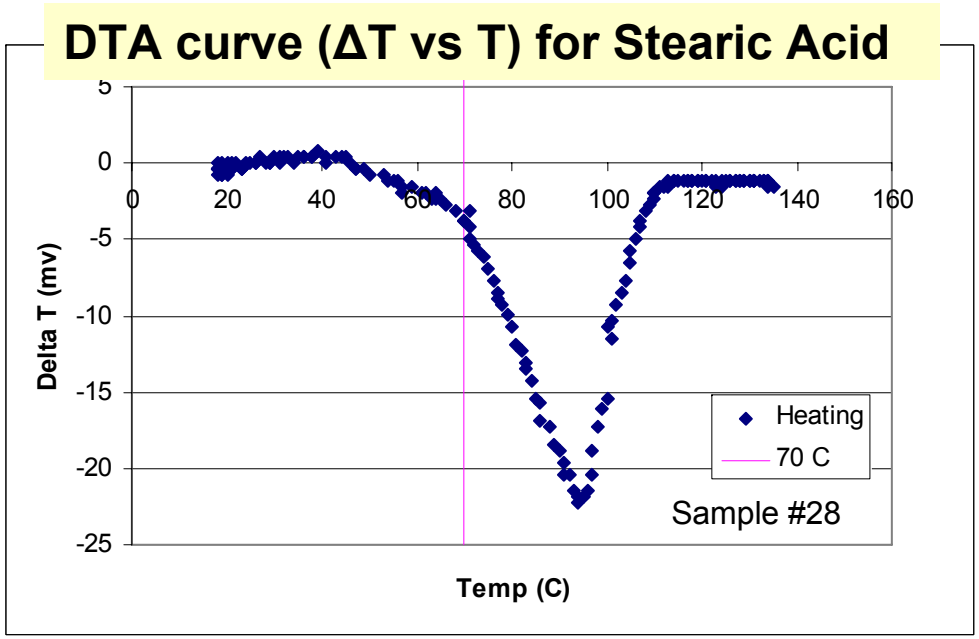
Has a module to read thermocouples and
$150 enough for data collection from 2 thermocouples.

Temperature and Delta T vs. time for the Stearic Acid



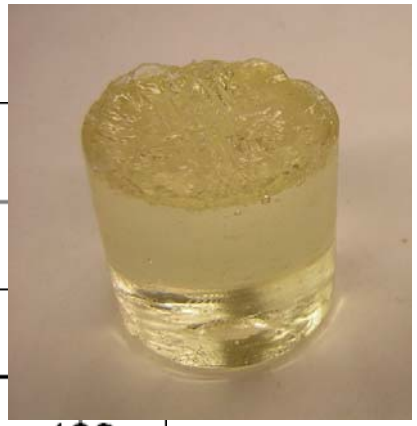
Using technical grade stearic acid (MP reported as 69-71º C)

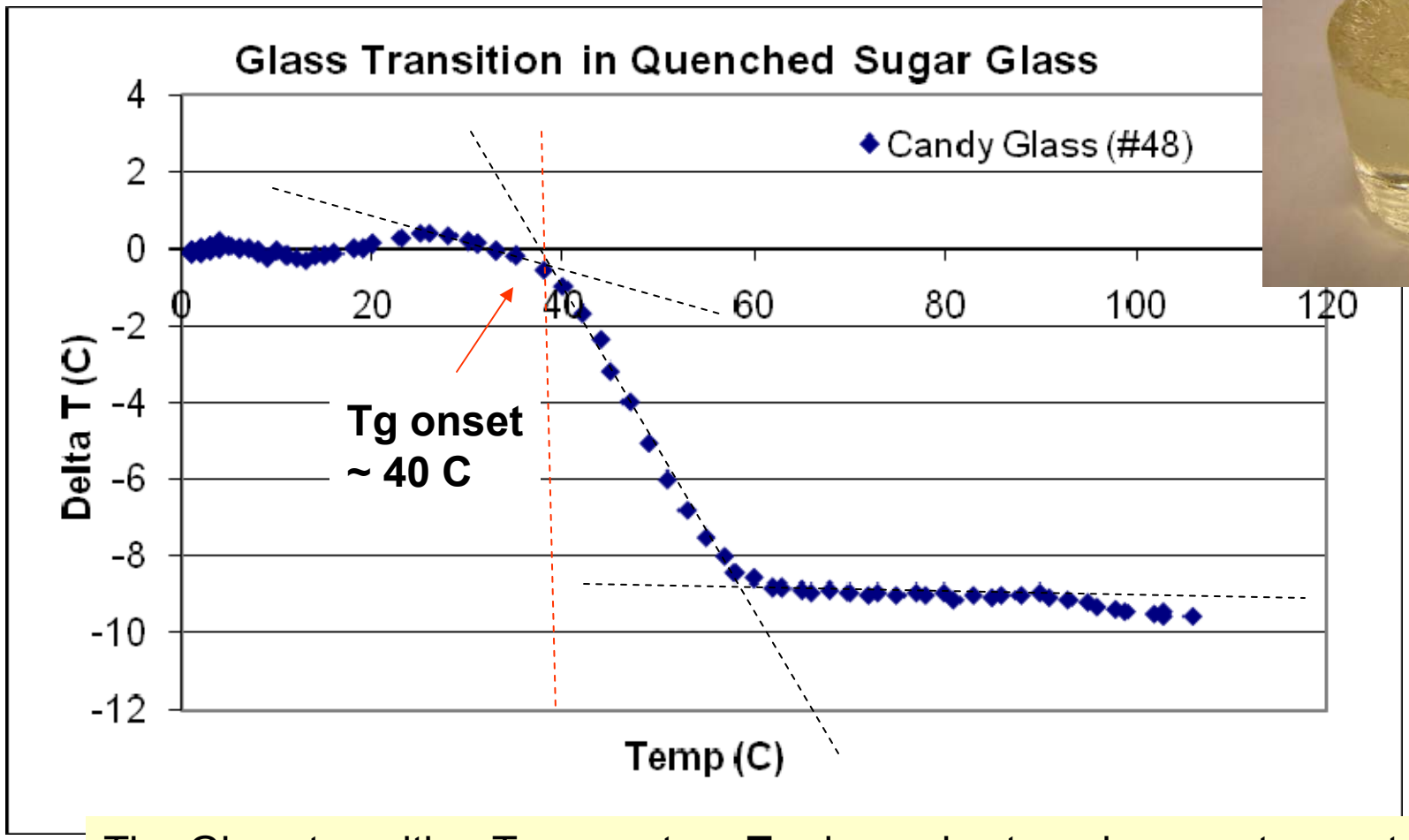




The MP is signaled as a kink in the DTA, which occurs here at 70º (vertical line).

Classic Glass Transition with Quenched Sugar Glass



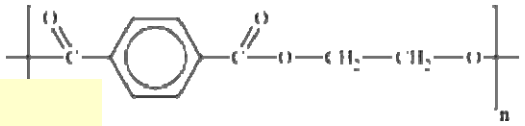


The Glass transition Temperature **Tg** depends strongly on water content of the sugar glass as well as on the thermal history of the sample (such as cooling rate). Many interesting experiments can be followed.

PET for Both Glass Transition and Crystallization

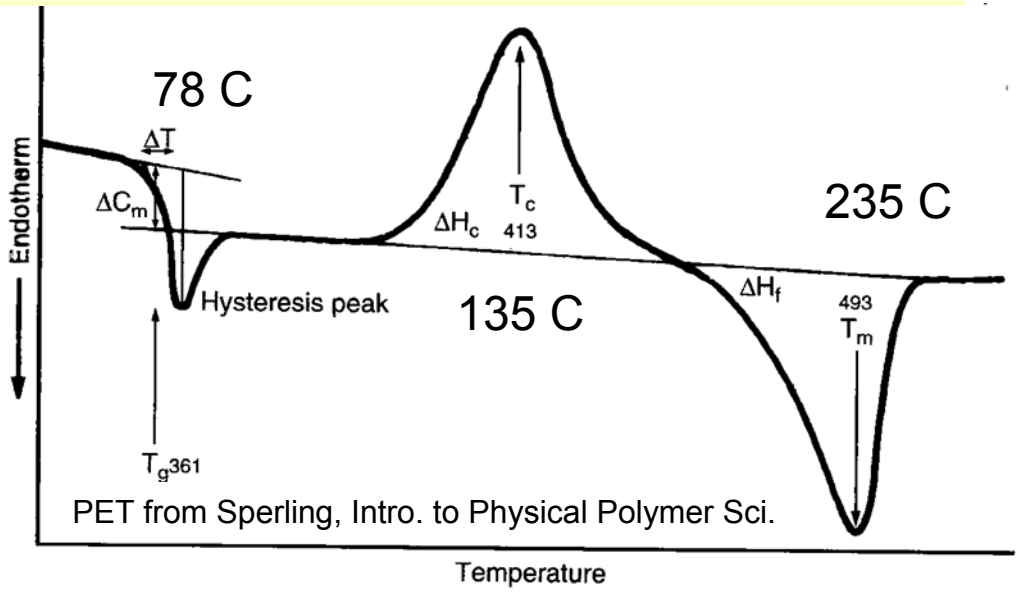
Polyethylene Terephthalate

PET is one of the common plastic materials used for beverage and other food packaging. It can be identified by the recycling code 1.



- glassy state at room temperature
- Tg near 75 C
- easily observable crystallization near 135 C
- Tm ~ 235 C.

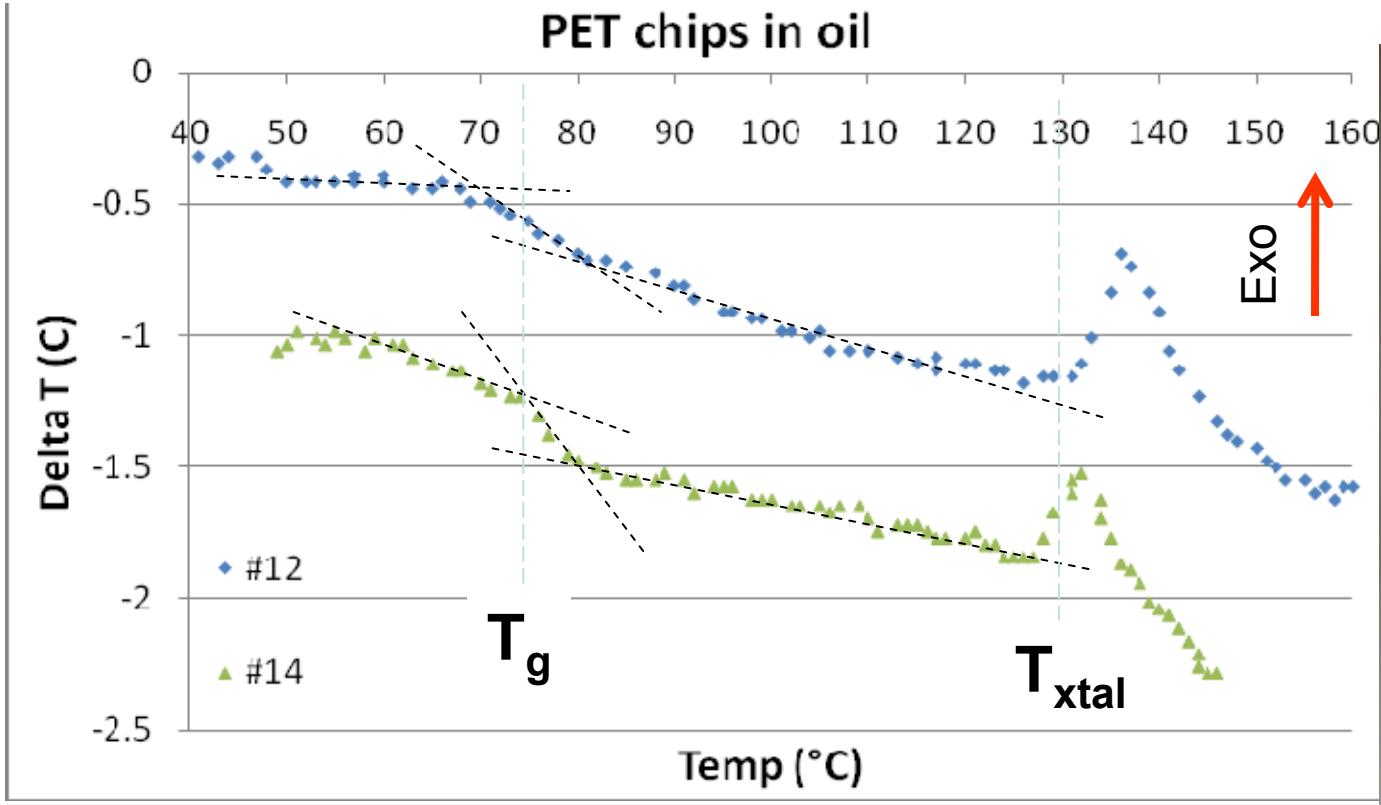
too hot for safety considerations.



PET from Sperling, Intro. to Physical Polymer Sci.

Polyethylene Terephthalate (PET) Chips in Oil

PET chips cut from the screw top of a Nestle water bottle combined with oil to provide thermal contact without melting.



Clear signal of T_g near the 73° value from DSC as well as the crystallization exotherm near 135° C.

Summary

Our DTA provides a simple, build-it-yourself means for students to explore thermal analysis, including
glass transition, melting and crystallization phenomena.
Demonstrate application with 3 common materials:

- Stearic acid - melt standard
- Candy glass - for glass transition and
- PET - with Tg and crystallization

Additional detail and instructions for building your own DTA are available on our IMI website below. Comments always welcome. wrh304@lehigh.edu

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Acknowledgement: This work has been supported by IMI-NFG, Lehigh University through National Science Foundations (NSF) Grants : DMR-0409588 and DMR-0844014

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