

Hyperbranched Polymers and Dendrimers as Additives for Polypropylene

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Abstract

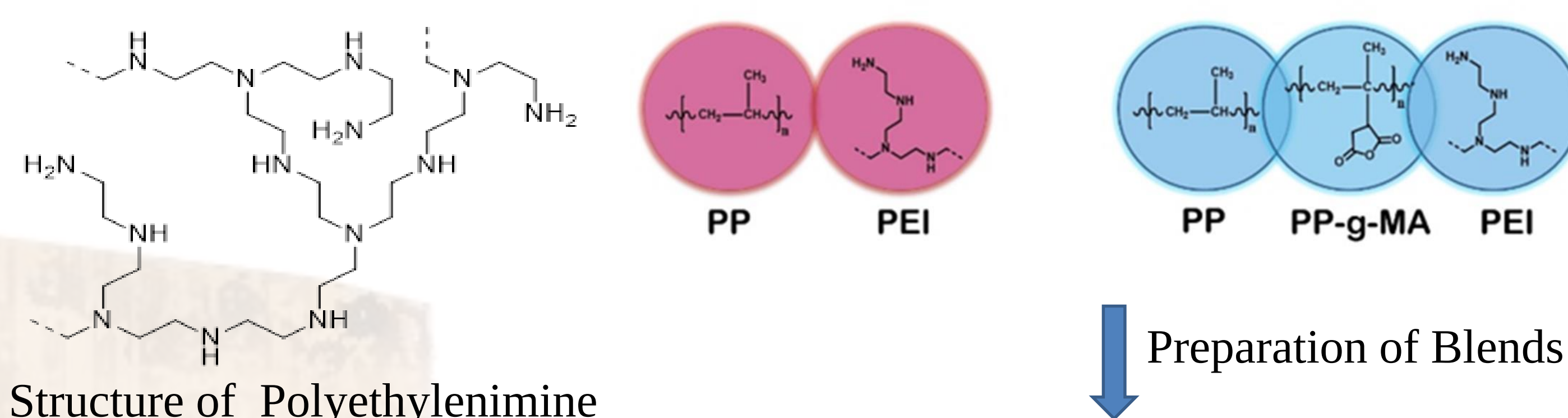
Hyperbranched polymers (HBP) or dendrimers have been used as additives for thermoplastics. Incorporation of HBPs or dendrimers in commodity thermoplastics, such as, polypropylene (PP) have proven to increase its toughening properties, nucleating efficiency, processability etc. Here, we report Polyethyleneimine (PEI), a hyperbranched polymer having primary, secondary and tertiary amine groups as a nucleating agent for polypropylene in the presence of a compatibilizer. Compatibilized PP/PEI blends show improved mechanical properties as well as crystallization behaviour. They also display ability to capture carbon dioxide, which was analyzed by thermogravimetric analysis (TGA).

Introduction

Polypropylene (PP) is the most popular commodity thermoplastic used worldwide. However, it is prone to oxidation and has poor impact properties, which limits its application range [1]. Hyperbranched polymers and dendrimers are 3-dimensional macromolecules that possess unique properties such as low viscosity, globular structure and large number of functional end groups [2]. Polyethyleneimine, a hyperbranched polymer having numerous amine functionalities has been used as an additive for polypropylene. PP/PEI blends compatibilized with maleic anhydride grafted PP (PP-g-MA) have shown enhanced thermal, mechanical and optical properties [3].

Materials and Methods

Polypropylene (Grade-PP1110MG, Mn = 121220 Da), Polyethyleneimine (Mw = 25000 g/mol), Maleic anhydride grafted PP (Grade-Optim P-425, MFI = 50 g/10 min)



DSC
TGA
PLOM
SEM
DMA
Mechanical
Properties

Characterization



Rheomix

Conclusions

It was observed that by addition of PEI, crystallisation peak of PP decreased, as confirmed by DSC and PLOM studies. PP-g-MA promoted the interaction between PP and PEI and improved the crystallization behaviour of the blends significantly. PLOM studies confirmed the ability of PEI to act as a nucleating agent for PP. In SEM, better interaction of compatibilized PP/PEI was observed. Mechanical testing of these blends showed that for PP/PEI blends, the impact properties improved in a significant way. These observations were further supported by DMA study. PP/PEI blends have a salient feature of adsorbing carbon dioxide due to numerous amine groups that trap carbon dioxide via carbamate formation.

Industrial Significance

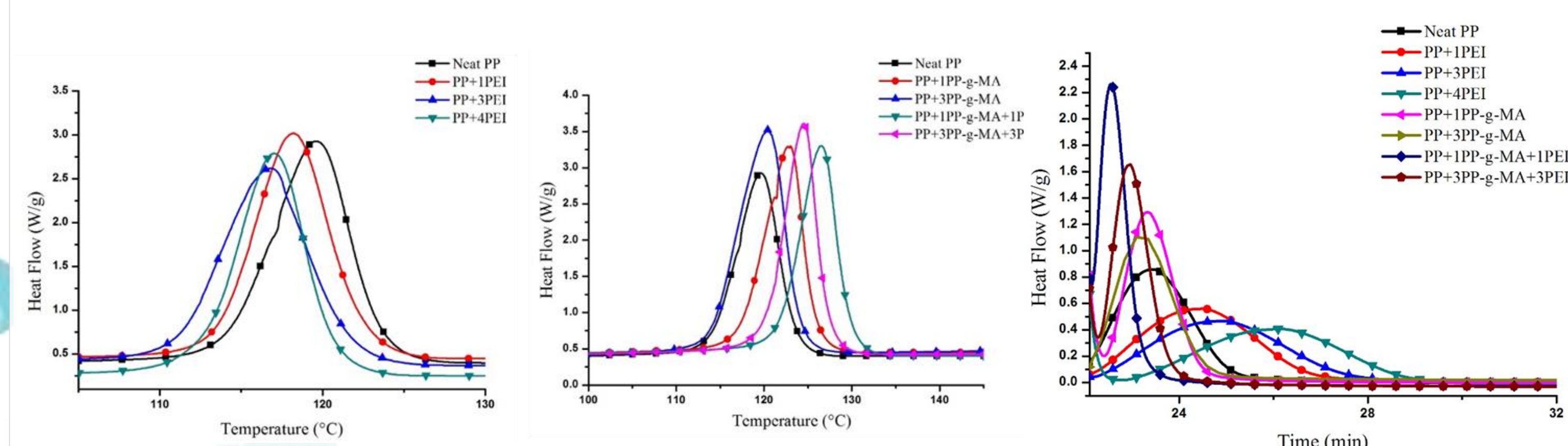
1. PEI can be used as a nucleating agent in the presence of PP-g-Ma as compatibilizer which can reduce the production cycle time of PP products.
2. PP/PEI can be used in the making of air filters due to its ability to capture carbon dioxide.

Technology Readiness Level:

The technology is ready to transfer.

Result

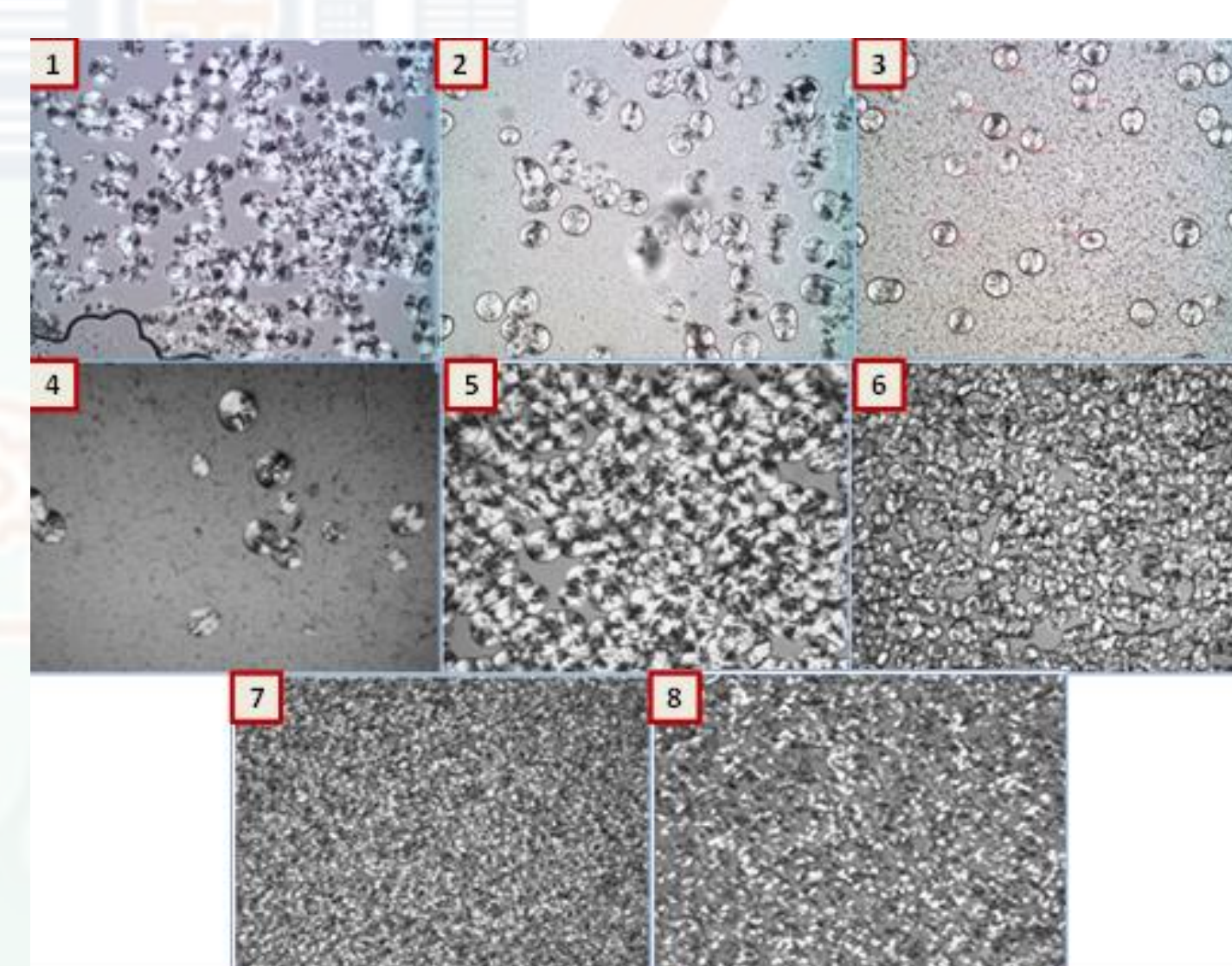
Crystallization behaviour of PP/PEI blends



Non-Isothermal crystallization

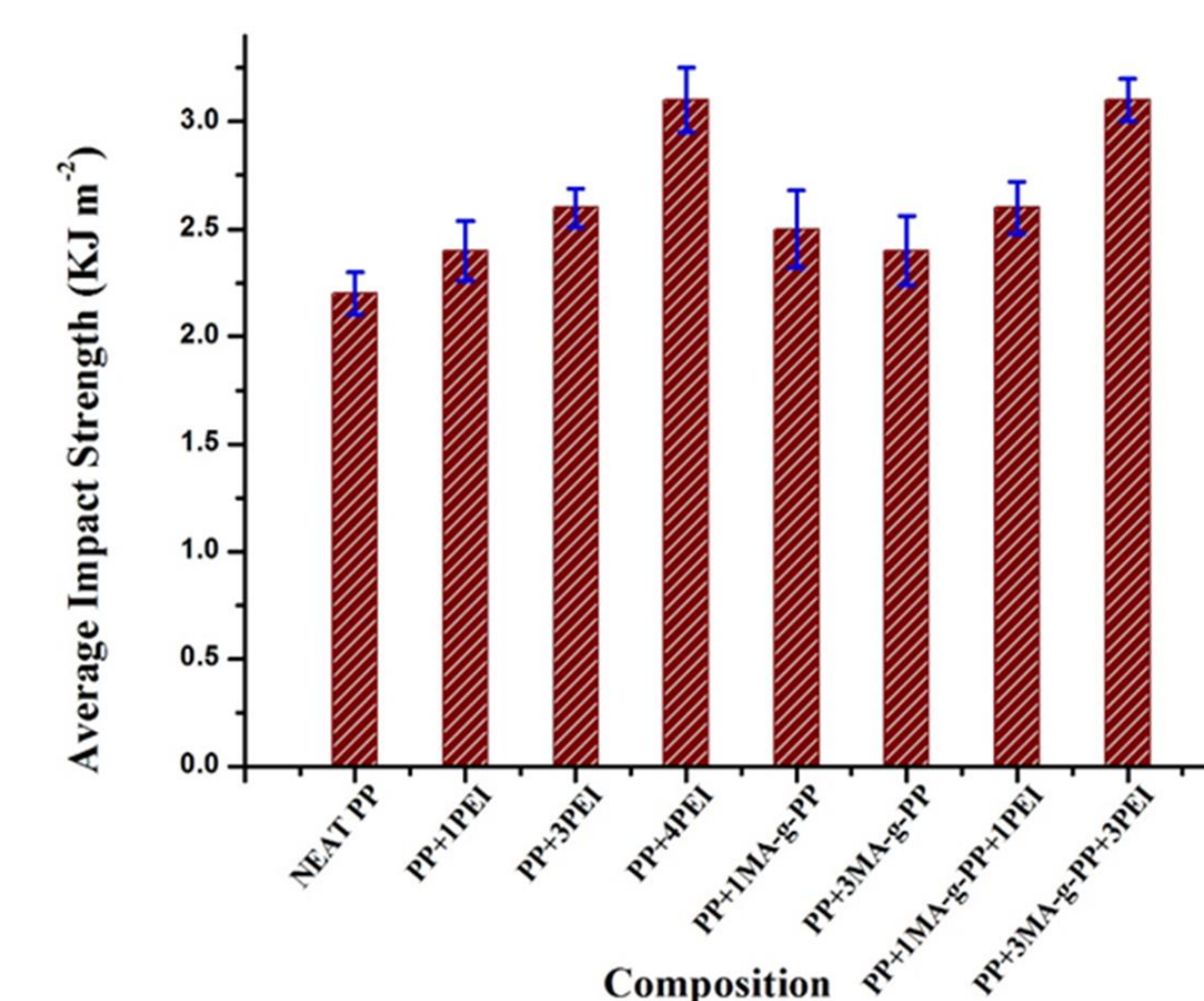
Isothermal crystallization (124 °C)

Polarized Light Optical Microscopy



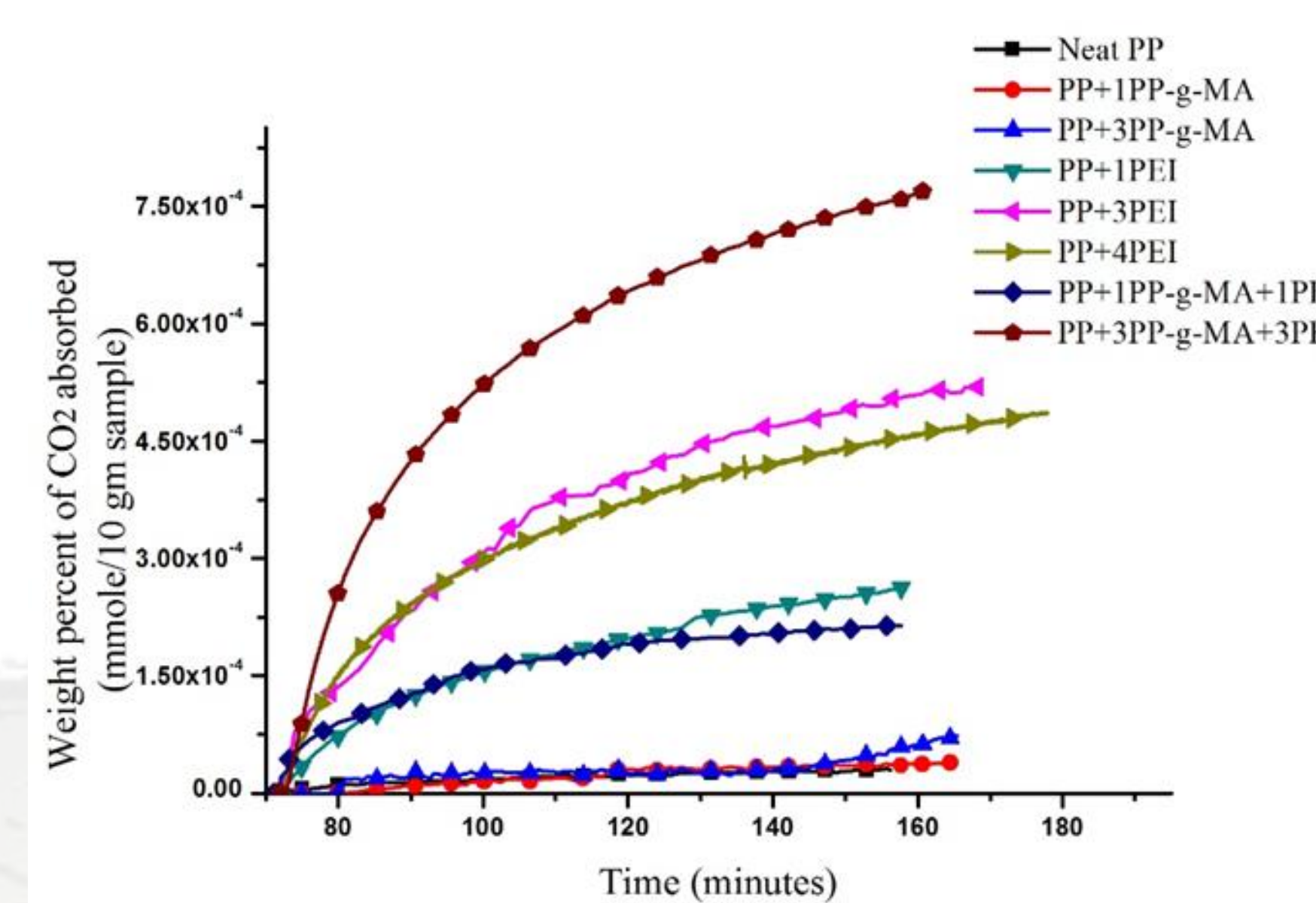
PLOM micrograph of (1) PP, (2) PP+1PEI, (3) PP+3PEI, (4) PP+4PEI, (5) PP+1PP-g-MA, (6) PP+3PP-g-MA, (7) PP+1PP-g-MA+1PEI, (8) PP+3PP-g-MA+3PEI

Impact strength



Impact strength of PP/PEI and PP-g-MA/PEI blends

CO₂ adsorption of PP/PEI blends



Carbon dioxide adsorption of a) Neat PP, b) PP+1PEI, c) PP+3PEI, d) PP+4PEI, e) PP+1PP-g-MA, f) PP+3PP-g-MA, g) PP+1PP-g-MA+1PEI, h) PP+3PP-g-MA+3PEI blends.

References

1. Gang X, Shi W et al, Eur Polym J. 2005;41:1828-37.
2. Fréchet M J, Hawker J J et al, J Macromol Sci A. 1996;33:1399-1425.
3. Patra P. K., Jaisingh A. et al, Polym Eng Sci. 2019,doi: 10.1002/pen.25211

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