

Thermal Properties of Thermoplastic Rubber (TPR) Reinforced with Polytetrafluoroethylene (PTFE) Particle Polymer Composite

R. Mahesh Kumar, N. Rajini

Abstract - Thermal exploration of thermoplastic rubber (TPR) and its composites has been playing a vital role in polymer industries during the past few decades. TPR is a compound which shows a thermoplastic character over its melting temperature and has elastomeric conduct within its design temperature range without cross-linking during fabrication. PTFE particles have a high temperature application and discover the best filler particle in the composite. Samples of 100% TPR and 10% PTFE by weight, 20% PTFE by weight mixed specimens with TPR were prepared by utilizing Injection molding strategies. Test results demonstrate PTFE filler included composites displaying high thermal conductivities.

Keywords: Thermoplastic Rubber (TPR) matrix, Polytetrafluoroethylene (PTFE) particle, Thermal properties, Injection molding manufacturing

I. INTRODUCTION

TPR is a copolymer composed of thermoplastic polymer and elastomer. The thermal testing of TPR polymer composites is a basic procedure for product design, improvement and assembling process.

The test reports of TPR polymer composites are used in the assembling procedure for car, in aviation, shopper, therapeutic and defense ventures. The wide variety of thermal testing strategies accessible currently decides the thermal properties of TPR composites for applications on a wide temperature scale [1].

Significant cost saving induces designers to utilize TPR's in plastic industry. Traditional rubber, regardless of whether natural or manufactured, is a thermosetting material that must experience a chemical cross-linking response during moulding, normally called curing or vulcanization. This response leads to non-process ability in any standard thermoplastic equipment [2]. The time that it takes for the vulcanization process to finish is somewhere close to few minute or a few hours. The thermoplastic moulding and extrusion of TPRs, avoids cross-connecting step and can accomplish quick cycle times, which can be as meagre as 20 seconds. TPRs are a unique class in thermoset applications by cost wise, environmental safe of designing materials [3].

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The melting capacity of TPRs makes them extremely reasonable for high-volume injection moulding and extrusion. As TPRs show high elasticity, our material display rubber like properties and offer an extensive variety of hardness, low pressure set, and high elongation.

TPR finds use in making suspension bushings for automotive applications due to its more prominent protection from twisting when contrasted with regular rubber bushings. TPR has witnessed developments in the heating, ventilation, and air conditioning (HVAC) industry as fans and casing, due to its features of the capacity, cost adequacy and flexibility [4]. TPR may likewise be utilized in medicinal gadgets and is additionally discovering an ever

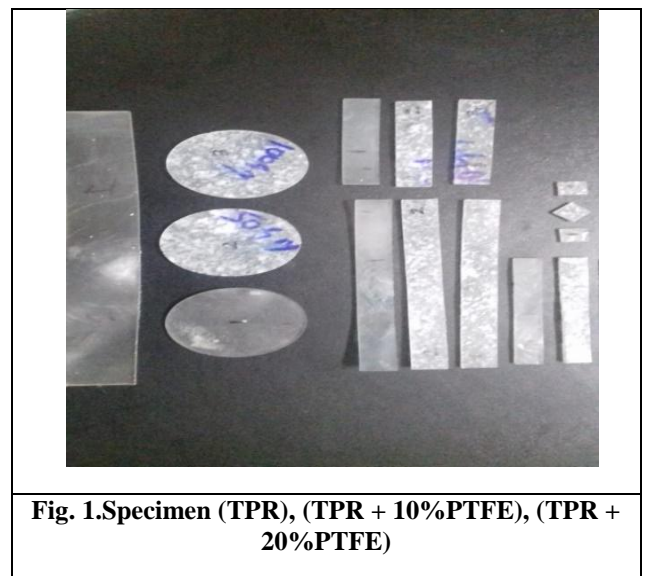


Fig. 1. Specimen (TPR), (TPR + 10%PTFE), (TPR + 20%PTFE)

increasing number of usages as an electrical cable jacket and inner insulation [5].

Carbon fluorine bonds in PTFE are recognized by their slippery surface, high melting point, high quality, strength, self-lubrication, great adaptability and protection from attack from all synthetic compounds [6]. Handling technique for PTFE is troublesome, because of high melting temperature (327°C). Subsequent to melting it does not accomplish fluid state and resembles a gel as it has no crystalline stage and high melt viscosity.

II. MATERIALS AND METHODS

Polytetrafluoroethylene powder particles (PTFE) were utilized for thermal reinforcement in this work. Powder PTFE polymers were acquired from M/s. Modoplast Company Pvt. Ltd, Kolkata, West Bengal, India. TPR polymer resin in pellet shape was industrially accessible and acquired from M/s. Specialty Polymer Solutions Inc., Chennai, Tamilnadu, India. The normal width of TPR pellets was roughly 2mm. The measure of PTFE powder was around 5 to 15 μm . For making sample estimate $200 \times 140 \times 3 \text{mm}^3$, polymer injection mold appropriate for semi-automatic injection molding machine (MACFIELD, MAC60) made up of EN8 mild steel plates were acquired from Mahesh Plastics, Madurai, Tamilnadu, India.

Thermochemical treatment of melt TPR polymer composites by injection molding process brought probability to control polymer structure (fitting) and in this manner enhancing its thermal conductivity [7]. The pellets and powder were pre-dried around 100°C in void oven for persistent 24 hour for removing dampness present and injection molded by feeding in the hopper of a twin screw injection molding machine (Fig. 2 DGP Windsor, 50T) to make rectangular formed test specimen estimate $200 \times 140 \times 3 \text{mm}^3$. The Processing temperature was kept at $190\text{--}210^\circ\text{C}$. The mold temperature was kept up at 35°C . The methodology was repeated for different syntheses of TPR and PTFE [8]. The sample plate was cut into different sizes by water jet machining technique.



Fig. 2. Injection Moulding Machine

A. Thermal conductivity

Thermal conductivity is the heat limit of a polymer composite to exchange heat energy at first glance through temperature rise. Heat is moved in polymer by electronic and vibrational effect [9]. Thermal conductivity estimations are done under consistent state condition and standard methodologies.

B. TGA

TGA examination revealed temperature slope and thermal degradation process in polymer composites [10]. Powdered samples of TPR and TPR/PTFE polymer

composite examples were utilized for testing. Tests with roughly 10mg weight were stacked in platinum dish and heated from $30\text{--}700^\circ\text{C}$ at a heating rate of $10^\circ\text{C min}^{-1}$ under nitrogen climate and comparing weight reduction were recorded.

C. Optical Microscopy Test

The PTFE dissemination was dissected using Motic Optimal Microscope outfitted with moticam 2500 camera. The PTFE particle distribution pictures in 10% by weight and 20% by weight structure were caught and shown.

III. RESULTS AND DISCUSSION

A. Thermal Conductivity Report (ASTME-1530)

Thermal conductivity test was conducted in the TPR composite materials under steady state at 55°C . The thermal conductivity of the TPR polymer composite was dependent on matrix-filler interface and filler characteristic [12]. The fillers with high perspective proportion, for example, particles, can frame more constant thermally conductive system in the polymer lattice and upgrading heat exchange. From the procured results it was researched that TPR polymer composites mixed with PTFE particle indicated most outrageous thermal conductivity of 0.124 W/mK. From the review one can see that PTFE powder redesigns the heat exchange scale.

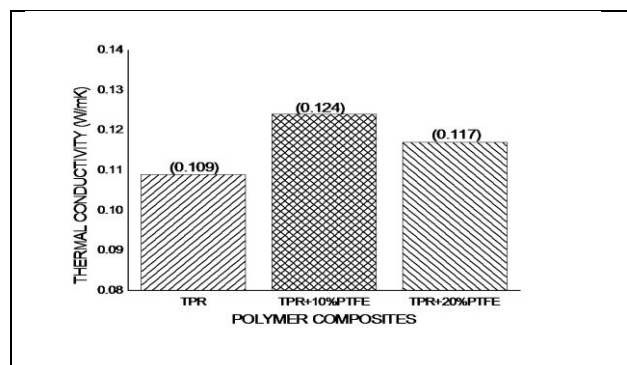


Fig. 3. Thermal conductivity for various compositions of TPR composite materials

B. TGA Test Report

The thermal degradation process was examined utilizing the nitrogen environment for TPR and TPR/PTFE composites. The final products as qualities of Thermogravimetric curves were drawn for TPR composite material over specific temperature gradient and rate of progress of heat [13]. The molecular plot of the TPR polymer composite sample was recognized by TGA curves.

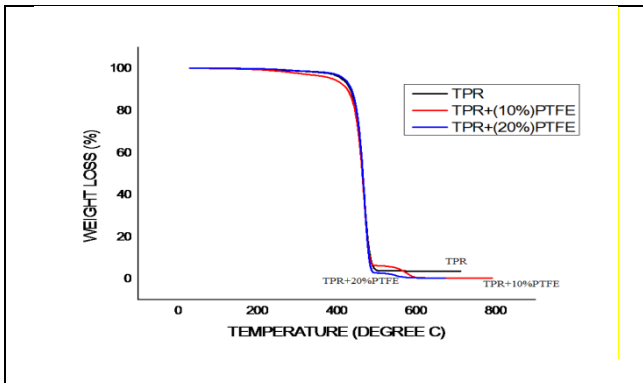


Fig. 4. Thermogravimetric analysis of TPR and Composites

C. Optical Microscopy Test

The PTFE distribution was analysed utilizing Motic Optimal Microscope furnished with moticam 2500 camera. The PTFE distribution images were taken for 10% by wt. composition of particle reinforced PTFE, and 20% by wt. composition of particle reinforced PTFE filled composite materials. From the analysis PTFE particles were well dispersed in the matrix and ensured perfect formation of composite.

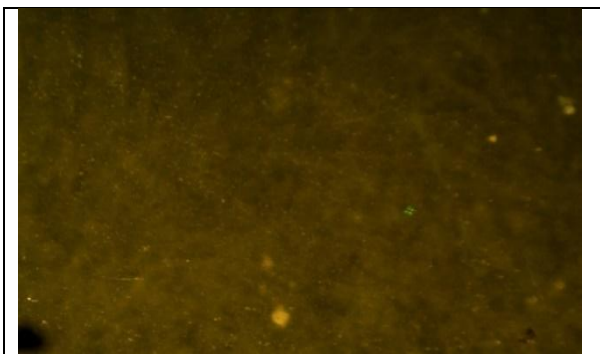


Fig. 5. Image of Thermoplastic Rubber

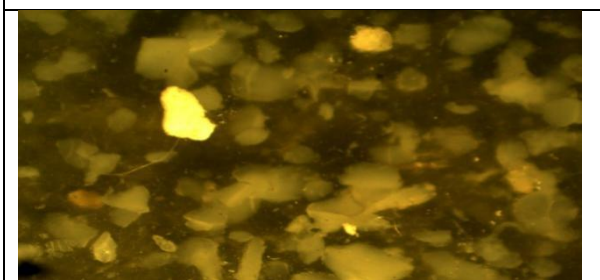


Fig. 6. Image of TPR+10%PTFE particles

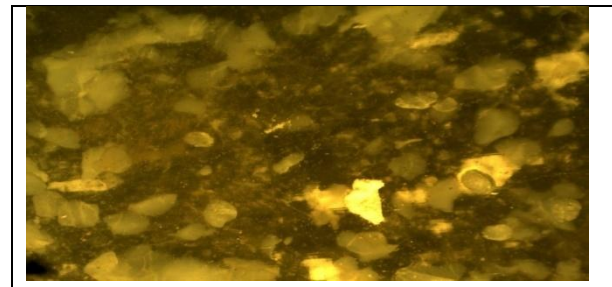


Fig. 7. Image of TPR+20%PTFE particles

IV. CONCLUSIONS

From the reports it was watched that polymer matrix added by (10% by weight) PTFE proves more thermal conductivity – 0.124 W/mK than Sample 1. The thermal properties graphs obtained from TGA exhibits more improved thermal properties for PTFE particle reinforced composites of TPR polymer.

REFERENCES

1. ThanisararatSaleesung, PongdhornSaeoui, ChakritSirisinha, Ricardo Baptista, "Mechanical and thermal properties of thermoplastic elastomer based on low density polyethylene and ultra-fine fully-vulcanized acrylonitrile butadiene rubber powder (UFNBRP)," *Polymer Testing, Science Direct*, vol. 29, 2010, pp. 977-983.
2. Volker Abetz, Christopher Hilger, ReimundStadler, "Infrared Spectroscopy on new multiphase thermoplastic elastomers based on hydrogen bond complexes – Temperature dependence and orientation behavior," *Makromol. Chem., Makromol. Symp*, vol. 52, 1991, pp. 131-140.
3. Ting An Lin, Ching-Wen Lou and Jia-Horng Lin, "The effects of thermoplastic Polyurethane on the structure and Mechanical properties of modified Polypropylene blends," *Applied Sciences, MDPI*, vol. 7, 2017.
4. D.Manas, M.Manas, M.Stanek, M.Danek, "Improvement of Plastic Properties," *Archives of Materials Science and Engineering*, vol. 32, 2011, pp. 69-76.
5. Salman Amin and Muhammed Amin, "Thermoplastic elastomeric (TPE) materials and their use in outdoor electrical insulation," *Rev. Advanced Material Sciences*, vol. 29, 2011, pp. 15-30.
6. J.R.Vail, B.A.Krick.B, K.R.Marchman, W.Gregory Sawyer, "Polytetrafluoroethylene (PTFE) fibre reinforced polyetheretherketone (PEEK) composites," *J. ISSN 0043-1648, Wear*, vol. 270, 2011, pp. 737-741.
7. P.Mente, T.E.Motaung and S.P.Hlangothi, "Natural rubber and reclaimed rubber composites – A systematic review," *Polymer Sciences, iMedPub Journals*, vol. 2, 2016.
8. SahrimHj.Ahmad, Mou'ad.A.Tarawneh, S.Y.Yahya and RozaidiRasid, "Reinforced thermoplastic rubber (TPNR) composites with different types of Carbon nanotubes (MWNTS)," *Researchgate*, vol. 21, 2011, pp. 443-468.
9. S.Riyajan, S.Chaiponban, N.Phuphewkeaw, "Activation energy and thermal behaviours of thermoplastic elastomer based on Natural rubber and Poly(vinyl alcohol), Prufen and Messen," *Testing and Measuring, KGK*, 2009, pp. 452-457.
10. EkwiipooKalkornsurapanee, Charoen Nakasan, Claudia Kummerlowe and Norbert Vennemann, "Development and preparation of High-performance thermoplastic vulcanizates based on blends of Natural rubber and Thermoplastic polyurethanes," *Journal of Applied polymer Science, Wiley Online Library*, 2012.
11. MohdAfran Omar and Norita Hassan, "Development of Thermoplastic Natural Rubber (TPNR) as a new binder in Metal injection moulding," *Journal of Engineering Science*, vol. 12, 2016, pp. 43-51.

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12. S.Hamdan, D.M.A.Hashim, M.Yusop, "Dynamic mechanical thermal analysis (DMTA) of thermoplastic natural rubber (TPNR) Barrium Ferrite ($\text{BaFe}_{12}\text{O}_{19}$) composites," *AJSTD*, vol. 21, 2003, pp. 69-79.
13. P.Mahallati, A.Arefazar, Gh.Naderi, "Thermal and morphological properties of Thermoplastic elastomer nanocomposites based on PA6/NBR," *Iranian Journal of Chemical Engineering*, vol. 8, 2011, pp. 56-65.

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