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# *STUDIES ON THE COMBINED EFFECT OF MULTIWALLED CARBON NANO TUBES (MWCNT) AND MALEIC ANHYDRIDE GRAFTED POLYPROPOLENE (MA-g-PP) ON THE MECHANICAL AND THERMAL PROPERTIES OF POLYPROPELENE (PP)*

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# ABSTRACT


- Multi-wall carbon Nanotubes (MWNTs) filled polypropylene (PP) Nanocomposites were prepared through diluting a PP/MWNT master batch in a PP matrix by melt compounding with a twin screw extruder. Polypropylene grafted Maleic anhydride (PP-g-MA) was used to promote the carbon Nanotubes dispersion. When PP-g- MA is added, dynamic moduli and viscosity further increases compared to PP/MWNT Nanocomposites. Tensile and Charpy impact resistance of the Nanocomposites also increased by the addition of PP-g-MA.

# ABSTRACT


- The present study confirms that PP-g-MA is efficient to promote the dispersion of MWNTs in PP matrix and serves as an adhesive to increase their interfacial strength and mechanical properties of PP/MWNT Nanocomposites.

- It was also found that MWNTs can act as nucleating agents and increase the crystallization temperature of the PP matrix in Nanocomposites.

# MATERIALS

- Polypropylene (PP)-multi wall carbon nanotubes (MWNTs) nano-composites were produced by mixing homo PP granules [Polychim polypropylene with a melt flow index of 12 g/10 min. at 190°C] and 2 wt% PP-g-MA [Dupont Fusabond] with the commercial masterbatch containing 20 wt% of MWNT ['Plasticyl 2001' supplied by Nanocyl, Belgium].
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- The MWCNTs 'Plasticyl 2001' supplied by Nanocyl, Belgium was used as filler reinforcement with purity higher than 90% with Range of Diameter of 9–11 nm and Mean Length of the Nanotubes of 1.2 µm.

# PREPARATION OF PP/MWCNTS COMPOSITES

- Polypropylene (PP)-multi wall carbon nanotubes (MWNTs) nanocomposites were produced by mixing homo PP granules and 2 wt% PP-g-MA with the commercial masterbatch containing 20 wt% of MWNT in a co-rotating twin screw extruder at barrel temperature of 195–210℃, and a screw speed of 50 rpm.

# PREPARATION OF PP/MWCNTS COMPOSITES

- The specifications of MWNTs in the masterbatch are as follows: range of diameter 9–11 nm, mean length of the nanotubes 1.2 μm, and purity higher than 90%.
- During melt extrusion ventilation was kept on to remove trapped air in blends.
- After pelletizing, the nanocomposite granules were compression moulded into 4 mm thick plates using a hydraulic press at 180℃ during 2 min for rheological experiments.

## PREPARATION OF PP/MWCNTS COMPOSITES

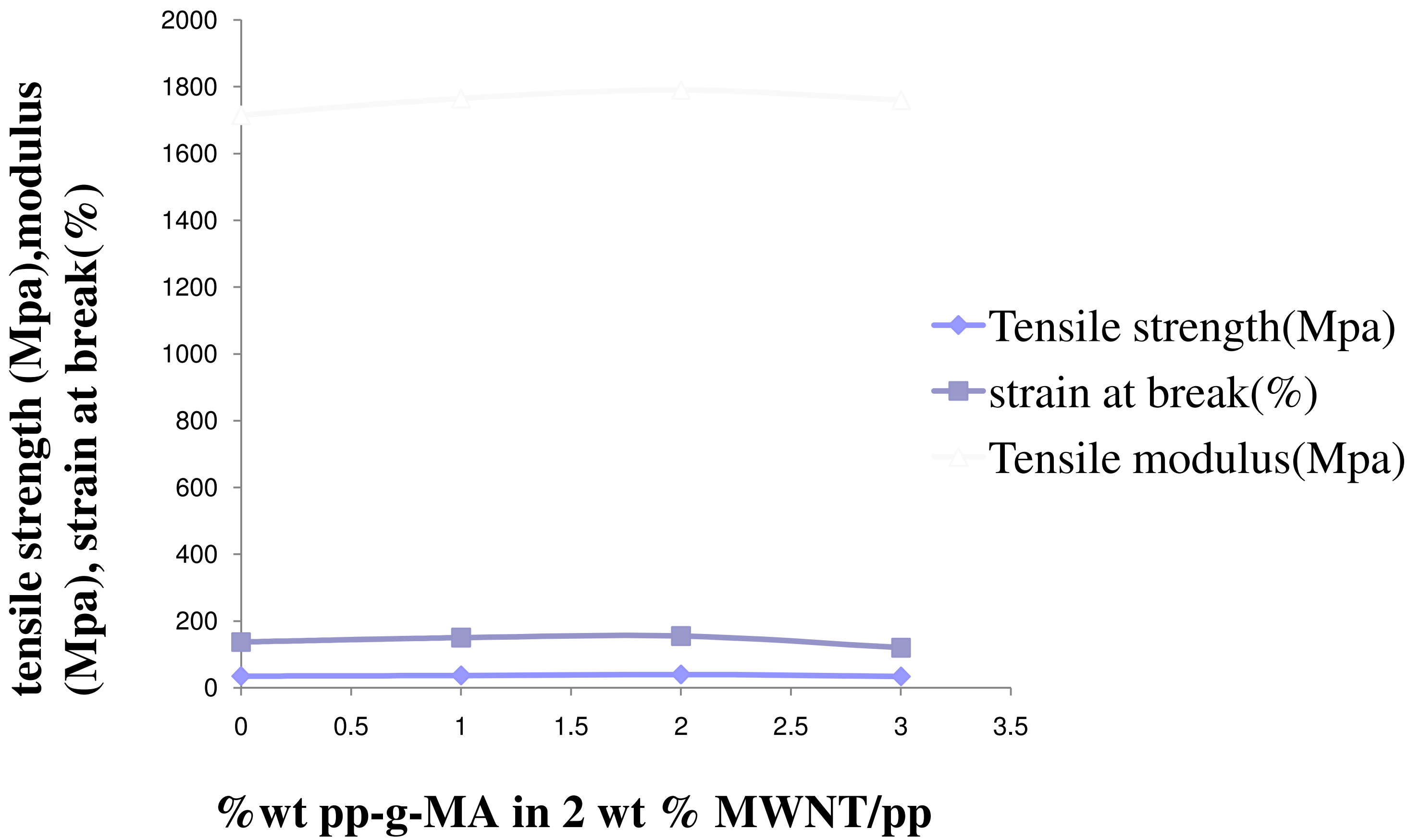
- Nanocomposite granules were Injection molded into standard test specimen for finding properties like tensile, impact and flexural test.
- The barrel temperature ranged 205–220℃ and the mould temperature was kept at 25℃.
- The holding pressure and screw rotational speed were 300 bar and 100 rpm, respectively.

# MECHANICAL PROPERTIES

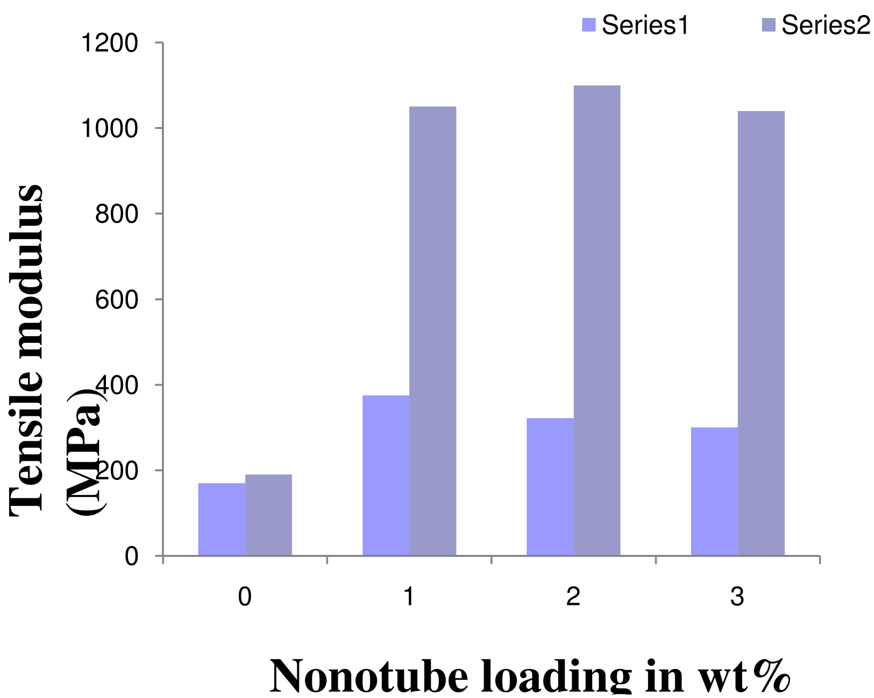
## Tensile properties of MWNT/PP composites

| Wt% of MWNT | Tensile modulus (Mpa) | Strain at break (%) | Tensile strength ($N/mm^2$) |
|---|---|---|---|
| 0 | 171 | 62 | 15 |
| 1 | 380 | 46 | 22 |
| 2 | 328 | 45 | 30 |
| 3 | 289 | 39 | 36 |

# Effect of PP-g-MA content on tensile properties of PP/MWNT Nanocomposites



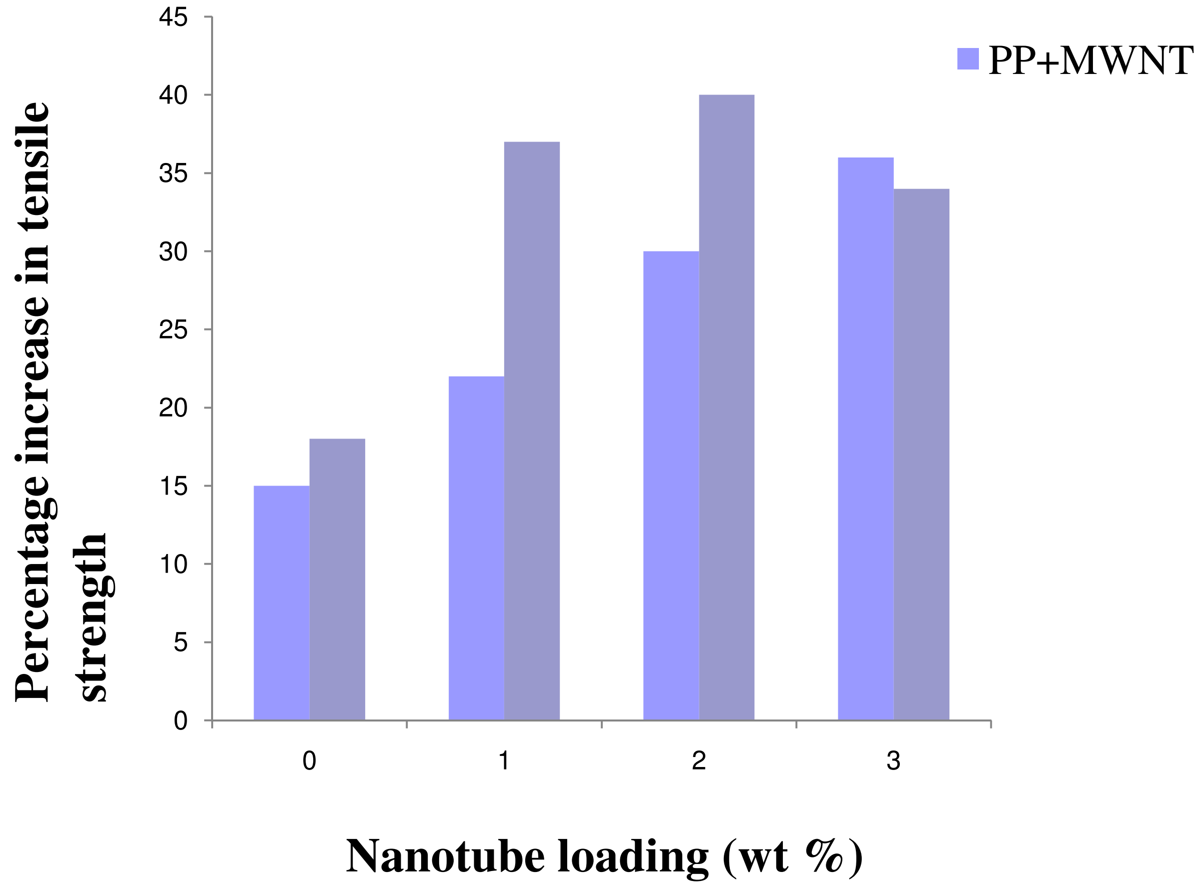
Percentage increase in tensile modulus with respect to PP and PP-g-MA as a function of MWNT content for the PP/MWNT and PP/MWNT/2 wt% PP-g-MA composites.



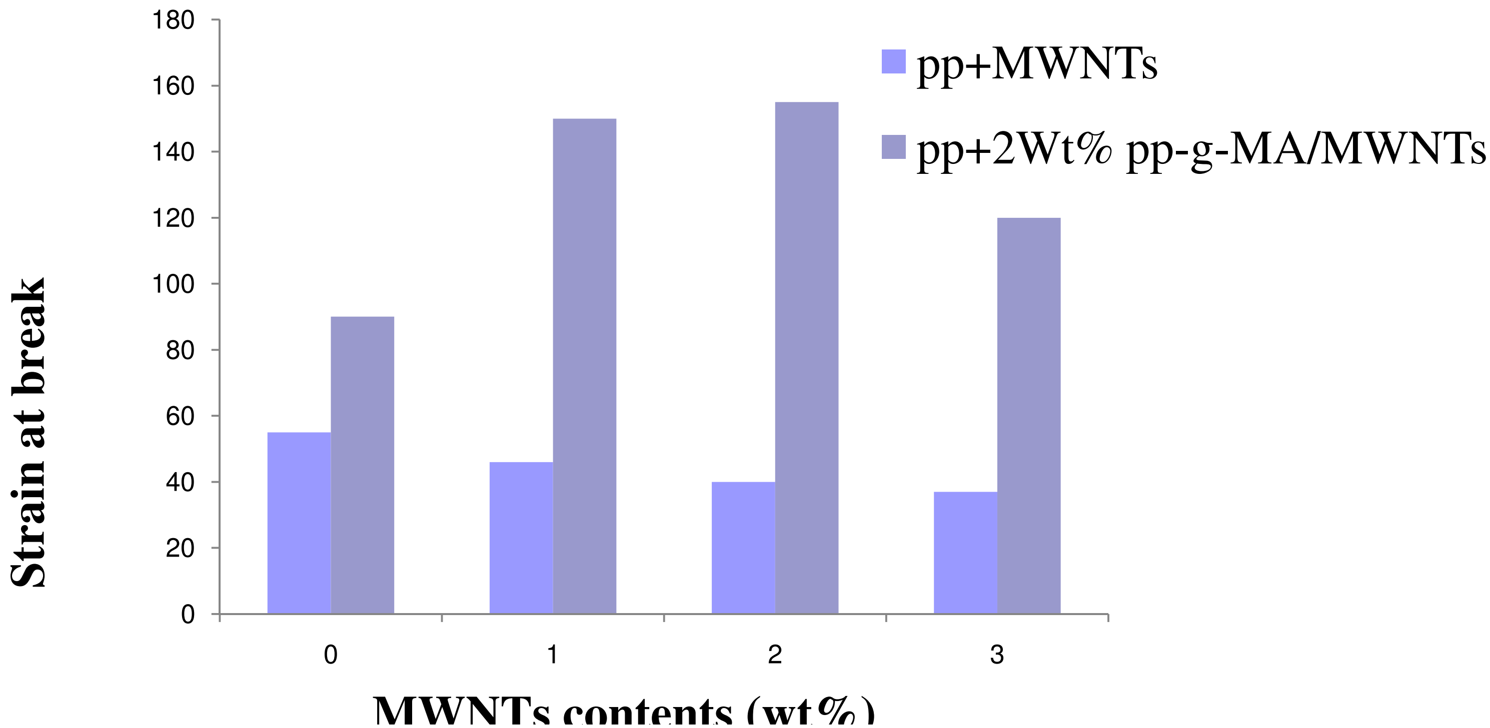

Tensile Strength for MWNT/MA-g-PP composite

| Wt% of WNT | Tensile modulus (Mpa) | Strain at break (%) | Tensile strength (N/mm2) |
|---|---|---|---|
| 0 | 1752 | 136 | 35 |
| 1 | 1799 | 153 | 37 |
| 2 | 1782 | 154 | 40 |
| 3 | 1777 | 122 | 34 |

## Percentage increase in tensile strength with respect PPand PP-g-MA as a function of MWNT content for the PP/MWNT and PP/MWNT/2 wt% PP-g-MA composites.



# Variation of percentage strain at break with MWNT content for the the PP/MWNT and PP/MWNT/2 wt% PP-g-MA composites



## Notched Charpy Impact Strength for PP/MWNT Composite

| Wt% of MWNT | Impact energy (KJ) | Notched charpy impact strength ($KJ/m^2$) |
|---|---|---|
| 0 | 7.44479×10-5 | 2.25 |
| 1 | 9.5260×10-5 | 2.9 |
| 2 | 10.5664×10-5 | 3.15 |
| 3 | 9.72108×10-5 | 2.95 |

## Notched Charpy Impact Strength for PP-g-MA/MWNT Composite.

| Wt% of MWNT | Impact energy (KJ) | Notched charpy impact strength (KJ/m2) |
|---|---|---|
| 0 | 8.45312×10-5 | 2.3 |
| 1 | 10.6964×10-5 | 3.25 |
| 2 | 12.256×10-5 | 3.75 |
| 3 | 13.914×10-5 | 4.25 |

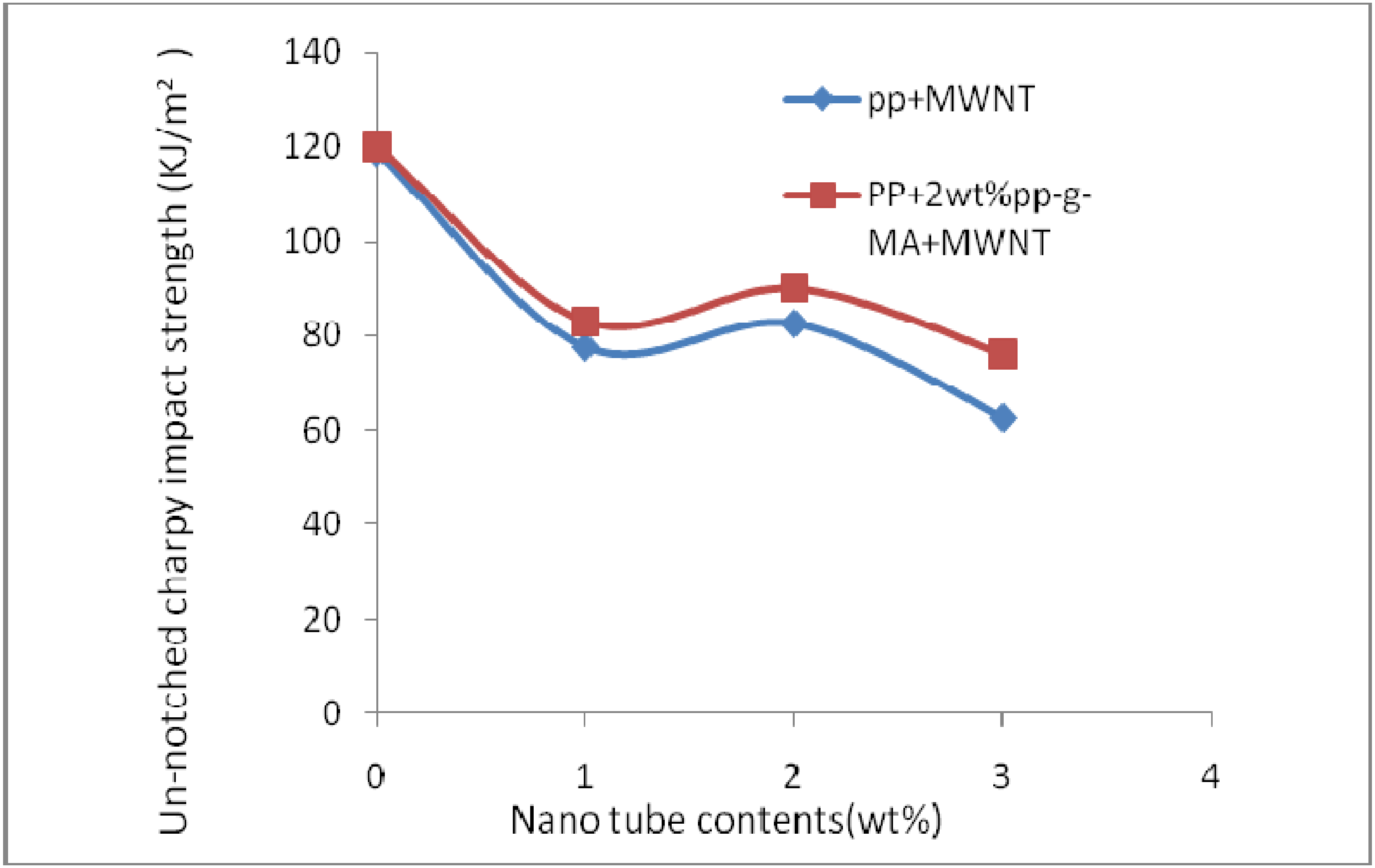
## Unnotched Charpy Impact Strength for PP/MWNT Composite.

| Wt% of MWNT | Impact energy (KJ) | Unnotched charpy impact strength (KJ/m2) |
|---|---|---|
| 0 | 4.9032×10-3 | 118.75 |
| 1 | 3.483×10-3 | 77.5 |
| 2 | 3.4633×10-3 | 82.5 |
| 3 | 2.6375×10-3 | 62.5 |

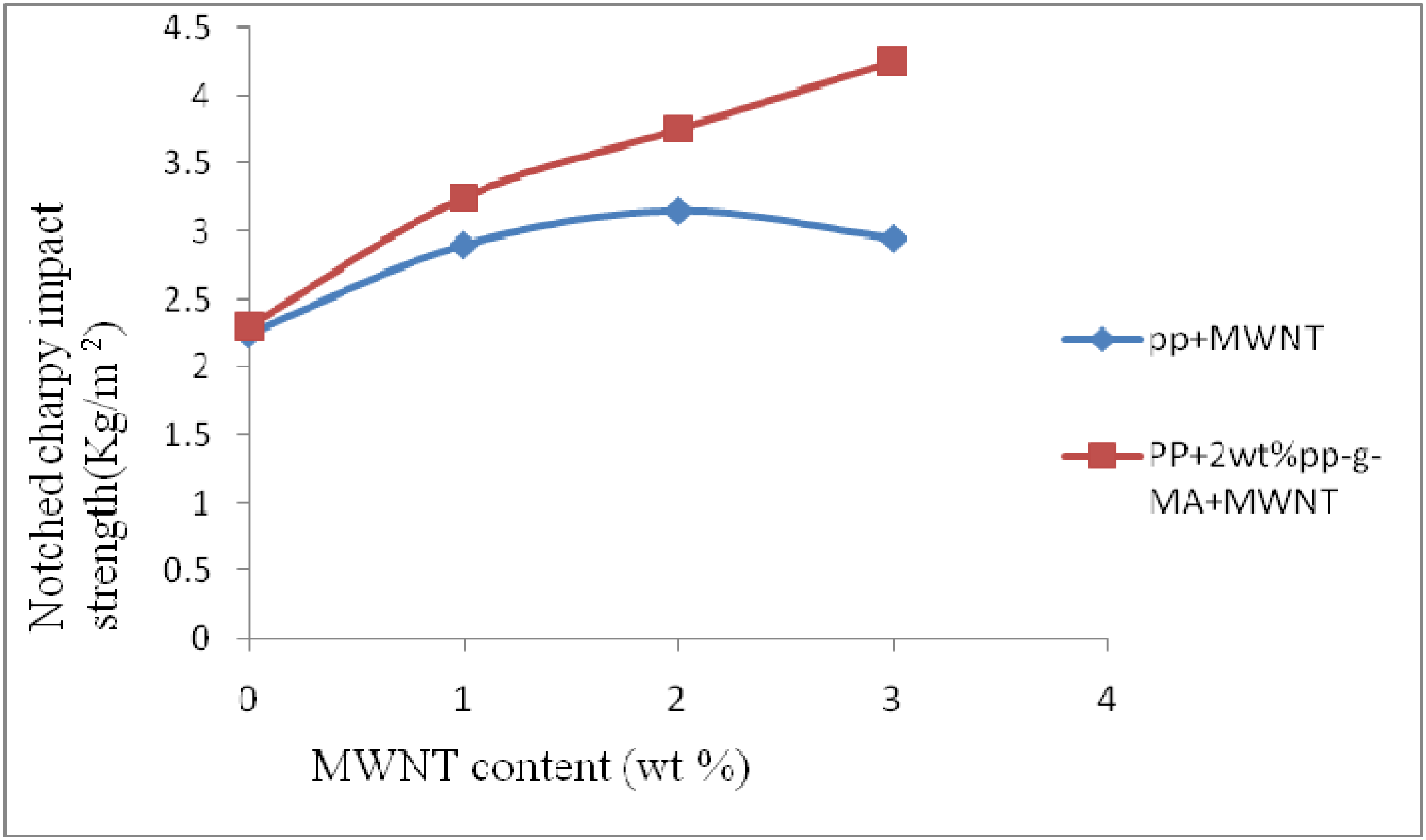
## Unnotched Charpy Impact Strength for MWNT/MA-g-PP composite.

| Wt% of MWNT | Impact energy (KJ) | Unnotched charpy impact strength (KJ/m2) |
|---|---|---|
| 0 | 4.9580×10-3 | 120 |
| 1 | 3.495×10-3 | 83 |
| 2 | 3.779×10-3 | 90 |
| 3 | 3.1699×10-3 | 76 |

# Impact properties of PP/MWNT



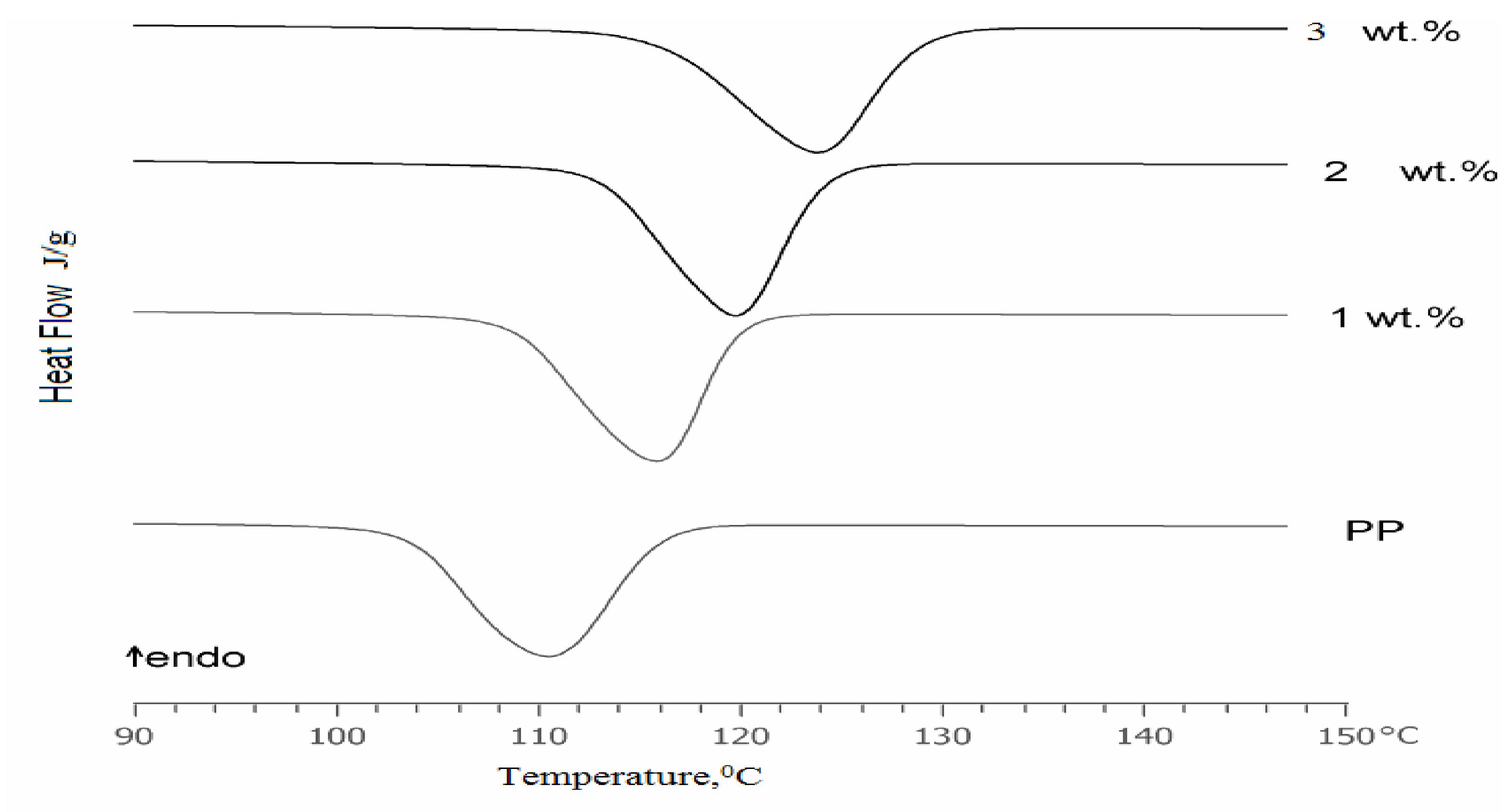
# PP/MWNT/2wt% PP-g-MA Nanocomposites



# DSC Results

| Sample | MWNTs [wt.%] | PP-g-MA [wt.%] | Tc [°C] | Xc [%] | ΔHm (J/g) |
|---|---|---|---|---|---|
| PP | 0 | 0 | 110.8 | 31.5 | 65.8 |
| PP/MWNTs | 1 | 0 | 115.6 | 31.0 | 65.4 |
| | 2 | 0 | 119.6 | 31.2 | 66.9 |
| | 3 | 0 | 123.8 | 29.1 | 64.0 |
| PP/PP-g-MA/MWNTs | 1 | 1 | 117.0 | 30.5 | 64.4 |
| | 2 | 2 | 120.5 | 29.4 | 63.0 |
| | 3 | 3 | 122.5 | 28.8 | 63.4 |

# DSC cooling curves of pure PP and PP-g-MA/MWNT nanocomposites.



# RESULTS & DISUSSIONS

- Multi-wall carbon nanotubes (MWNTs) filled polypropylene (PP) nanocomposites were prepared by melt compounding via masterbatch dilution technique. Polypropylene grafted maleic anhydride (PP-g-MA) was added to promote the carbon nanotubes dispersion.

- The mechanical characterization has shown that both the tensile and bending moduli and strengths of the nanocomposites increased by the addition of nanotubes, and the addition of PP-g-MA further improved these properties.

## RESULTS & DISUSSIONS

- However that tensile elongation at break decreases with the addition of PP-gMA.
- The Charpy impact strength increases, passes through a maximum and then decreases for notched samples, whereas for un-notched samples, a decrease is observed with the addition of MWNTs due to the presence of nanotubes aggregates.
- Nevertheless, the addition of 2 wt% PP-g-MA to the composites tends to improve these impact properties.

## Conclusions

- It has been demonstrated that the use of PP-g-MA has lead to the better dispersion of carbon nanotubes in a PP matrix, and thus better mechanical properties and [lower rheological percolation threshold.] Moreover the possibility to coat the nanotubes with PP-g-MA directly in the extruder can promote, insitu during the extrusion, the disentanglement of the carbon nanotubes. This technique may also be extended to other matrices by changing the type of compatibilizer.

- It can also be conculded that by Diluting thermoplastics/ MWNTs masterbatches to manufacture plastic parts is a very promising route.Allows to retain the functional benefits of well-dispersed MWNTs, and limiting the handling difficulties in plastics processing industrial workshops.

- Finally it can be concluded that MWNTs can act as nucleating agents and increase the crystallization temperature of the PP matrix in nanocomposites.

THANK YOU

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