

Mechanical Strengthening of Poly(ethylene terephthalate) By Nitration

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Application of PET

plastic and packaging



Sailcloth



Felt cloth and Clothing



dielectric



thermal insulation



magnetic tape



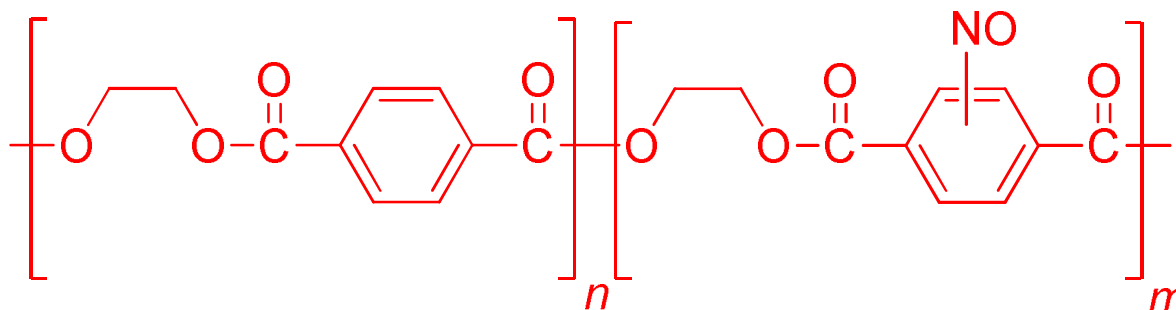
Image from <http://en.wikipedia.org>

Project Goals

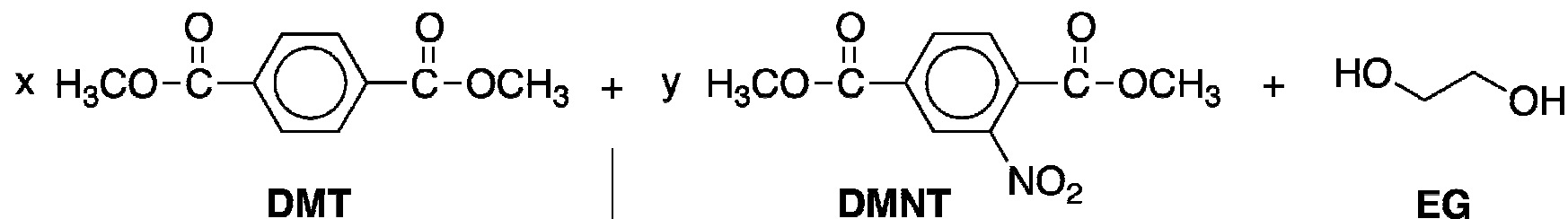
- Characterize the mechanical properties of nitrated-PET
- Identify copolymer that has best mechanical properties for processing (extrusion and capacitor winding)

Project Significance

- Nitro groups can disrupt crystallinity
 - Processing advantages
 - Improved material properties (solubility, pilling, brittleness, etc.)

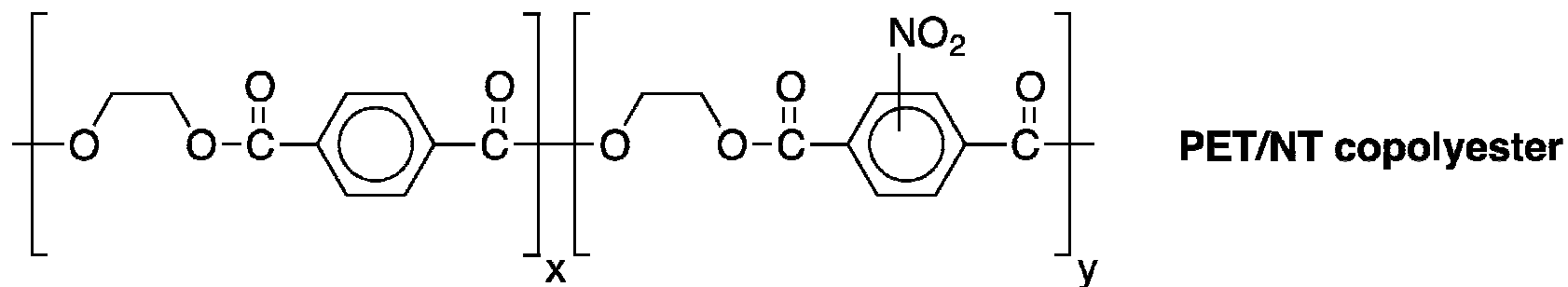


Synthesis



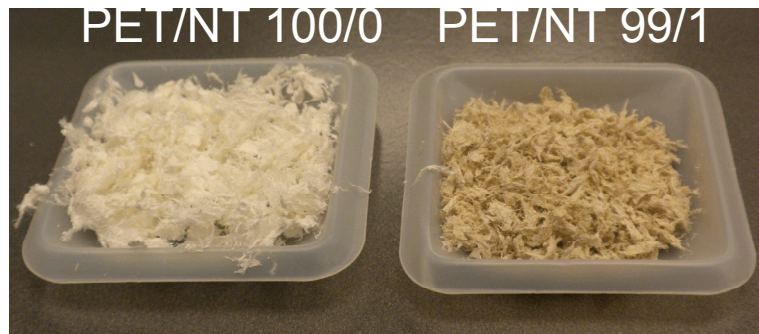
TBT = Titanium(IV) *t*-butoxide

1. Transesterification: TBT, 190 °C
2. Polycondensation: 220 °C - 270 °C



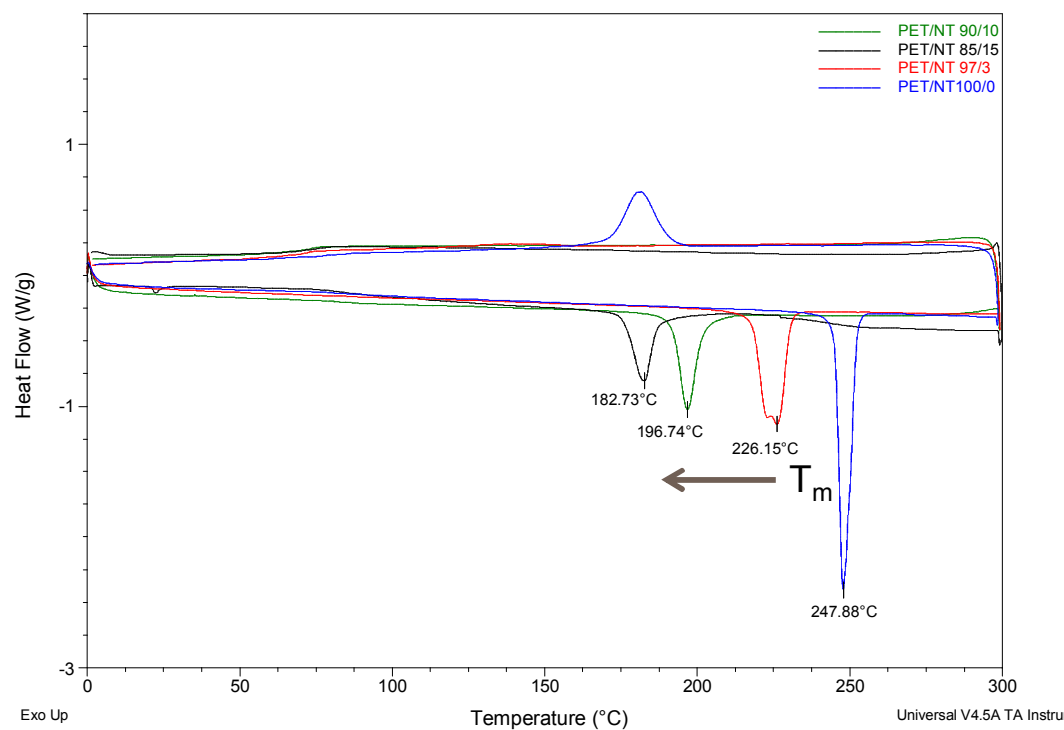
Film Preparation

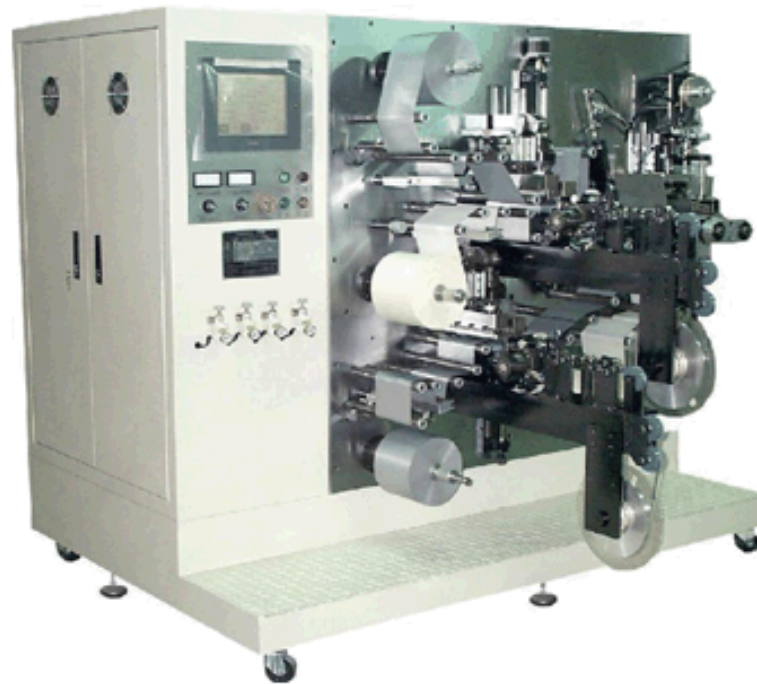
- Polymer is dissolved in 1,1,1,3,3,3-hexafluoroisopropanol
- Casted into film using a drawdown machine
- Dried and then annealed 20 °C below T_m for 12 hours.



Thermal Characterization

%NT	T_g (°C)	T_m (°C)	ΔH (J/g)
0	76	247	59
3	77	226	47
10	76	197	32
15	80	183	28





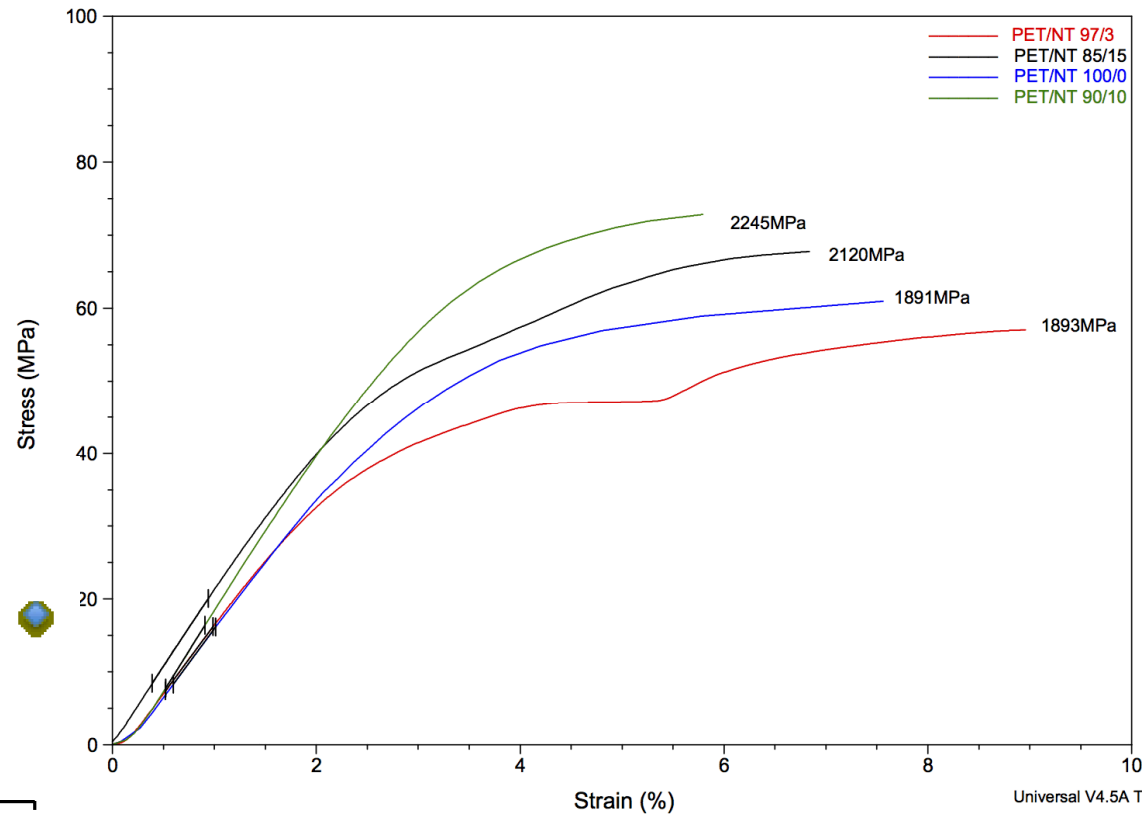
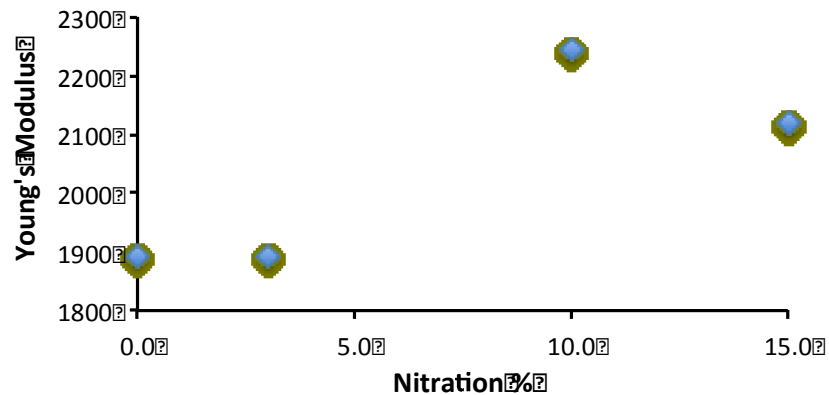
Study of Viscoelastic Properties: Below Melt Transition

MECHANICAL CHARACTERIZATION

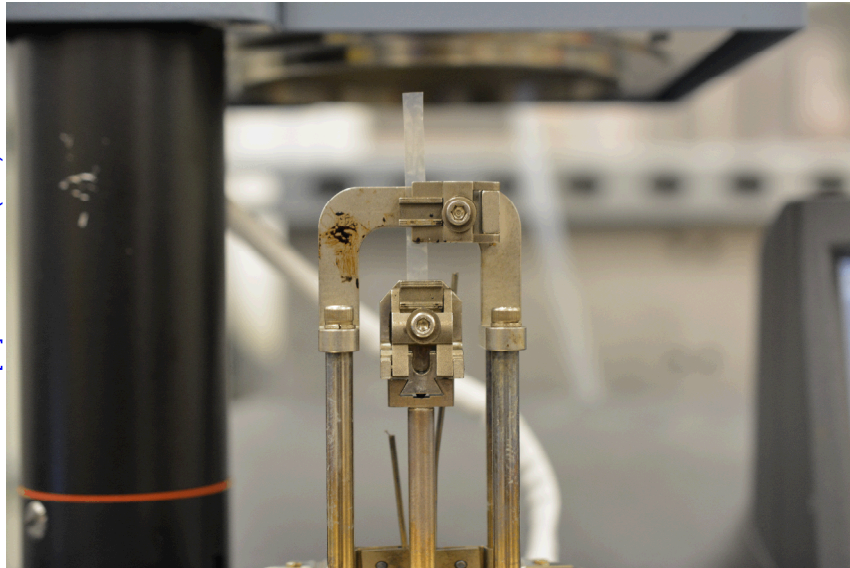
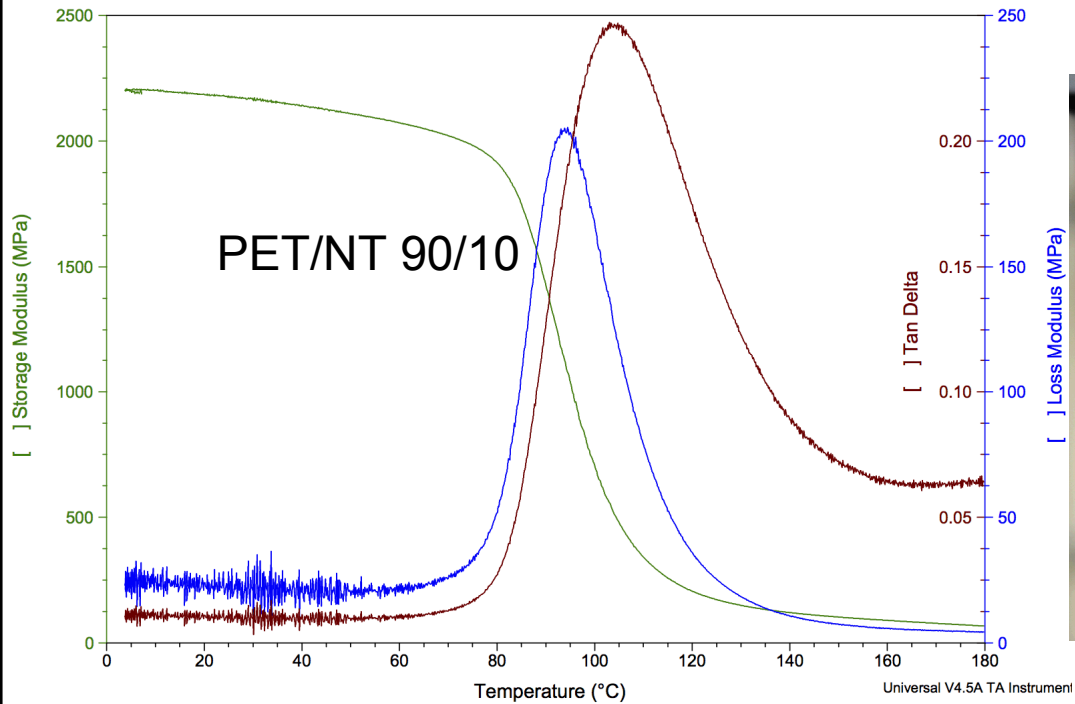
Image from <http://b2b-machinery.com>

Stress-Strain Study

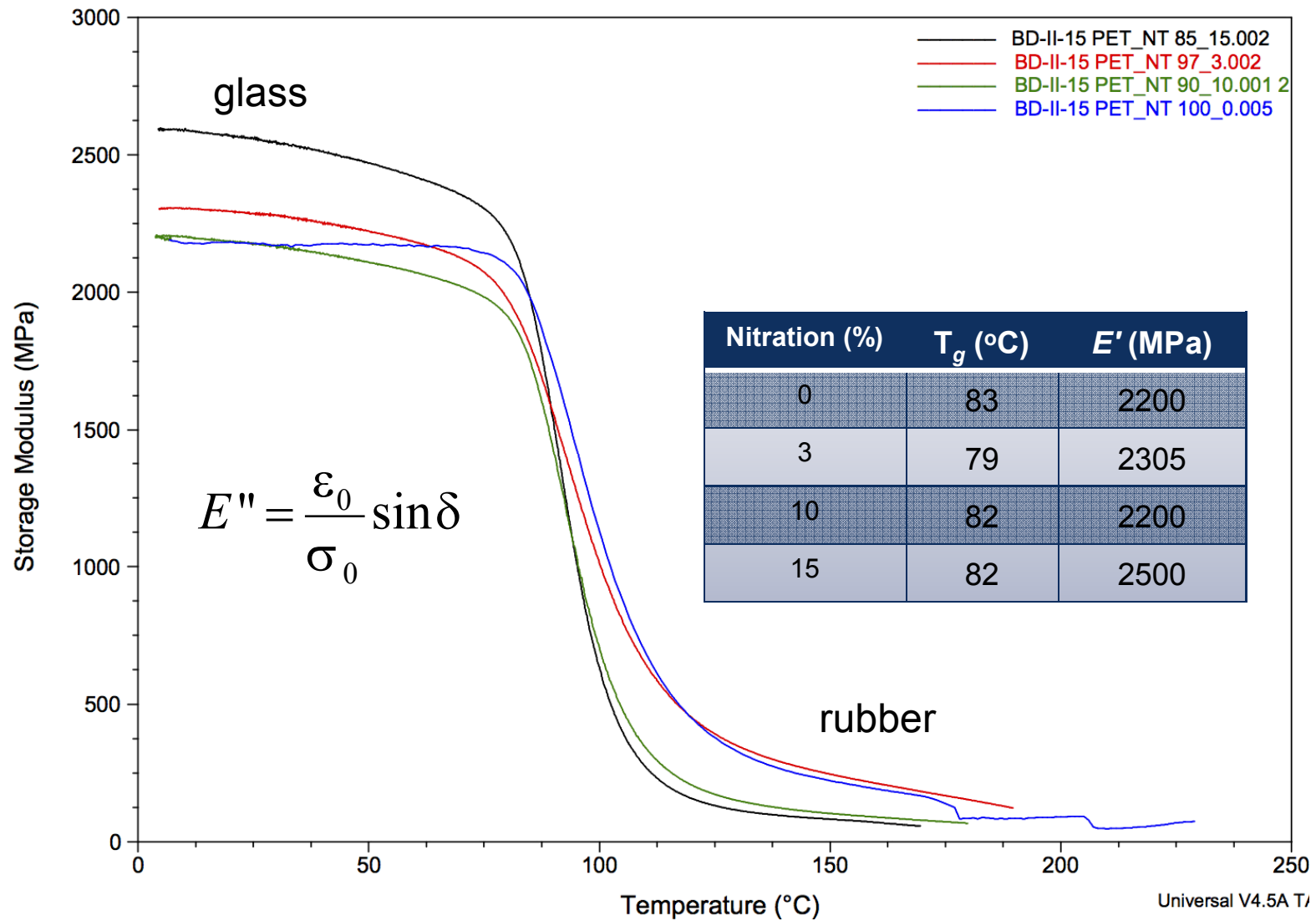
Nitration (%)	M_v	Modulus (MPa)
0	49000	1891
3	23000	1893
10	29000	2245
15	57000	2120



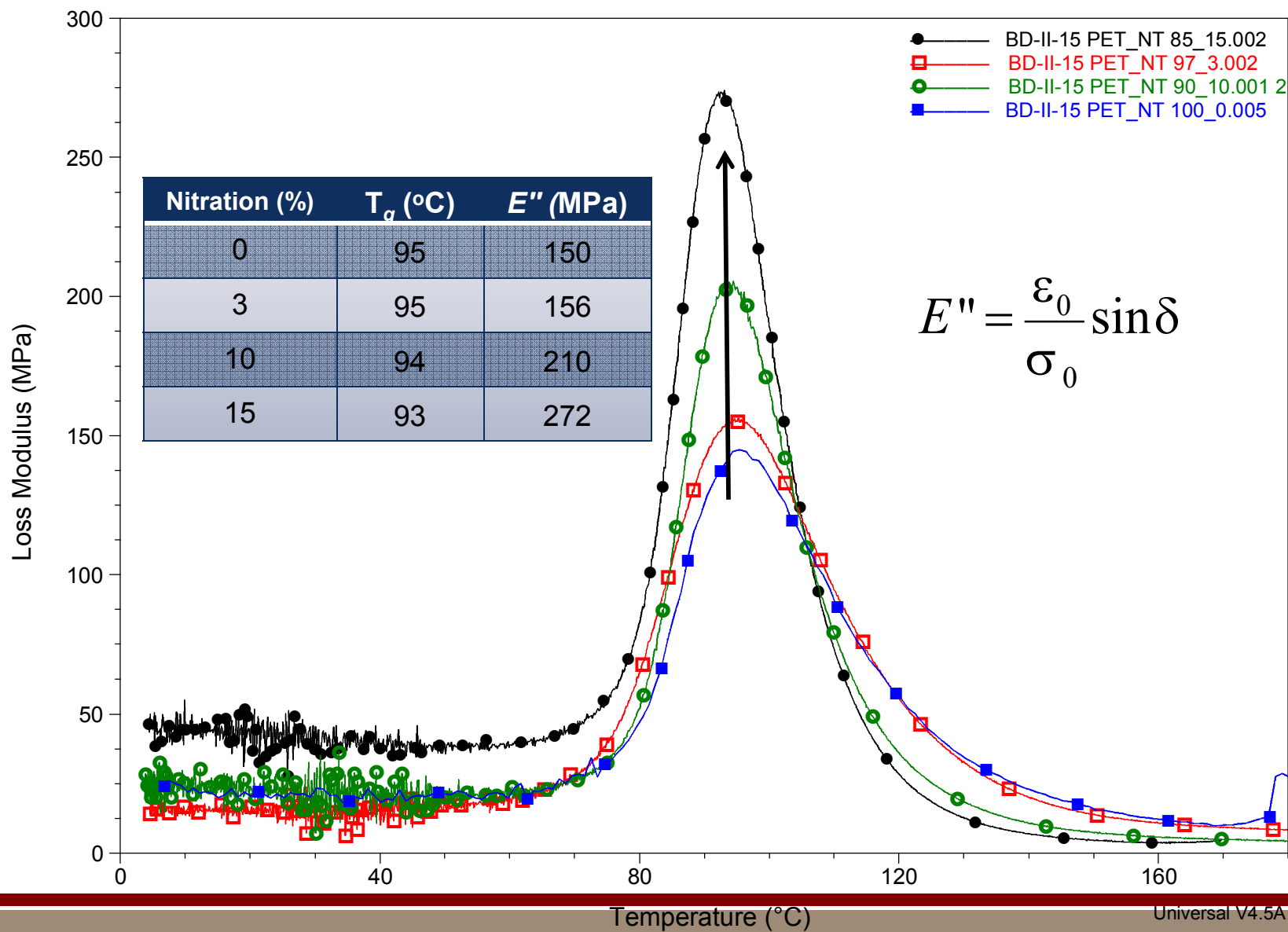
Viscoelastic Properties: Glass and Rubber Transition



Storage Modulus of PET Copolymers



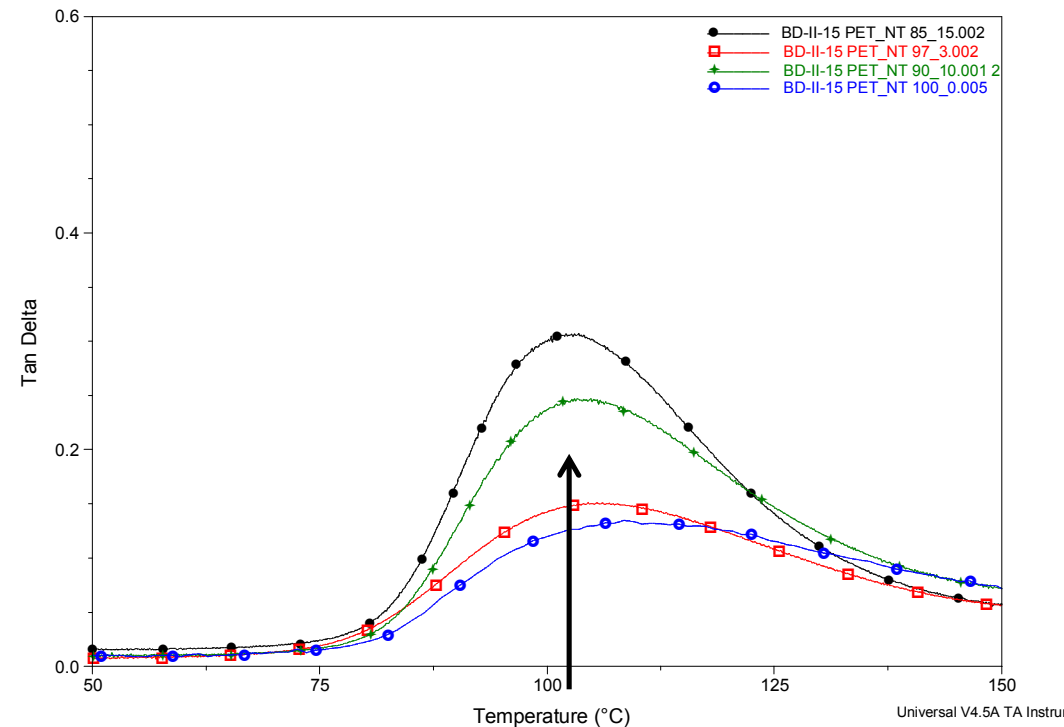
Loss Modulus of PET Copolymers



Tan Delta of PET Copolymers

Nitration (%)	T _g (°C)	Tan Delta
0	109	0.13
3	106	0.15
10	104	0.25
15	103	0.31

$$\tan \delta = \frac{E''}{E'}$$



- nitro group is assisting with collective motion
- nitro group break up packing
- Small effect because small pendent group

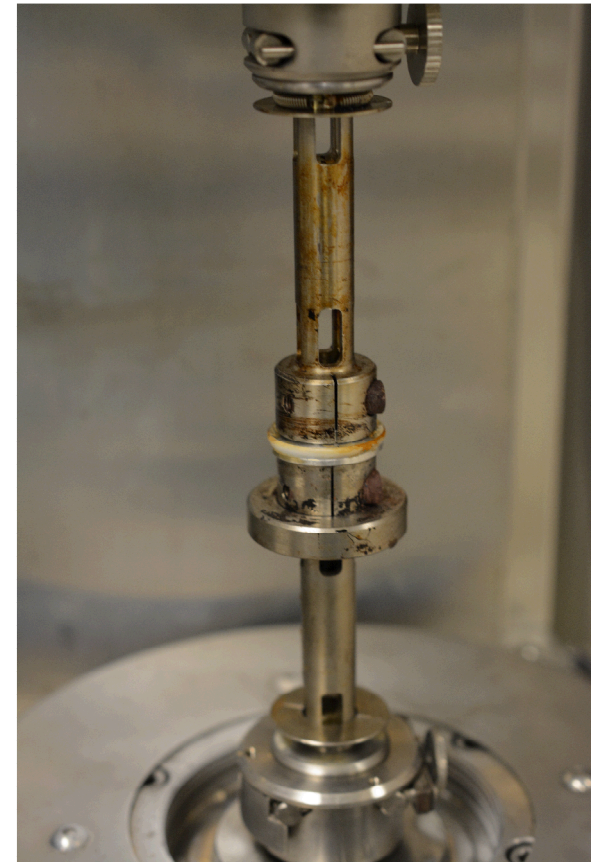
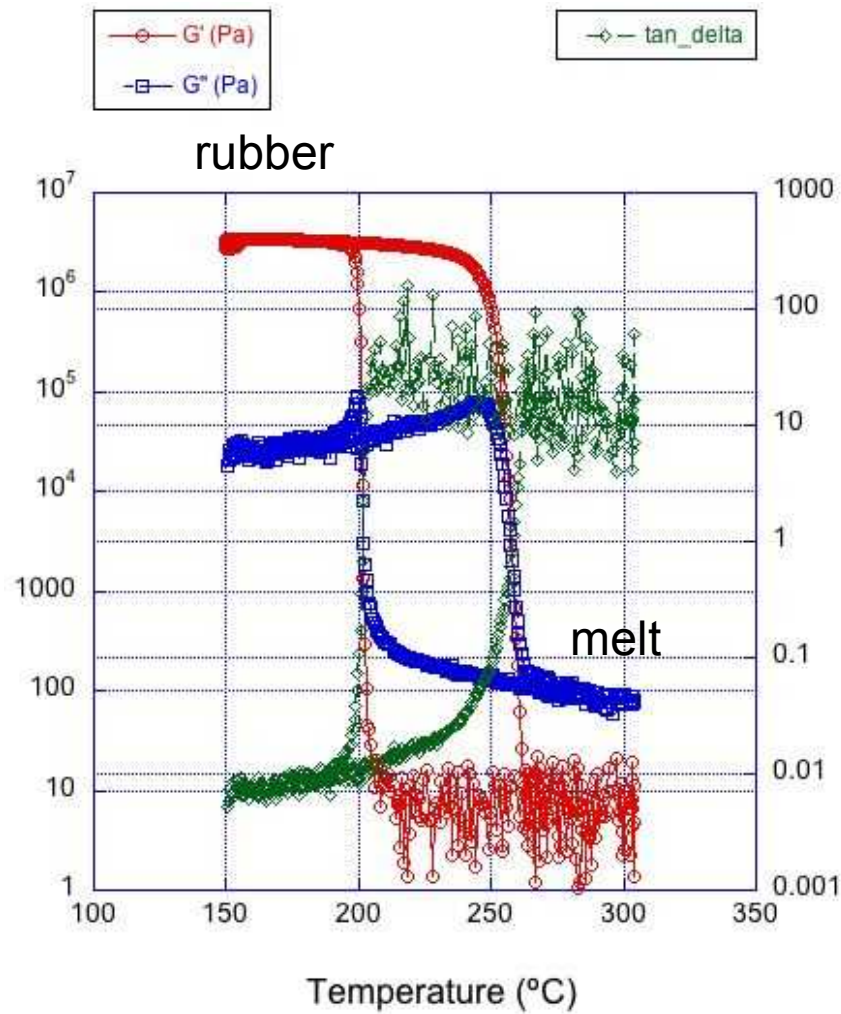


Study of Viscoelastic Properties for extrusion: Above Melt Transition

MECHANICAL CHARACTERIZATION

Image from <http://cnkaichi.en.made-in-china.com>

Viscoelastic Properties



Conclusion

- Nitrated-PET shows mechanical strengthening occurs upon nitration
- As nitration increases the tan delta increase
- Nitration allow processing to occur at lower temperature

Acknowledgements

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