Reval PET

Structure and Properties of Recycled Polymer Blends

Recycled PET bottles

Proyecto cofinanciado por el Fondo Europeo de Desarrollo Regional

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UPV/EHU and INA/UNIZAR
Advanced Multiphasic Polymers (AMP) Group
PhD Student/ Uniiversity of the Basque Country (UPV/EHU)

Why the need of this study?

PE/PP caps

PET

PET transparent bottles

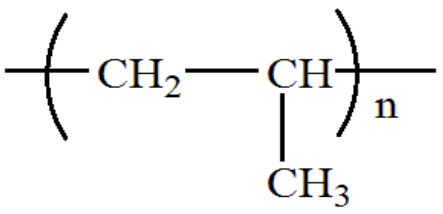
PET + TiO_2

PET opaque bottles with TiO_2 nanoparticles

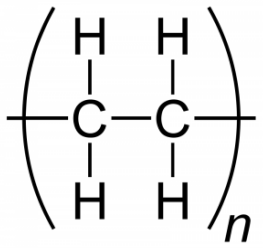
PET waste

PET
Polyolefins (PE and PP)
TiO_2 nanoparticles

Why the need of this study?

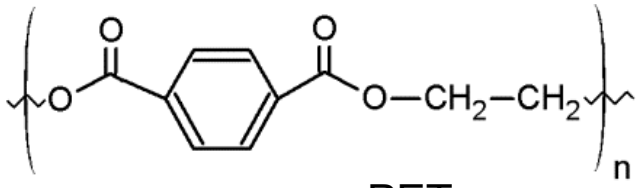


PP



HDPE

hydrophobic



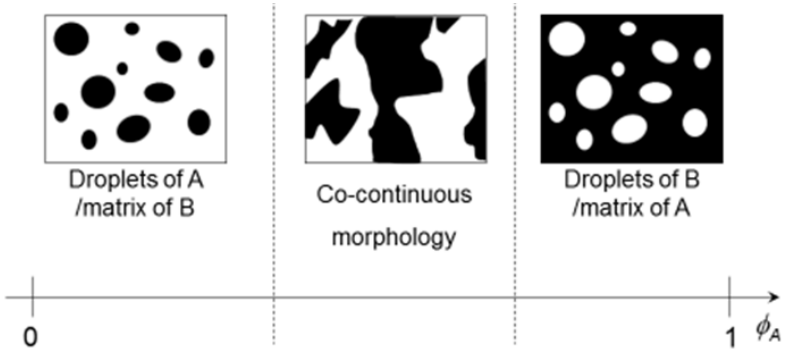
PET

Much less hydrophobic

Why the need of this study?

PET
Polyolefins (PE and PP)
TiO_2 nanoparticles

Mixture of different types of polymers



Presence of TiO_2 nanoparticles

RECYCLING

Effects on:
✓Crystallization
✓Mechanical Properties

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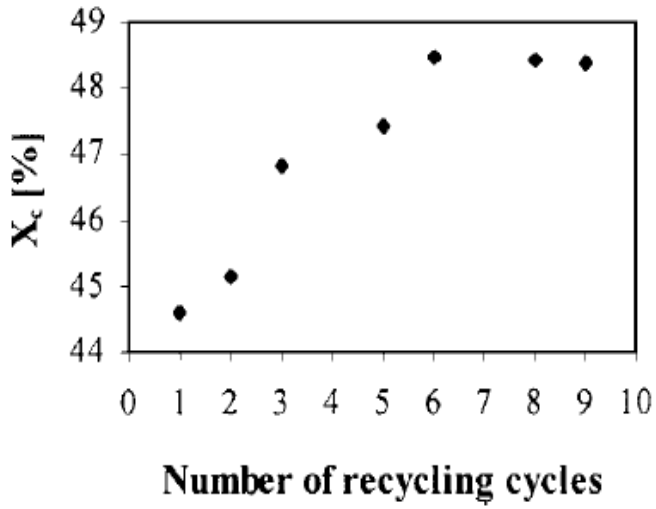
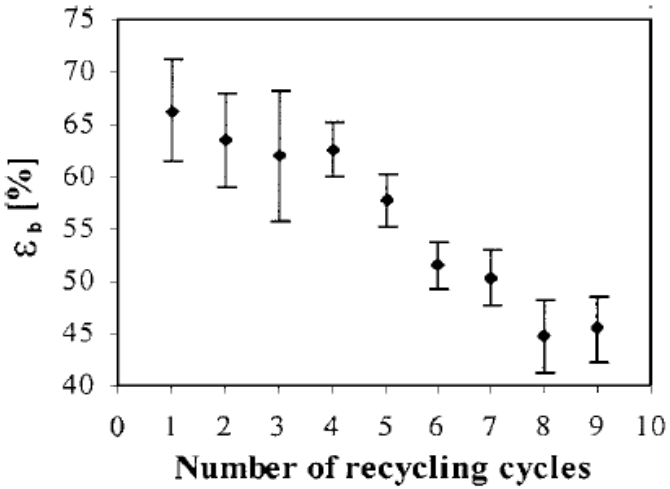
Why the need of this study?

Crystallinity (PP sample)

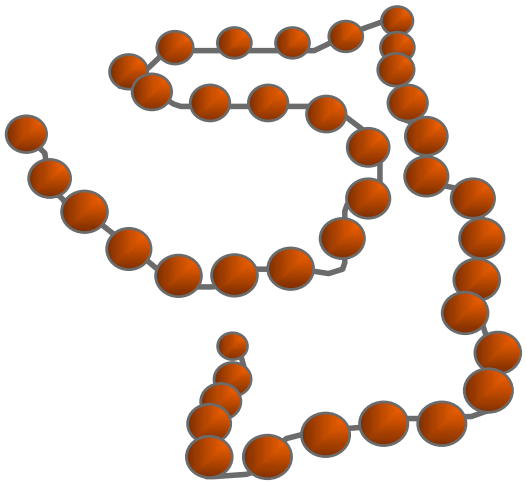


Mechanical Properties (PP sample)



**J.Aurrekoetxea; M.A.Sarrionandia; I.Urrutibeascoa; M.L.Maspoch."Effects of recycling on the microstructure and the mechanical properties of isotactic polypropylene". Journal of Materials Science, 36 (2001) 2607-2613*

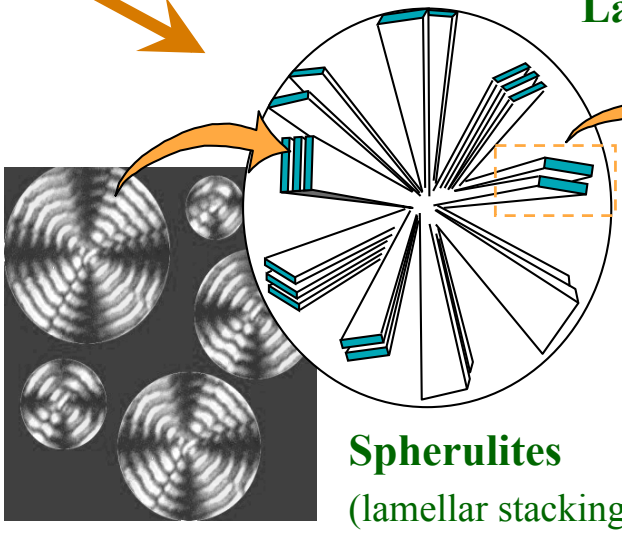
Why the need of this study?

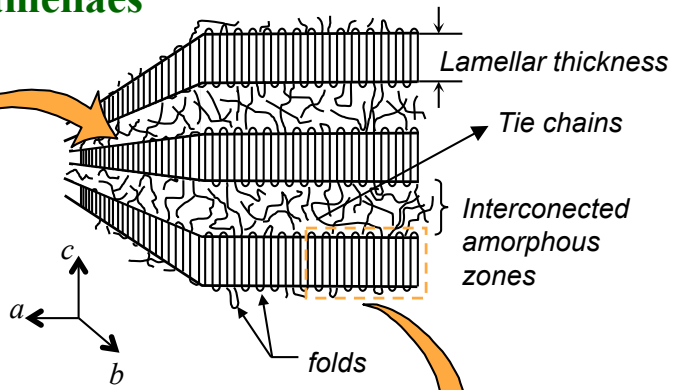


Amorphous polymers

Random Coil

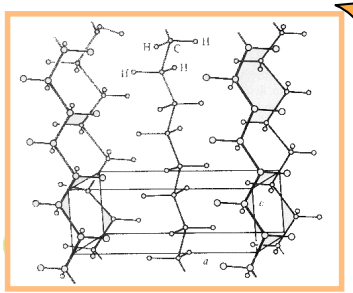
Lamellaes





Spherulites

(lamellar stacking)



Semi-crystalline polymers

Materials

rPET

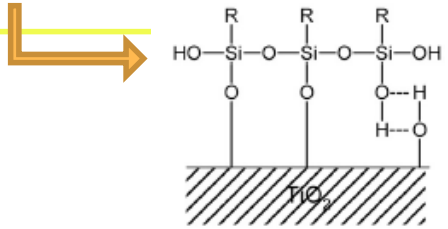
rPP

3 types of TiO_2

Hydrophilic

Hydrophobic

INA Modified hydrophobic



Sample Preparation. *Blending by **melt-extrusion**. Twin screw extruder.*

1. Drying 80 °C in vacuum (48h)
2. Extrusion:
   T_1= 215°C; T_2= T_3=T_4= 270°C
   40 rpm

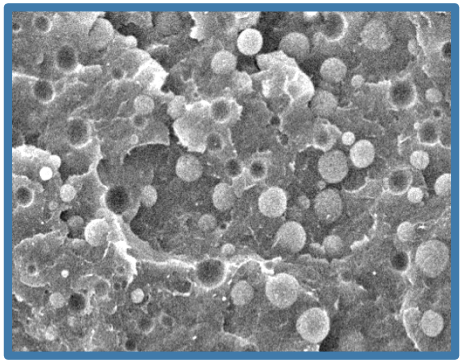
80rPP/20rPET
(2% TiO_2)

+ 1% TiO_2
+ 3% TiO_2
+ 5% TiO_2
+ 7.5% TiO_2
+ 10% TiO_2

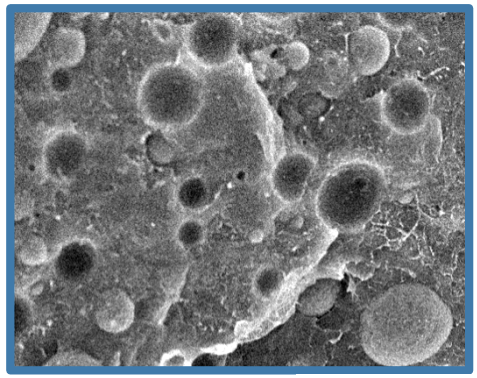
Morphological Characterization. SEM

80rPP/20rPET

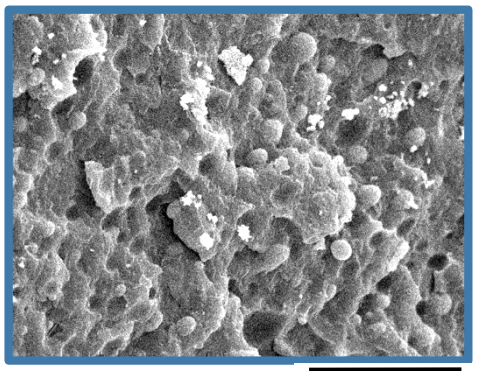
Hydrophilic TiO_2



3% TiO_2 30 µm



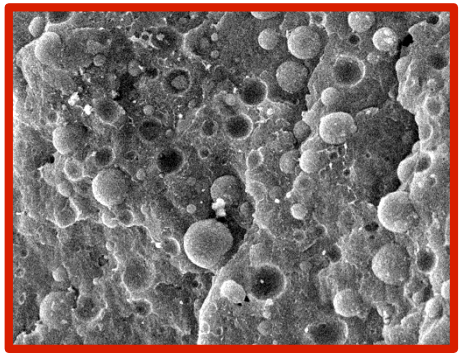
7% TiO_2 30 µm



12% TiO_2 30 µm

80rPP/20rPET

Hydrophobic TiO_2



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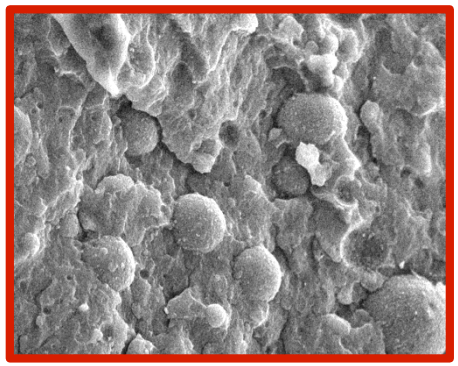

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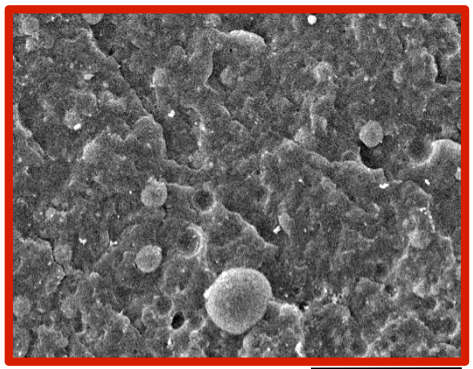
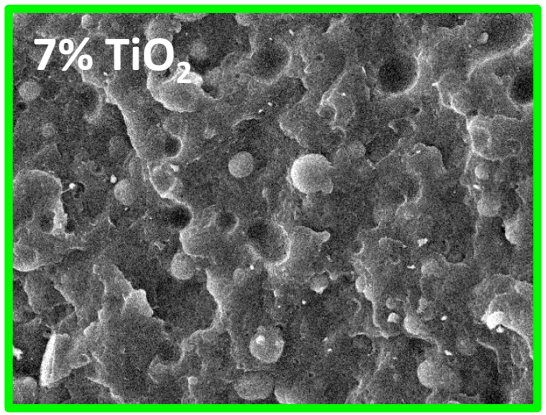


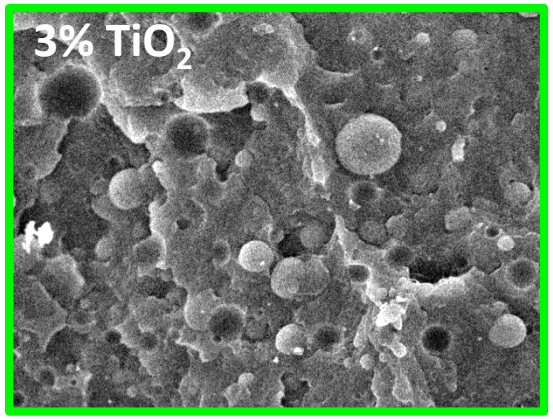
12% TiO_2 30 µm

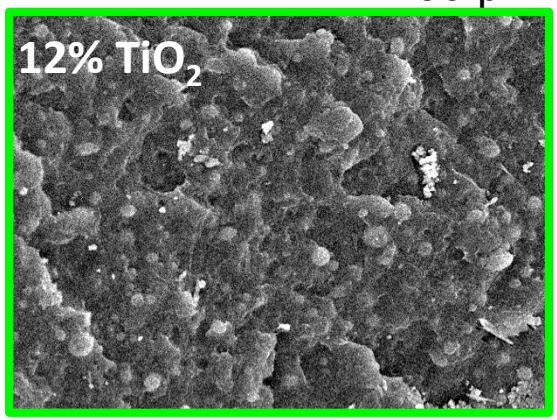
Morphological Characterization. SEM

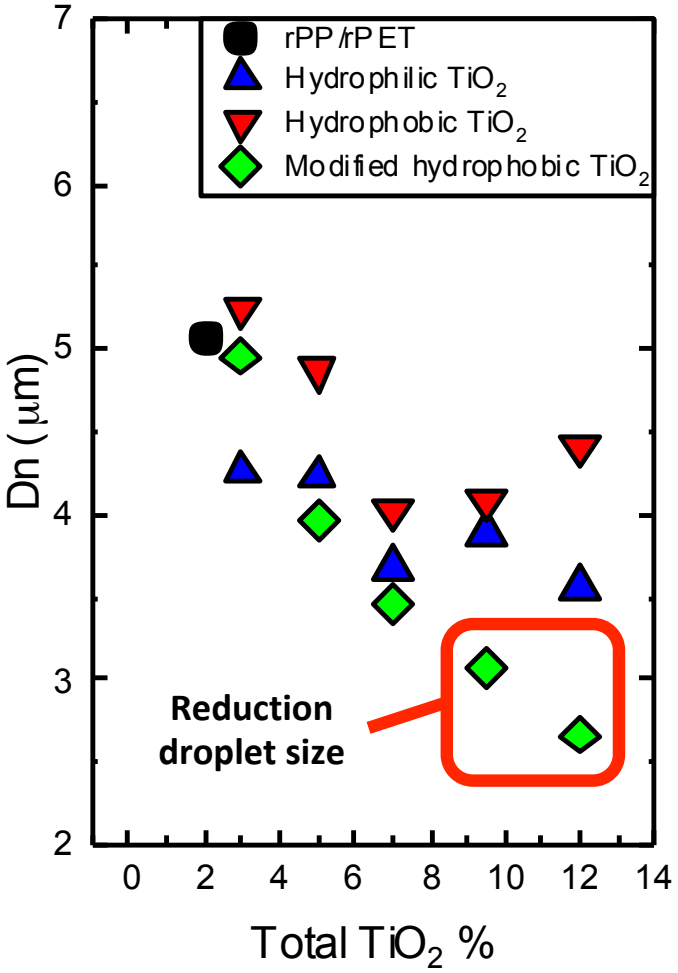
80rPP/20rPET

Hydrophobically modified TiO_2 by INA (Zaragoza)









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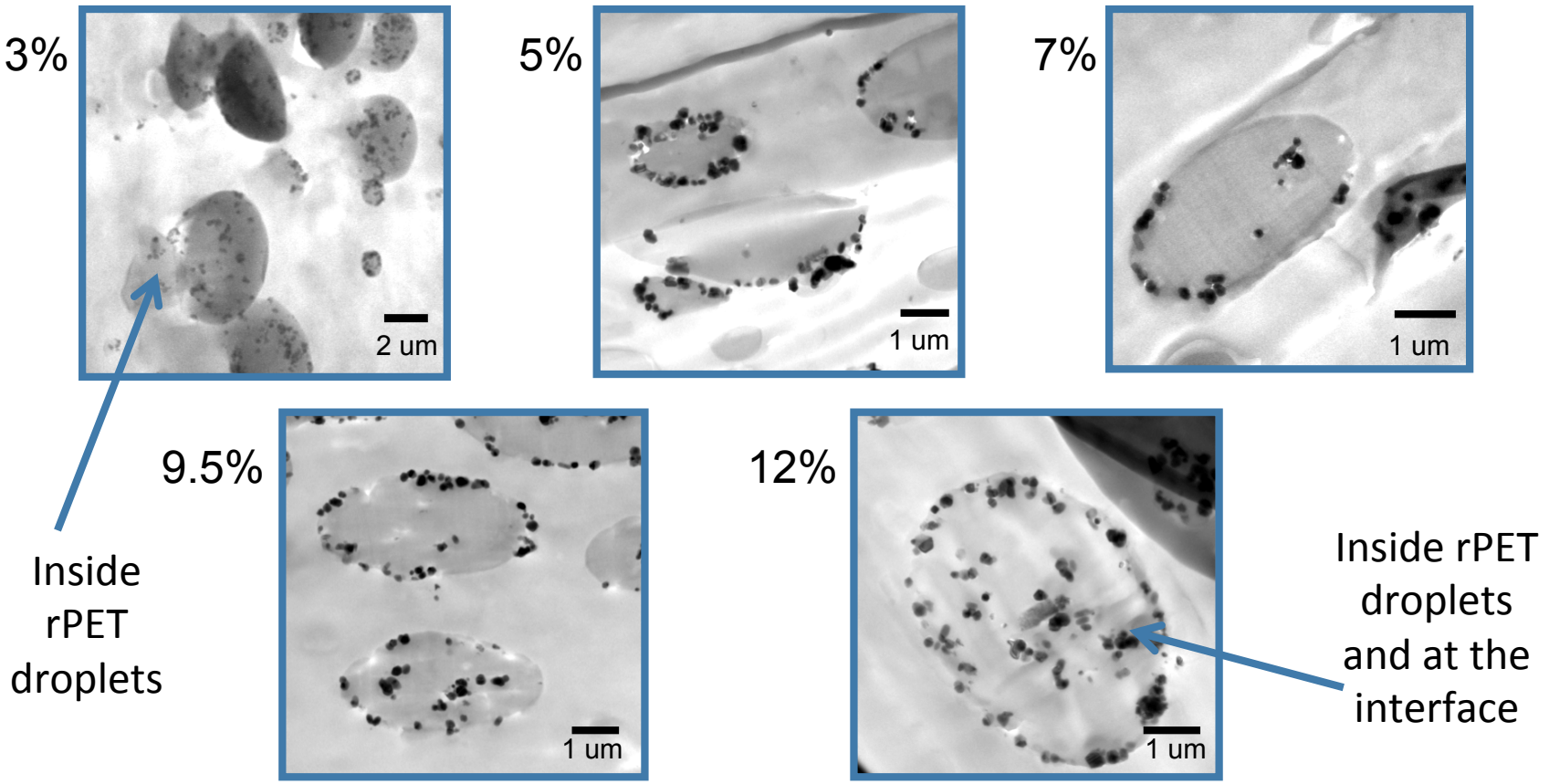
Morphological Characterization. TEM

80rPP/20rPET/hydrophilic TiO_2



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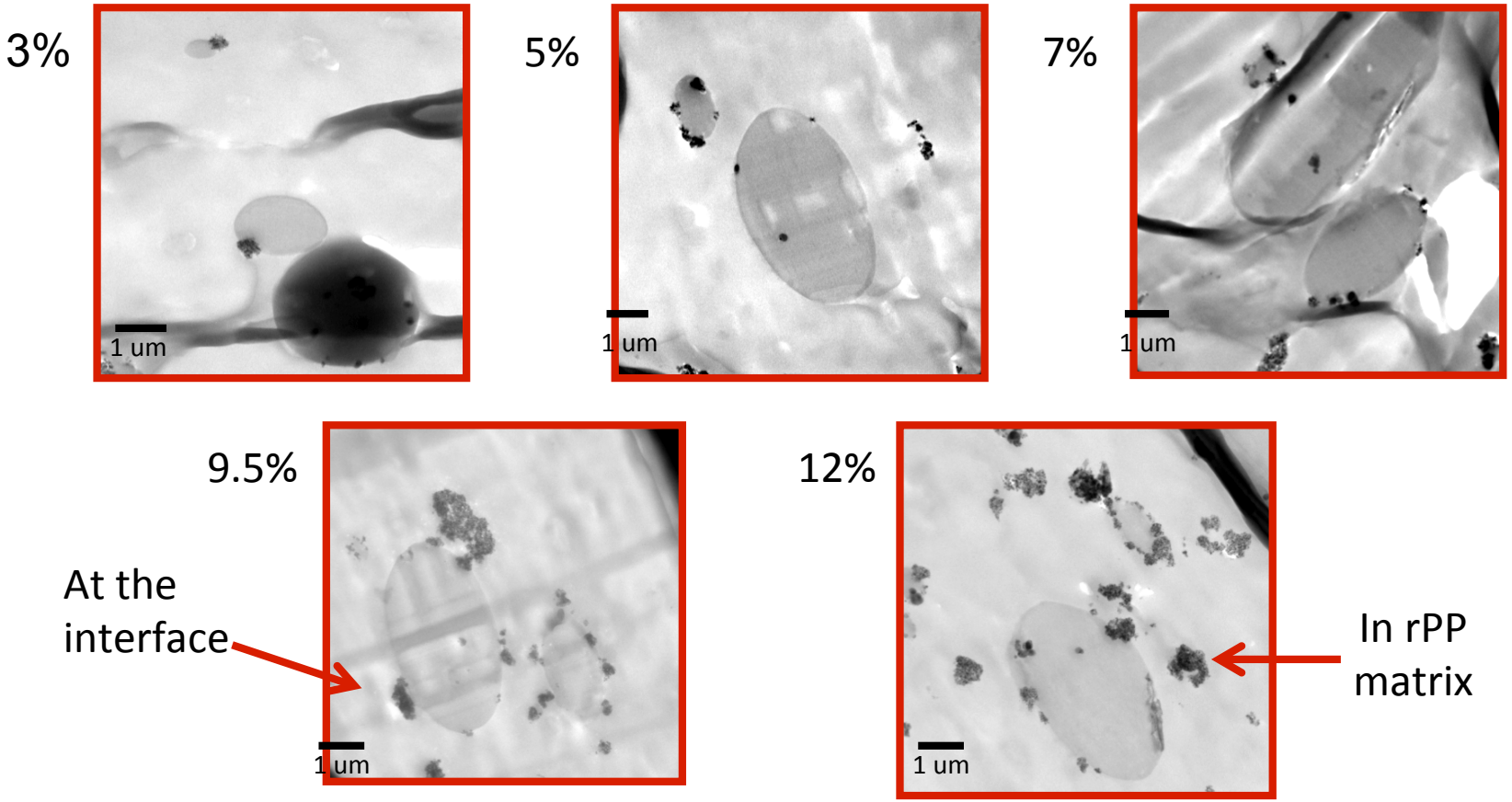
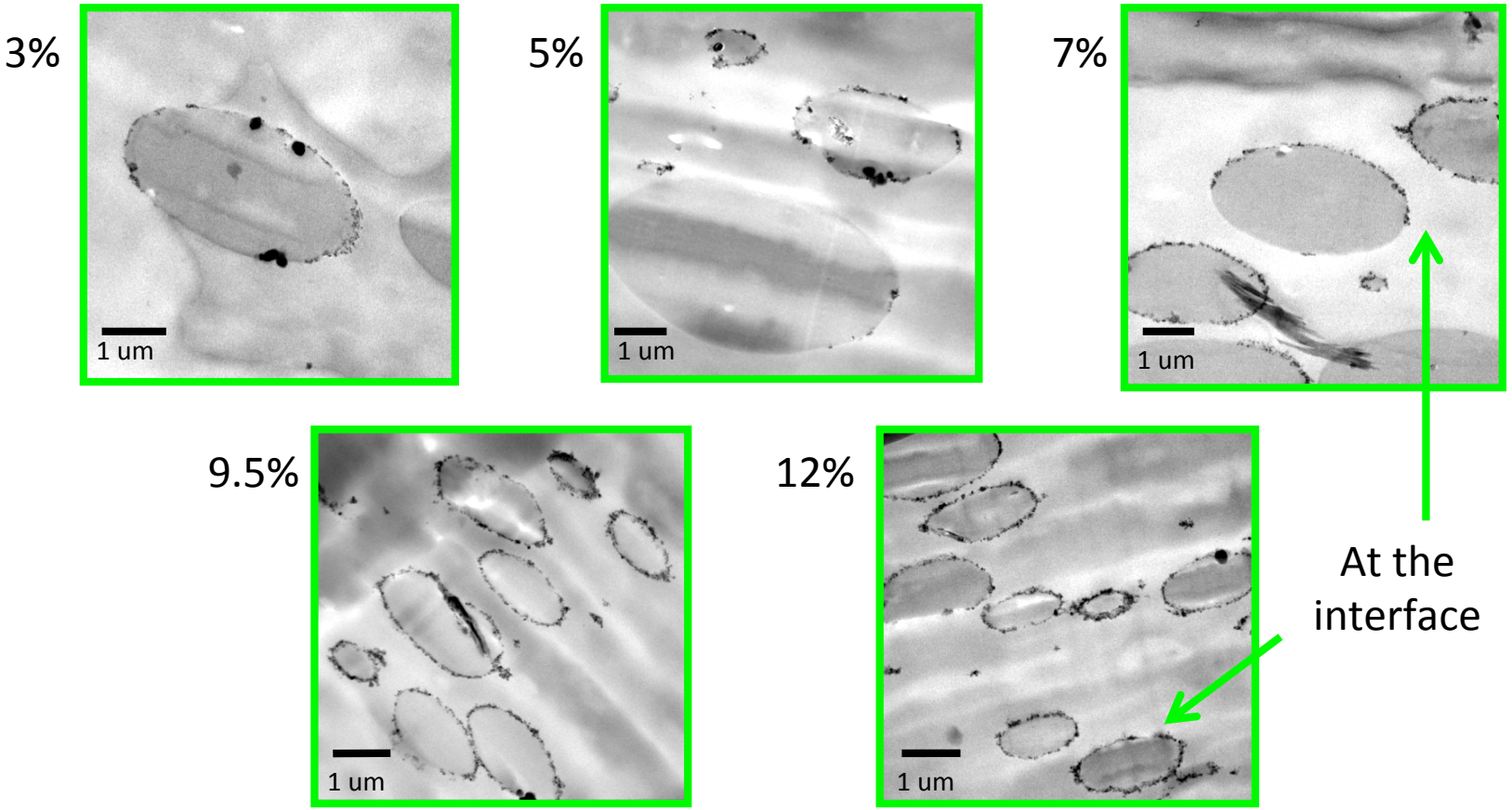
Morphological Characterization. TEM

80rPP/20rPET/hydrophobic TiO_2



Morphological Characterization. TEM

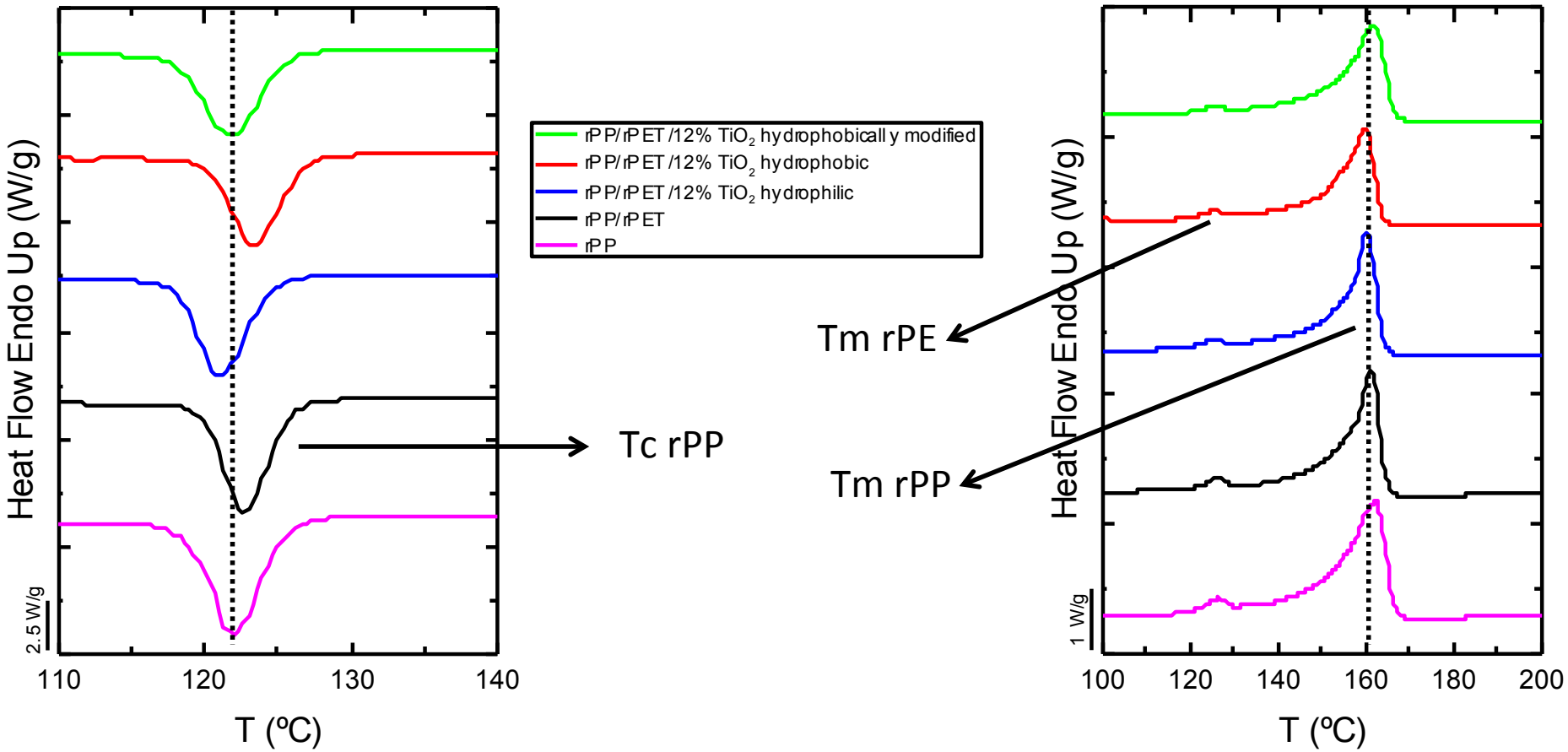
80rPP/20rPET/hydrophobically modified TiO_2



Thermal Characterization. DSC

Non-isothermal characterization. rPP

80rPP/20rPET



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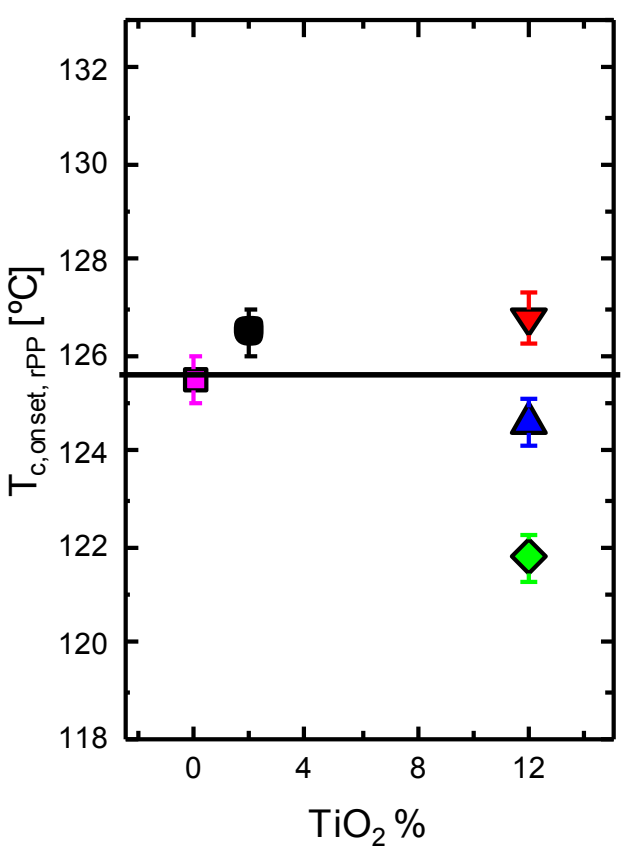
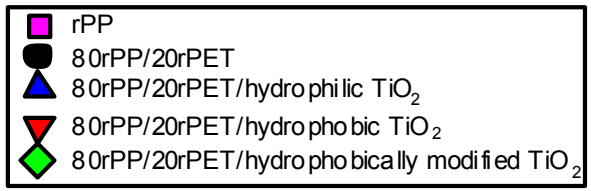
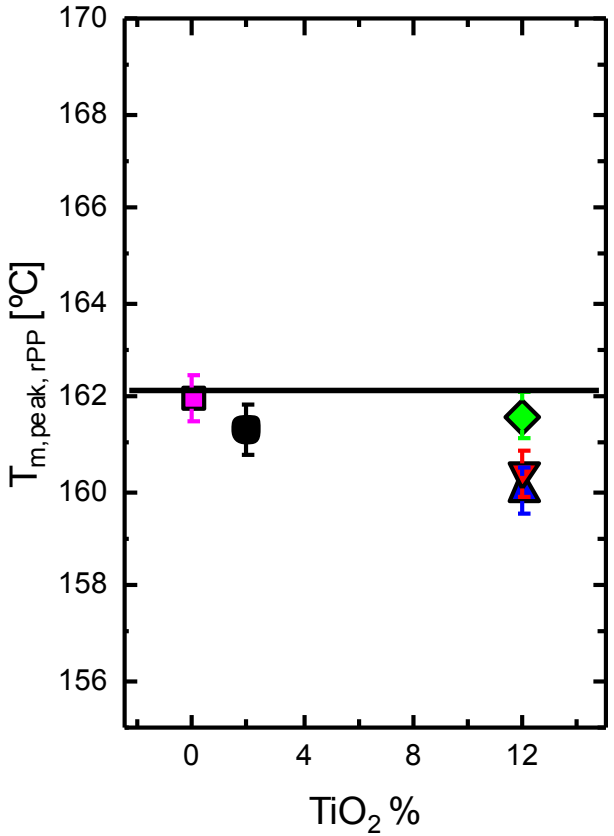




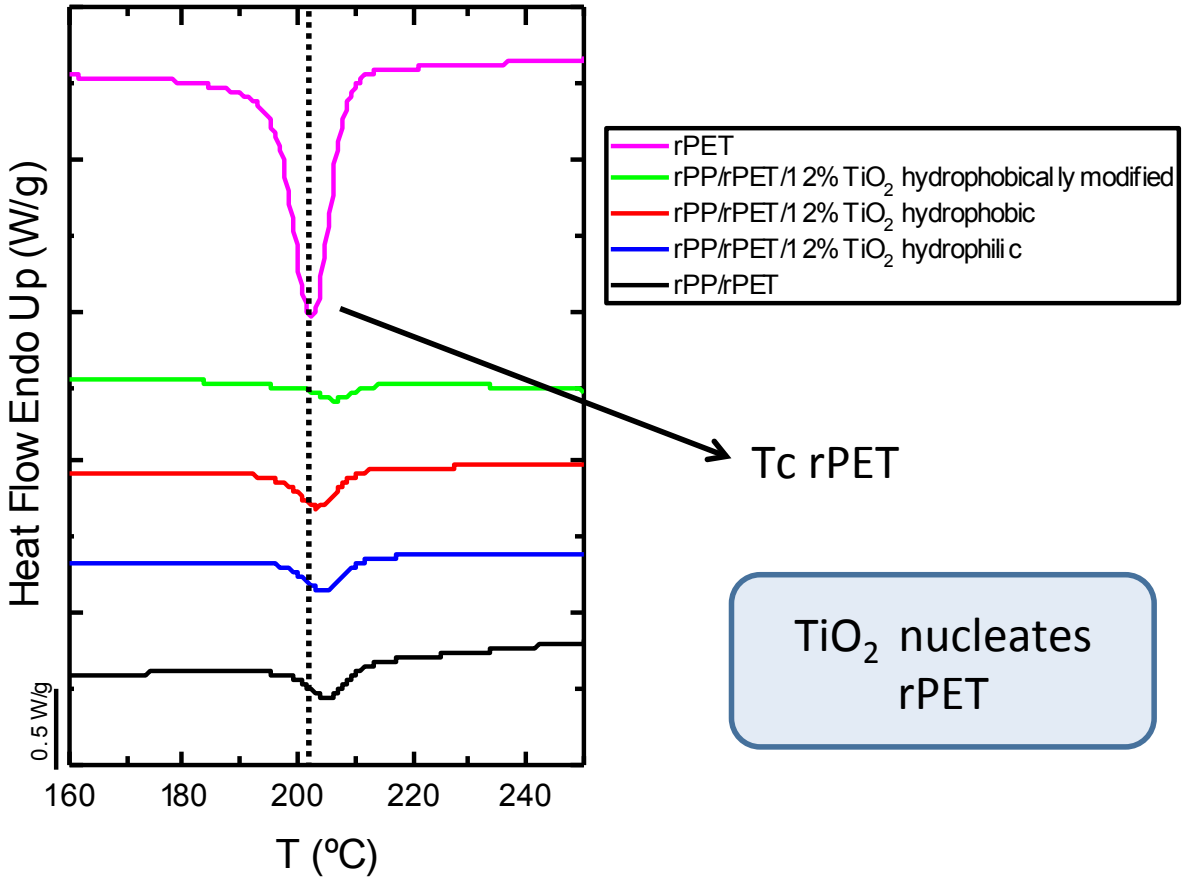
TiO_2 does not nucleate rPP



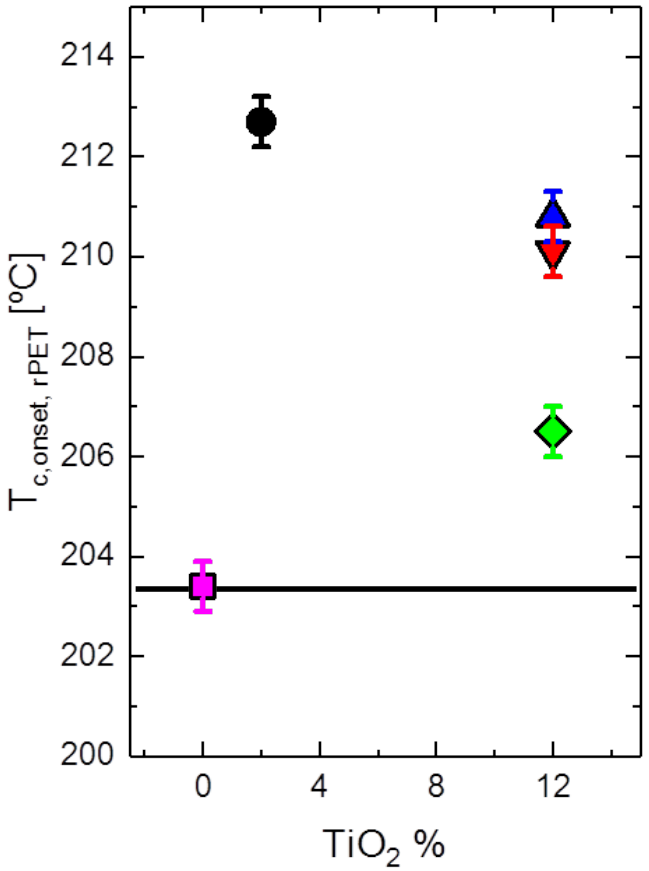
Thermal Characterization. DSC

Non-isothermal characterization. rPET

80rPP/20rPET



TiO_2 nucleates rPET



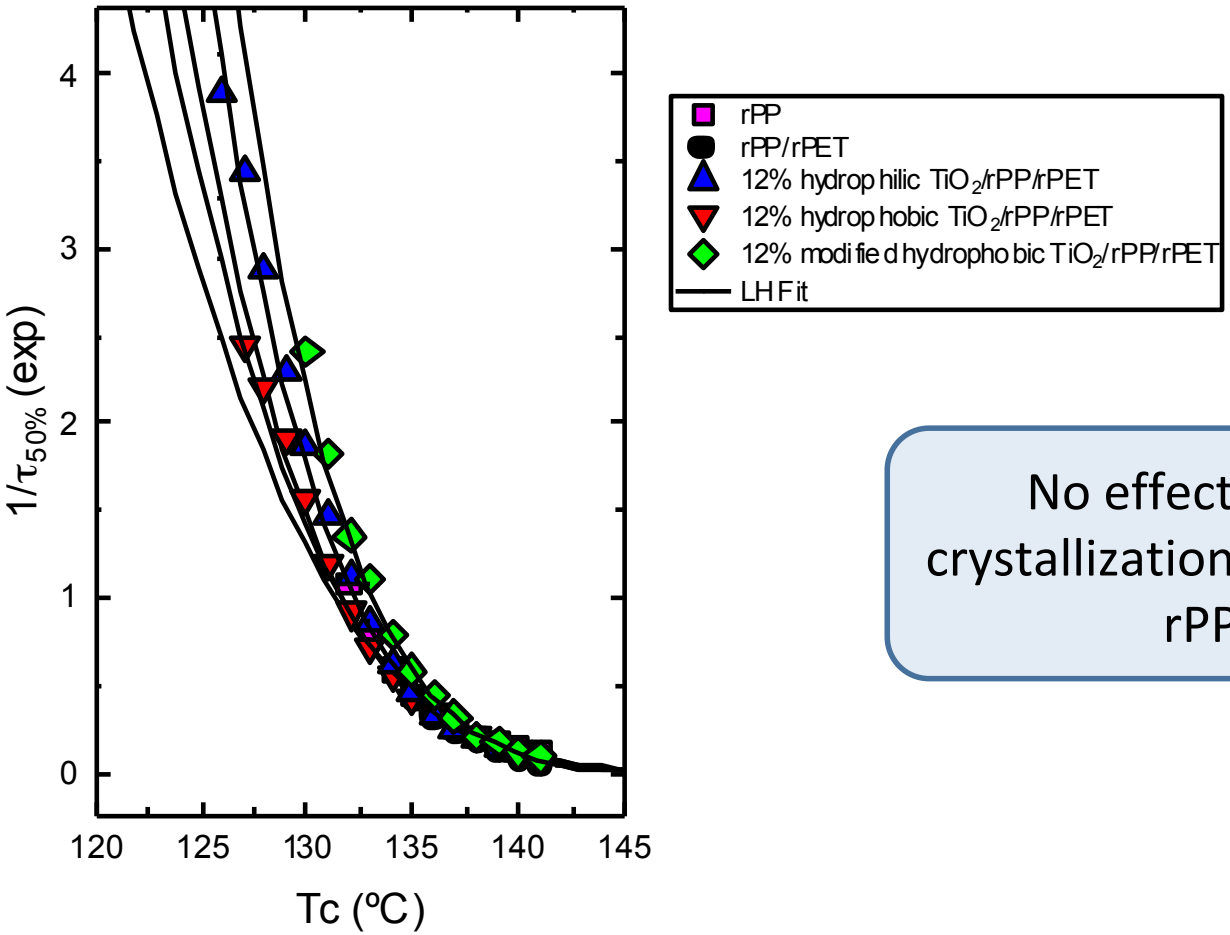
Thermal Characterization. DSC

80rPP/20rPET

Isothermal characterization. Effect of TiO_2 nanoparticles

rPP component

12% TiO_2



No effect in the crystallization kinetics of rPP

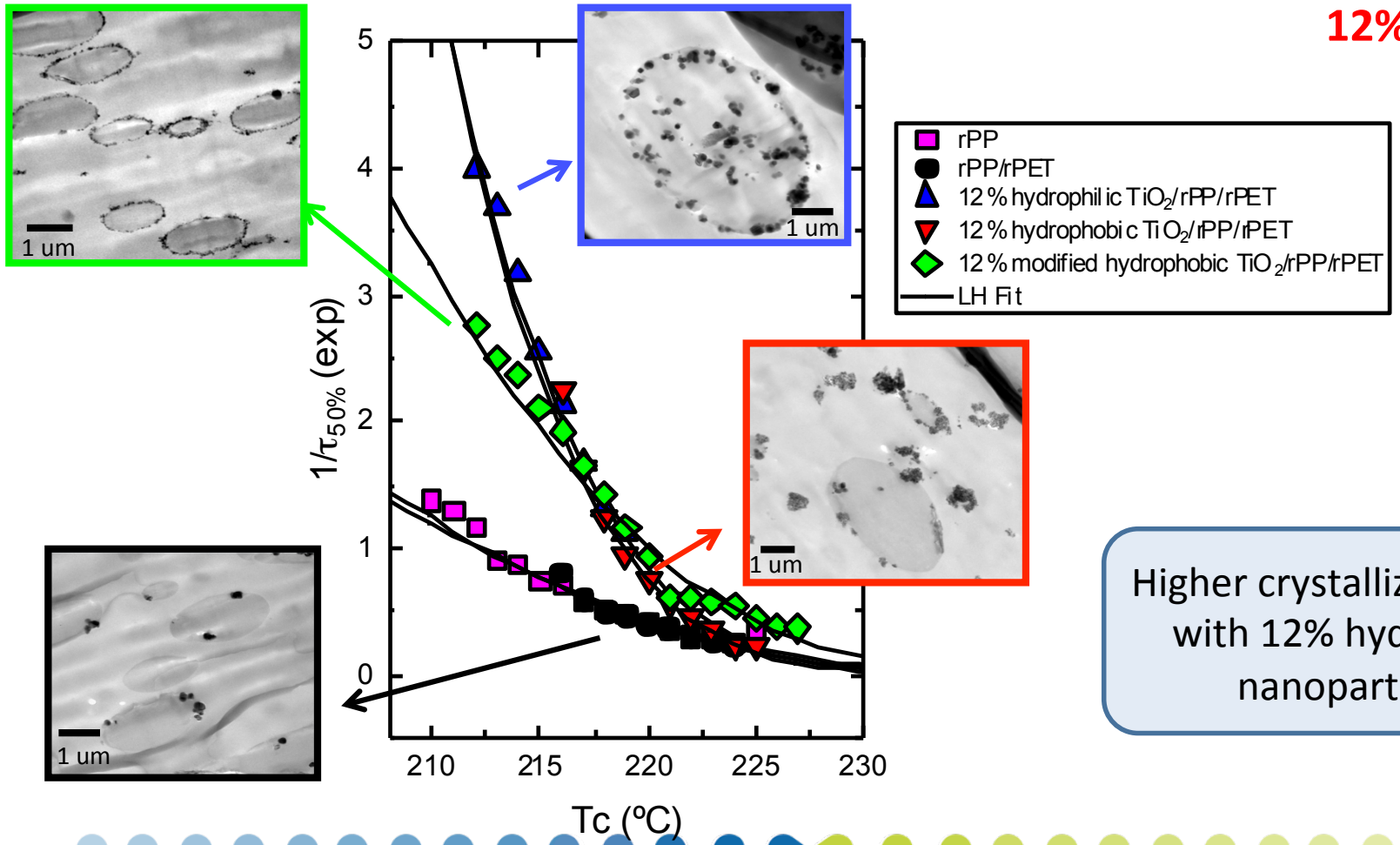
Thermal Characterization. DSC

80rPP/20rPET

rPET component

Isothermal characterization. Effect of TiO_2 nanoparticles

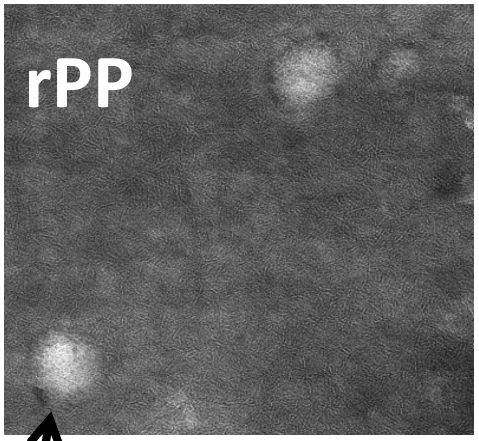
12% TiO_2

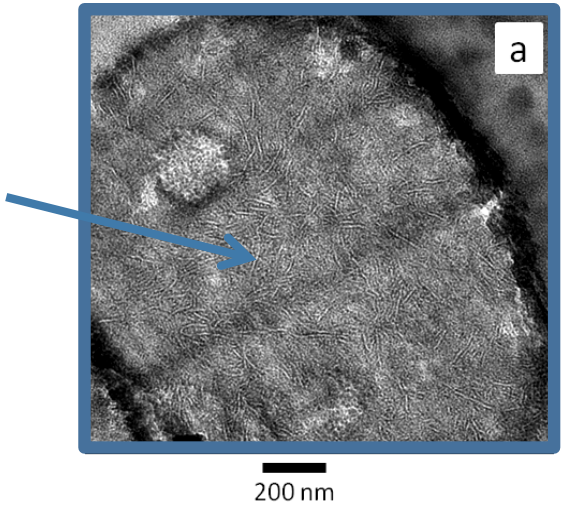


Higher crystallization rate with 12% hydrophilic nanoparticles

Morphological Characterization. TEM

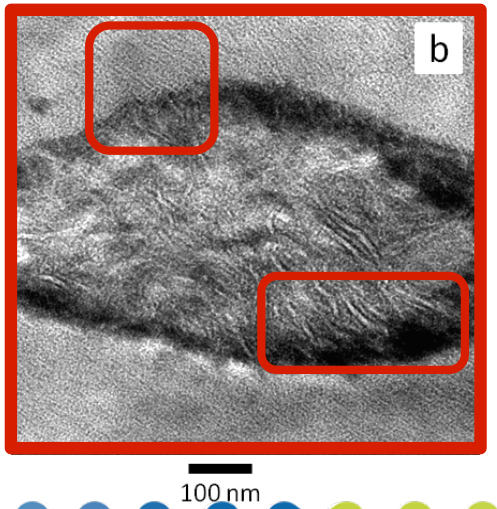
80rPP/20rPET

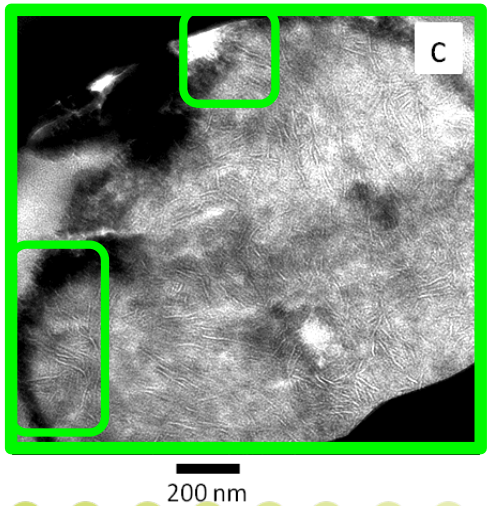




a. Hydrophilic TiO_2
b. Hydrophobic TiO_2
c. Hydrophobically modified TiO_2

Samples stained by a RuO_4 solution in order to see the lamellae





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Conclusions

✓ Significant reduction of the rPET droplet size with 9.5 and 12% hydrophobically modified TiO_2 nanoparticles

✓The addition of TiO_2 nanoparticles accelerates the crystallization of rPET but it does not significantly affect rPP. The acceleration increases with the TiO_2 content.

✓ TEM images show how nanoparticles locate inside rPET droplets in the case of hydrophilic TiO_2 nanoparticles. For the hydrophobic case they are located both at the interphase and PP matrix, and with the hydrofobically modified nanoparticles the TiO_2 nanoparticles are preferentially located at the interphase.