Reversing and non-reversing contribution to the melting o[HDPE/GNPs nanocomposites

Thermal Analysis and Calorimetry 2021 (TAC 2021)

E. Tarani[1], C. Schick[2], G. Vourlias[1], D.N. Bikiaris[3], K. Chrissafis[1]

[1]Physics Department, Aristotle University of Thessaloniki, GR 54124 Thessaloniki, Greece
[2]Institute of Physics, University of Rostock, Albert Einstein Str. 23-24, 18059 Rostock, Germany
[3]Department of Chemistry, Aristotle University of Thessaloniki, GR 54124 Thessaloniki, Greece

Corresponding author: etarani@physics.auth.gr

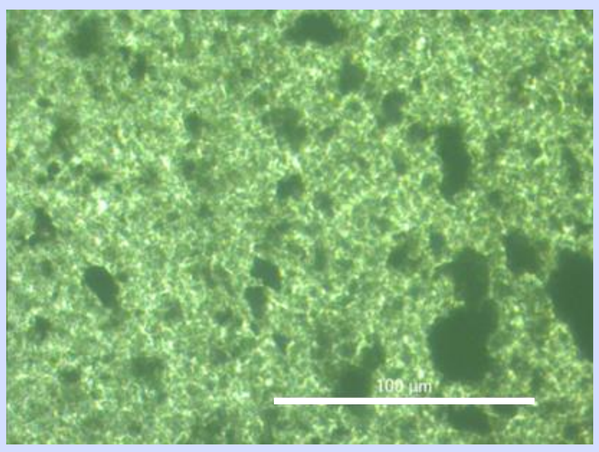
Aim of the research

Thermally conductive polymeric materials used in solar cells, sensors, energy storage devices, pipes, etc., are in great demand due to their high thermal and chemical stability, radiation resistance, low dielectric constant and good mechanical properties. Industrial and academic are highly interested in graphene-polymer nanocomposites due to large production quantities of graphene from the low-cost graphite. In this work, High Density Polyethylene (HDPE)- graphene nanoparticles (GNPs) nanocomposites with five different weight percents of GNPs have been prepared. The GNPs used in this research work were of three different platelet diameter: 5 μm (GNPs M5), 15 μm (GNPs M15) and 25 μm (GNPs M25). All the nanocomposites were prepared using melt rheo-mixing for 8 min at 190°C in a Haake-Buchler Rheomixer (model 600).

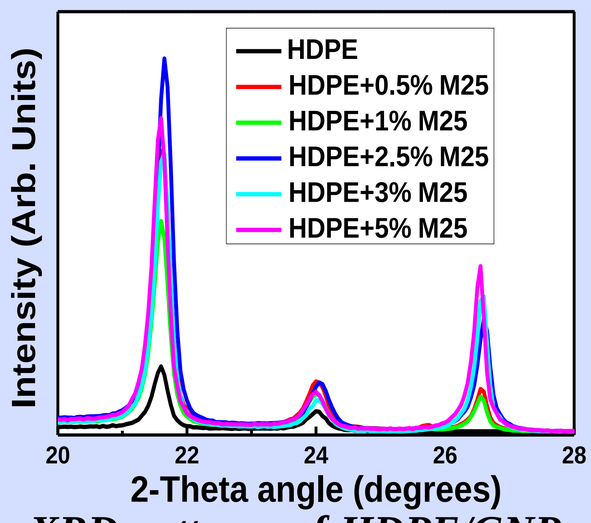
Examination Methods

- **XRD: 2 cycle Rigaku Ultima+ diffractometer with Cukα radiation**
- **PLM: Nikon, Optiphot-2**
- **DSC: Pyris Diamond from Perkin-Elmer**
- **FSC: Mettler-Toledo Flash DSC 1**

Structure Characterization

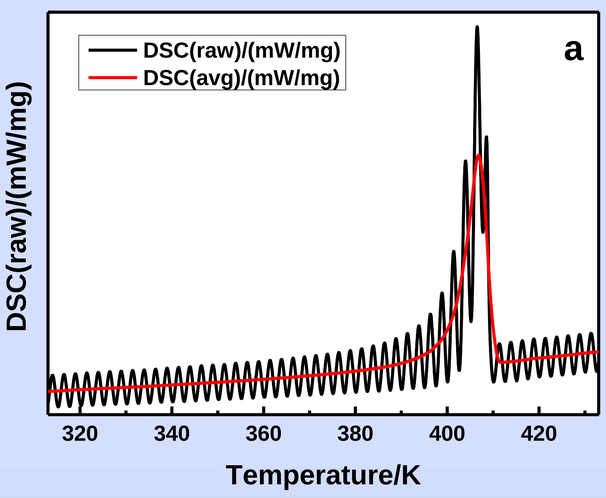


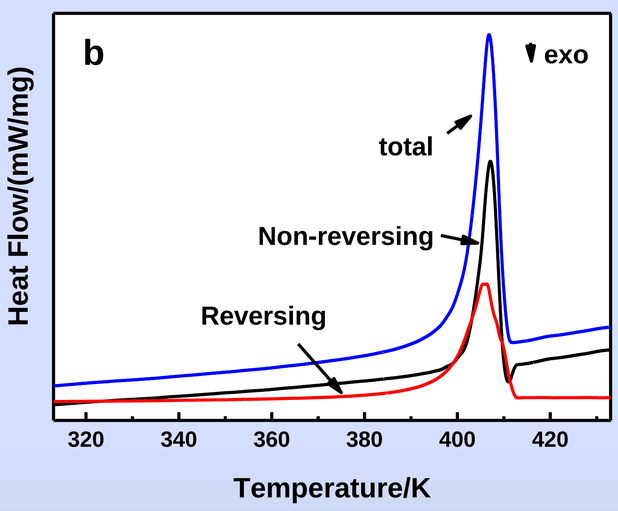
Polarized optical microscopy of HDPE/*2.5 wt.% GNPs M25*

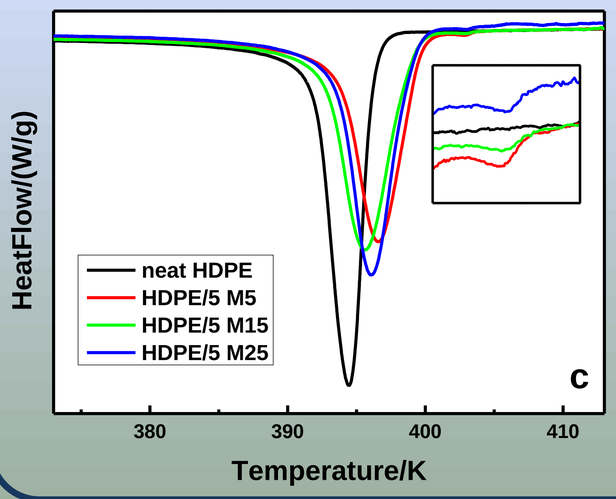


XRD patterns of HDPE/GNP M25 for various graphene loadings.

Temperature-modulated Differential Scanning Calorimetry (TM-DSC)



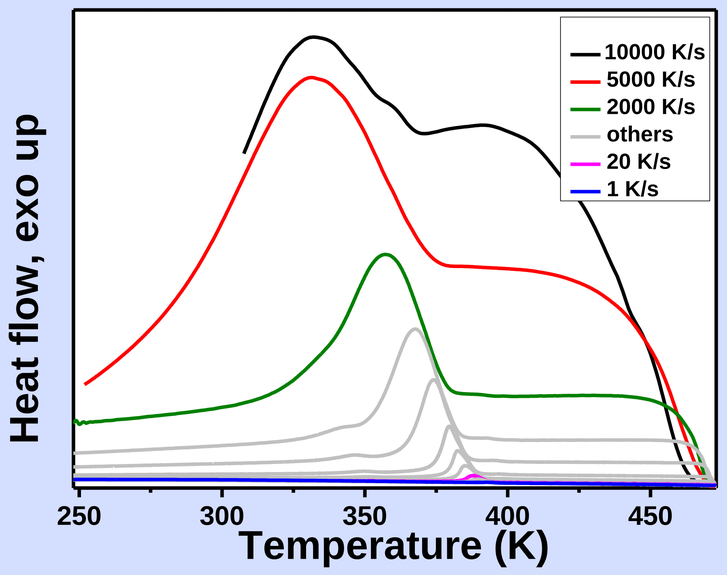


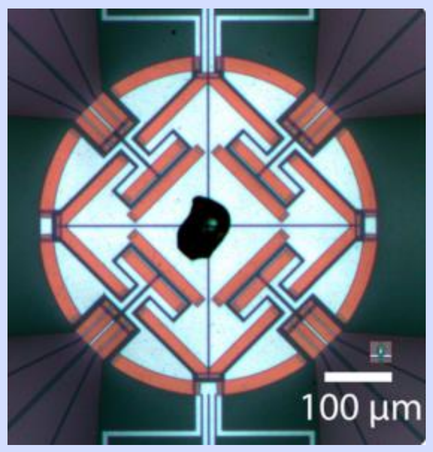


TM- DSC curves of HDPE/ 5 wt.% M25 (a), total heat flow, non- reversing heat flow and reversing heat flow (b) and cooling curves of HDPE nanocomposites filled with t wt.% of GNPs (c)

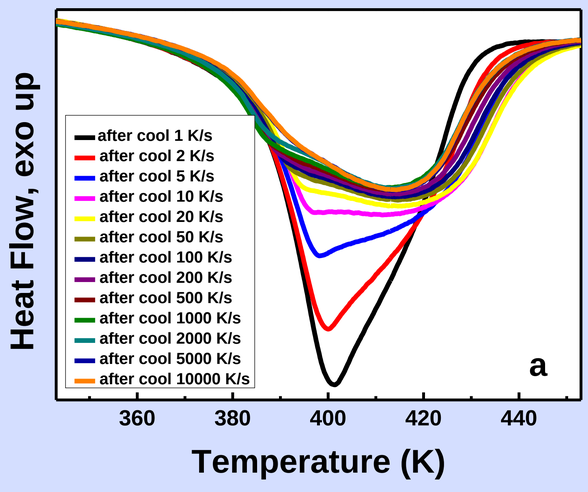
Differential Scanning Calorimetry (DSC, FSC)

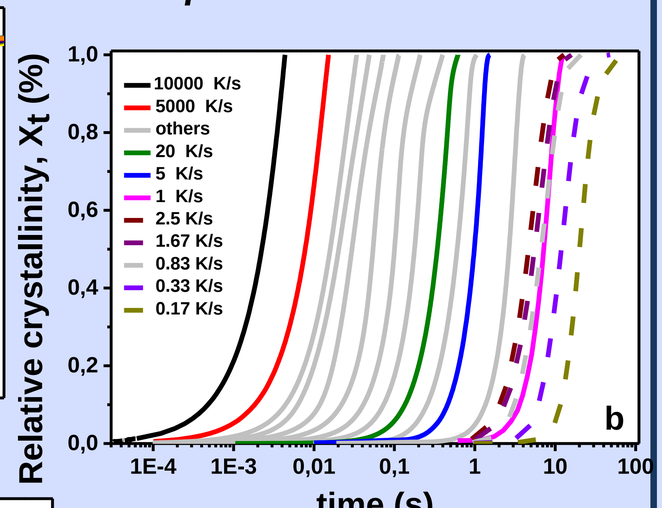
Cooling curves (a) and melting peak temperatures (b) of HDPE/M5 at rates from 0.17 to 2.5 K/s measured by conventional DSC

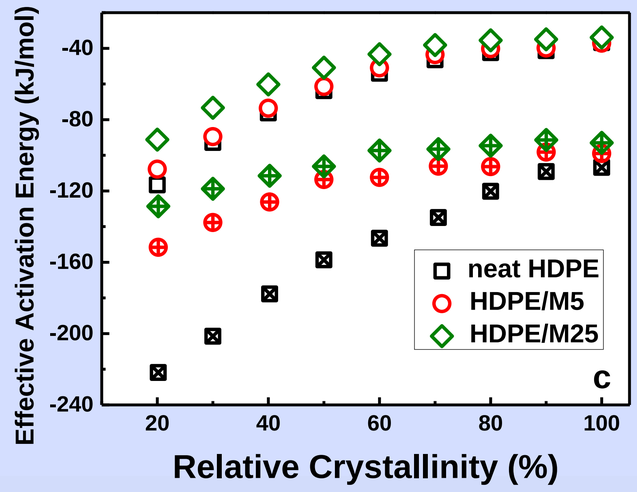




FSC experiments for non-isothermal crystallization of HDPE/M5 at cooling rates from 1 to 10000 K/s







Melting peak temperatures (a) and plots of relative crystallinity for neat HDPE (b) as a function of time for non-isothermal crystallization at cooling rates from 1 to 10000 K/s collected by FSC (line) and conventional DSC (dot line) for cooling rates from 0.17 to 2.5 K/s.
Dependence of the effective activation energy on the relative crystallinity (c) for HDPE and its graphene nanocomposites determined by conventional (center filled symbols) and FSC (open symbols).

Conclusions

- **Several melting events took place during the melting behavior of neat HDPE and HDPE/GNPs nanocomposites, which were associated with the formation of small ordered domains that do not form a high-order superstructure and the large nucleation density of GNPs.**
- **The crystallization kinetics under non-isothermal conditions showed that the nanocomposites are crystallized at higher rates due to the increased number of nucleation sites.**
- **The activation energy values versus the relative extent of crystallization revealed that GNPs block the movement of the molecular segments and make crystallization be difficult, especially at the final stage of the process.**