International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.10 No.14, pp 93-100, 2017

Review on Thermal Behaviour of Synthetic Rubber Composite

A.G.Ganeshkumar, S.Shylin H Jose, R.Silambarasan*

Department of Mechanical Engineering, Adhiyamaan College of Engineering, (Autonomous)
Hosur-635109, Tamil Nadu, India

Abstract : Nowadays, Rubber products are being developed to provide acceptable engineering properties and to fulfil technical requirements through rubber blends or rubber composites. Printed circuit boardis a small size material so quickly converted to the powder form using router method. The Printed Circuit Board added to the rubber composite for improving the mechanical properties, thermal properties andconsider the characteristics and to reduce the cost of the final product. In this study, styrene butadiene rubber has blended with the printed circuit board powder in the various compositions. The rubber composites prepared by using the two-roll open mill technique process. The result will be as, improvement in thermo gravimetric analysis, thermal conductivity and also improvement mechanical properties.
Key words : Printed circuit board, Styrene-butadiene rubber, and tworolls open mill technique, mechanical and thermal properties.

Introduction:

Printed circuit boards are present in all electronic equipment, so with the sharp increase of electronic waste, the recovery of printed circuit board components has become a critical research field. In this paper the author presents a study of the reclamation and reuse of non-metallic materials recovered from waste printed circuit board[1]. This paper reports on an extended investigation of the properties of WEEE, in particular small appliances. Analytical methods to characterize the waste equipment are described. The results of the experimental analyses show that the mechanical properties, the material composition and polymer composition[2]. The printed circuit board is an important subject and to which increasing attention is paid, both in treatment of waste as well as recovery of valuable material terms. Precede physical and mechanical method. Two-step crushing process is employed, and standard sieve is applied to screen crushed material different size are observed. Then nonmetal of the printed circuit board is separated by physical methods, including pneumatic separation, electrostatic separation and magnetic separation [3]. The compression of the studied mobile phones printed circuit boards was 63 wt.% metals; 24 wt.% ceramics and 13 wt.% polymers; and of the printed circuit boards from studied personal computers was 45 wt.% metals; 27 wt.% polymers; 28 wt.% ceramics [4]. The e-waste comprises discarded electronic appliances, of which computers and mobile telephones are disproportionately abundant because of their short lifespan. The current global production of e-waste is estimated to be 20-25 million tons per year. E-waste contains valuable metals are Pb, Sb, Hg, Cd, Ni, and Cu [5]. The non-metallic powders obtained from communicated recycled paper-based printed circuit boards as an additive to polyvinyl chloride (PCV) substrate. The physical properties of the non-metallic PCB (NMMPCB) powders were measured, and the morphological, mechanical and thermal properties of the NMPCB/PVC composite material were investigated. The non-metallic printed paper board powders, when added below a threshold, tended to increase the tensile strength and bending strength of PVC [6]. The non-metallic fractions (NMFs), which take up almost 70wt. % of waste PCBs, were treated by combustion or land filling in the past. However, combustion of the NMFs will cause the formation of highly toxic polybrominated dibenzodioxins and dibenzofurans (PBDD/Fs) while land filling of the NMFs will lead to secondary pollution caused by heavy metals and brominated flame retardants (BFRs) leaching groundwater [7].The increase in Poly carbon black (PCB) content increases the tensile strength, tear strength, modulus, and abrasion resistance of Styrene Butadiene Rubber (SBR). When the amount of PCB increases from 10 phr to 50 phr, the tensile strength of SBR increases by 9 times [8].The influences of waste rubber loading on mechanical and thermal conductivity properties were investigated for NR composite [9]. Styrene butadiene rubber (SBR) is a general purpose synthetic rubber with good abrasion resistance and good aging stability. SBR helps to improve the mechanical properties, abrasion resistance, thermal stability and oxidative stability of NR [10].

Experimental

Materials

The ASTM test method of rubber D832 and D4483.Styrene butadiene rubber (SBR) has been blended with the printed circuit board (PCB) powder in the various compositions. 212 micron sieve was used to obtain a fine powder, which can be used as an ad-mixture in rubber. Two types of composites (SBR/PCB) and (SBR/PCB) were prepared, the blend ratio is 100/0 95/5, 85/15, 75/25, 65/35, and, 50/50.

Thermogravimetric analysis

The ASTM test method of rubber D3850and E1131.Thermogravimetric analysis (TGA) is one of the members of the family of thermal analysis techniques used to characterize a wide variety of materials. The thermal stability was investigated by non-isothermal thermo-gravimetric (TG, DTA) using a Setaram Setsys Evolution 1750 instrument (France). The heating was carried out at temperature range from room temperature to 700 ^oC with a heating rate of 20 $^oC\ min^{-1}$ under nitrogen gas atmosphere with the gas flow rate of 20 $cm^3\ min^{-1}$. Range The weight of samples ranged from 5 to 8 mg. The following process is commonly used as rubber material.

Thermal conductivity

ASTM Standards D2717-95, D5930-01 andE1225-04.From gathering of all journal papers, mostly rubber material is used as follows: Lee's method of a bad conductor was used to determine the thermal conductivity of synthetic rubber (SBR/PCB) and rubberized concrete with rubbercomposites. Thermal conductivity, k, is a material property of a material that indicates its ability to conduct heat. Conduction will take place if there is a temperature gradient in a solid medium. Energy is transferred from more energetic to less energetic molecules when neighboring molecules collide. Conductive heat flow occurs in direction of the decreasing temperature because higher temperature is associated with higher molecular energy. Fourier's law expresses conductive heat transfer

$$k = (Q*X)/(A\ (T_1-T_2))$$

Where Q is the steady state rate of heat transfer, K is the thermal conductivity of the sample (W/m C), A is the cross sectional area (mm^2), x is the thickness of the sample (mm) and (T_1 - T_2) is the temperature difference across the sample thickness (^oC).

Results and Discussion

Thermogravimetric analysis

TGA measures the amount and rate (velocity) of change in the mass of a sample as a function of temperature or time in a controlled atmosphere. The measurements are used primarily to determine the thermal and/or oxidative stabilities of materials as well as their compositional properties. The technique can analyze materials that exhibit either mass loss or gain due to decomposition, oxidation or loss of volatiles (such as moisture). TGA measurements provide valuable information that can be used to select materials for certain end-use applications, predict product performance and improve product quality.

Budrugeac explain heat resistance in nonisothermal conditions using thermal analyses (thermogravimetric analysis TG; derivative thermogravimetric analysis DTG; differential thermal analysis DTA) [11]. Investigate the molecular chain reactions of blends at higher temperatures [12]. A lot of studies have demonstrated the physical-mechanical properties of such blends [13]. Thermogravimetric analysis is used as an effective study the degradation of materials to determine the order of reaction and also to estimate other kinetic parameters such as the activation energy, the frequency factor, and the rate of decomposition[14]. The thermal stability of the unfilled and 80 phr of CB filled NR/BR/SBR ternary rubber blend composites was investigated. Thermal stability of polymers is the most important for a wide range of their applications [15]. Filler and matrix would contribute to higher thermal stability by hindering the diffusion of volatile decomposition products. However, this phenomenon was only applicable before the decomposition of the LENR coating layer. Once the decomposition of natural rubber, as well as the LENR had started, the LENR-coated OPA filled natural rubber composites became less thermally stable; as the diffusion rate of the volatile decomposition increased [16].This interesting finding means the higher thermal stability possessed by the LENR-coated OPA filled natural rubber composites was due to better interfacial adhesion between oil palm ash OPA and the LENR coating layer[17] (Figure 1,2).

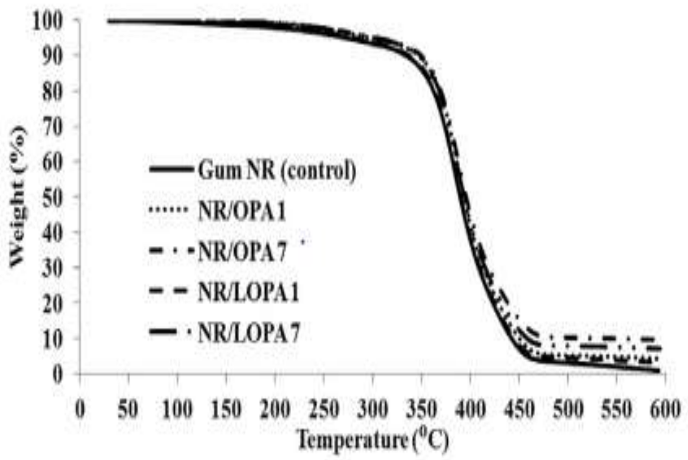

Figure 1.Thermal stability of the non-coated OPA and LENR-coated OPA filled Natural rubber composites.

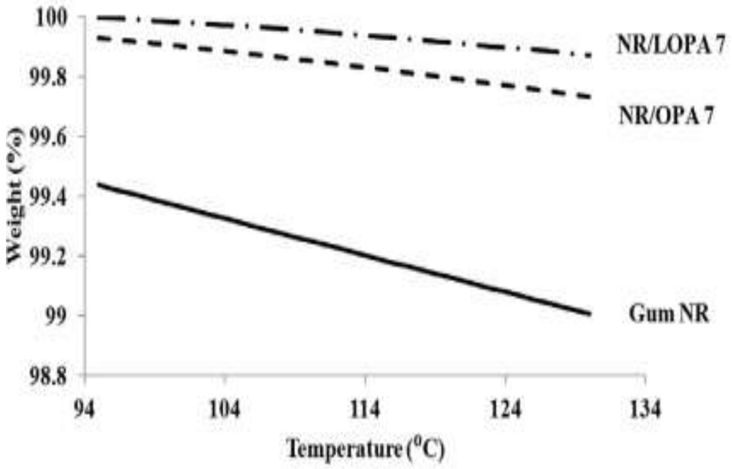

Figure 2.Thermal stability of the gum NR, non-coated OPA, and LENR-coated OPA filled natural rubber composites at 7 phr, ranging from 95 ^oC to 130 ^oC

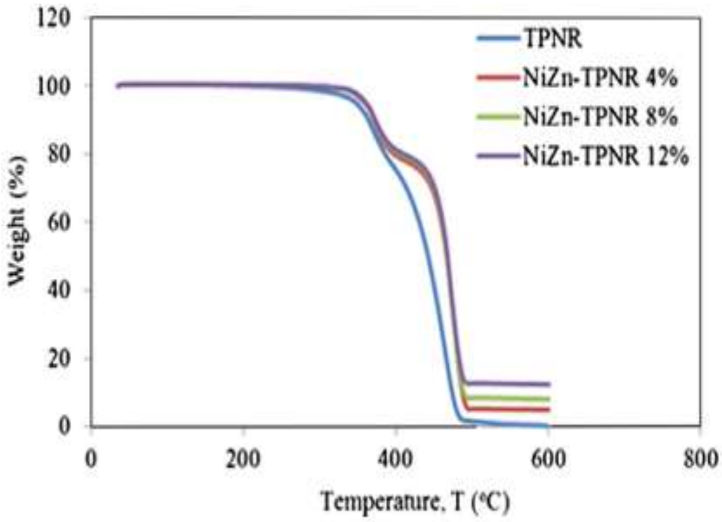

Figure 3.TGA thermograms of NiZn-TPNR nanocomposite of different filler loadings

The temperature reached to 600°C (Figure3), the weight loss change as a function of temperature became negligible due to the complete degradation ofThermoplastic natural rubber (TPNR) matrix into carbonaceous products, and the observed weight percentage residues were referred to the remaining non-decomposed magnetic nanoparticles. Thermogravimetric analysis (TGA) measurements were performed under nitrogen atmosphere by using a Thermogravimetric Analyzer, Perkin Elmer (TGA 7), and USA. All samples were heated from 50 to 700°C with the heating rate of 10°C/min. From the above given samples, filler material is adding to respective ratio and shows it increase in thermal stability other than original material. Even though not only for this SBR and TPNR, all types of rubber material can have some original thermal stability property. But adding some filler material, they can also increase in their thermal stability.

Thermal conductivity

Lee test of bad conductors and the temperature gradient through the sample. The evaluation of thermal conductivity is based on assuming that the heat loss from the sides of the sample is negligible. Thus, to keep the loss from the sides small, the sides of samples were isolated using glass wool sheets. The sample was made in form of a disk with 75 mm diameter and 30 mm thickness. The device consists of two brass discs and there is a steam heater source to cause a heat gradients and the specimen is positioned between the brass discs. Two thermometers T1 and T2 were inserted into two holes in the brass discs to evaluate the temperature gradient. The test continued until reach the thermal equilibrium where T2 is constant for more than 10 min (the steady stated of heat transfer)[18, 19] (Figure 4, 5).

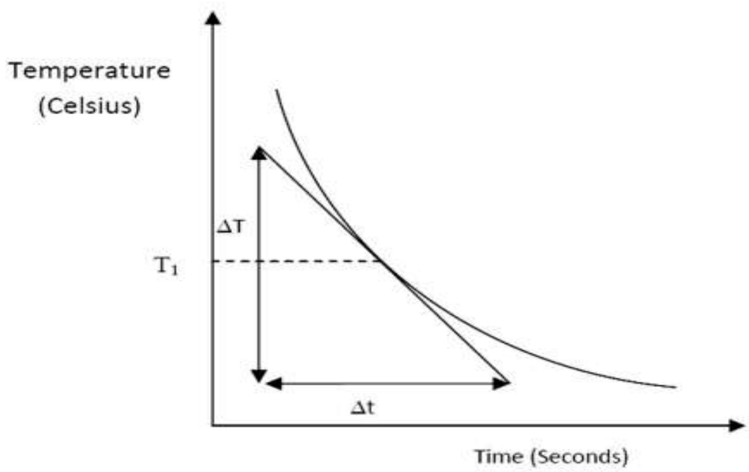

Figure 4.The temperature–time relation for calculation of Q

Figure 5.Configuration of Lee test of bad conductors and the temperature gradient through the sample

To determine the heat transfer Q, the steam chamber was removed and the temperature reduction in the brass disc is recorded through time up to (T1 -10 ^{o}C).

Q = mh (dT/dt)

Where m is the mass of the brass disk (gm) is the specific heat of brass = 0.380 J/gm ^{o}Cdt is the temperature reduction from T2 to T2 -10 through time dt

Studied the thermal properties at different percentages of sand replacement by rubber particles using the hot plate method(Table1). Sukontasukkul concluded that, the reduction in thermal conductivity of rubberized concrete at 10% and 30% fine aggregate replacement by weight is about 20% and 50%, respectively. The k-values achieved by Sukontasukkul are lower than the k-values presented in the present study (Table 2). This may be attributed to the smaller rubber particles and different test method that was used by Sukontasukkul [20]. k-values of rubberized concrete at rubber volume fractions 20%, 40%, 60%, 80% and 100% are 0.96, 0.85, 0.73, 0.67 and 0.6 W/m^{o}C, and k-values of synthetic rubber (SBR, NBR) 0.143-1.48 W/mK, 0.15-1.25 W/mK respectively.

Table 1. Density and water absorption conventional and rubberized concrete at different percentage of sand replacement by rubber

Sand replacement by rubber (%)	**Density (t/m^3)**	**Reduction in density (%)**	**Water absorption (%)**
Control	2.43	0	3.62
20	2.22	9	4.88
40	2.12	13	5.20
60	2.07	15	6.30
80	2.00	18	6.89
100	1.94	20	7.00

Table 2. Thermal conductivity of some common materials

Material	**Thermal conductivity k (w/m^{o}C)**
Clay brick	0.82
Foamed concrete	0.7
Autoclaved concrete	0.6
Rubber – cement composites	0.47
Rubber – epoxy composites	0.25
Gypsum boards	0.17- 0.23
Extruded polystyrene boards	0.03

From the test results, it can be concluded that, thermal conductivity of concrete decreases with the increase in rubber content, which may be attributed to the reduction in concrete density and the effect of the intrusion of rubber particles as an insulator material. Furthermore, the reduction in k-values at 20% and 100% rubber content is 34% and 59%, respectively, comparing to that for conventional concrete.He discussed other desirable features and noted that materials should possess the ability to limit heat gain or loss from surfaces operating at temperatures above or below ambient temperature. He defined thermal conductivity as a measure of the effectiveness of a material in conducting heat (Figure 6, 7).

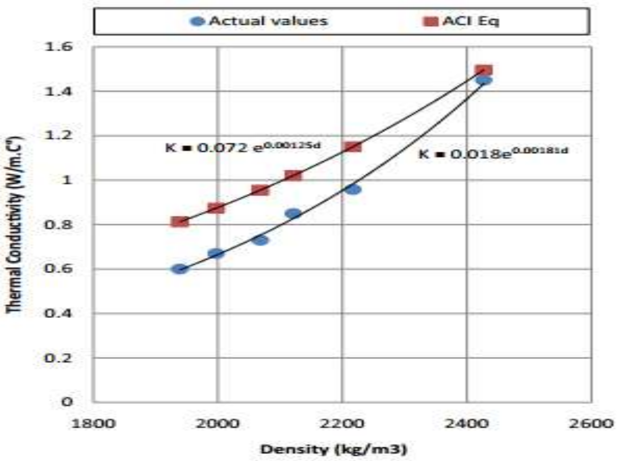

Figure 6. The correlation between the thermal conductivity and density

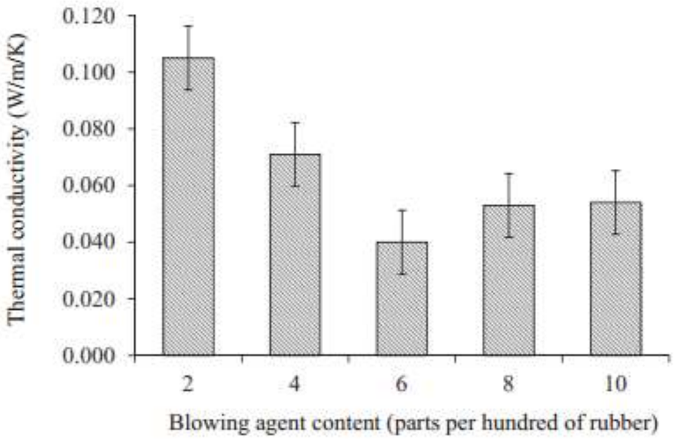

Figure 7. Thermal conductivity results of natural rubber foam with varying contents of benzenesulfonyl hydrazide blowing agent content (error bars = ±SE)

Therefore, knowledge of the thermal conductivity values allows a quantitative comparison to be made between the effectiveness of different thermal insulation materials. For example, the thermal conductivity values of rock wool, fiberglass and polyethylene are 0.037 W/m/K, 0.040 W/m/K and 0.041 W/m/ K, respectively [21]. The chemical blowing agent influenced the structure and mechanical properties of ethylene propylene dyne monomer (EPDM) foam by increasing the number of cell structures, increasing the porosity, lowering the thermal conductivity and increasing the concentration of the blowing agent for optimum interfacial adhesion [22].

Conclusion

The mechanical properties and thermal properties reveals that thermogravimetric analysis, thermal conductivity by increasing filler material (PCB). In the thermogravimetric analysis, the SBR, NBR and other rubber materials having lesser thermal stability in nature. By adding the filler material thermal stability will be increasing based on percentage. If decomposition take place in rubber or filler material there decrease in thermal stability which is applicable for all rubber material. Then thermal conductivity of SBR, NBR is less, to increasing it we go for addition filler material. Based on the percentage of filler material the thermal conductivity will be increased more and more.

References

1. MOU Peng, XIANG Dong, DUAN Guanghong, 2007,'Products made from non-metallic materials reclaimed from waste printed Circuitboards' ISSN 1007-0214 07/18 pp.276-283, Vol.12, No.3.
2. Perrine Chancerel, SusanneRotter, 2009, ‘Recycling-oriented characterization of small waste electrical and electronic equipment'. Waste Management ISSN 29 20092336–2352.
3. Guo Chao, Wang Hui, Liang Wei, Fu Jiangang, Yi Xin, (2011) 'Liberation characteristic and physical separation of printed circuit board (PCB)'. Waste Management ISSN 31 2011 2161–2166.
4. Luciana Harue Yamane, Viviane Tavares de Moraes, Denise Crocce Romano Espinosa, Jorge Alberto Soares Tenório, (2011) 'Recycling of WEEE: Characterization of spent printed circuit boards from mobile phones and computers'. Waste Management ISSN 31 2011 2553–2558.
5. Brett H. Robinson, (2009) 'E-waste: An assessment of global production and environmental impacts'. Science of the Total Environment 408 2009pp.183–191.
6. Xinjie Wang, Yuwen Guo , Jingyang Liu , Qi Qiao , Jijun Liang, PVC-based composite material containing recycled non-metallic printed circuit board (PCB) powders. Journal of Environmental Management ISSN 91, 2010, 2505-2510.
7. Jiuyong Guo, Jie Guo, Zhenming Xu, (2009) Recycling of non-metallic fractions from waste printed circuit boards: A review. Journal of Hazardous Materials ISSN 168, 2009, 567–590.
8. Aihua Du, MingshengWu, Changyan Su & Hong Chen, The Characterization of Pyrolytic Carbon Black Prepared from Used Tires and Its Application in Styrene– Butadiene Rubber (SBR), Journal of Macromolecular Science, Part B: Physics, 2008, Vol.47, No.2, pp.268-275.
9. M.M. Abdel Kader, S.M. Abdel-wehab, M.A. Helal, H.H. Hassan. Evaluation of thermal insulation and mechanical properties of waste rubber/natural rubber composite.HBRC Journal, Vol.8, 2012, pp.69-74.
10. AnyapornBoonmahitthisud and SaowarojChuayjuljit. Effects of Nanosized Polystyrene and Polystyrene-Encapsulated Nanosilica on Physical Properties of Natural Rubber/Styrene-Butadiene-Rubber Nanocomposites.Polymer–Plastics Technology and Engineering, Vol.51, 2012, pp.311–316.
11. Budrugeac P. Thermooxidative Degradation of Some Nitrile-Butadiene Rubbers, Polym.Degrad. Stabil, 1992, Vol.38, No.2, pp.165-172.
12. Ciutacu S, Budruqeac P, Segal E. Thermooxidative Degradation of Nitrile-Butadiene Rubber,J. Therm. Anal., 1991, Vol.37, No.6, pp.1179- 1191.
13. Manshaie R, Nouri Khorasani S, Jahanbani Veshare S, Rezaei Abadchi M. Effect of electron beam irradiation on the properties of natural rubber (NR)/styrene–butadiene rubber (SBR) blend, Radiation Physics and Chemistry 2011,Vol.80, pp.100–106.
14. Motiee F, Taghvaei-Ganjali S, Malekzadeh M. Investigation of correlation between rheological properties of rubber compounds based on natural rubber/styrene-butadiene rubber with their thermal behaviors, International Journal of Industrial Chemistry 2013, Vol.4, No.16.
15. Dickens B. Thermal degradation and oxidation polystyrene studied by factor jump thermogravimetric. Polym. Degrad. Stab. 1980, Vol.2, pp.249-268.
16. Jovanović V, Samaržija-Jovanović S, Budinski-Simendić J, Marković G, Marinović-CincovićM. Composites based on carbon black reinforced NBR/EPDM rubber blends, CompositesPart B 2013, Vol.45, pp.333–340.
17. S. Abdolmohammadi, S. Siyamak, N.A. Ibrahim, W.M.Z.W. Yunus, M.Z.A. Rahman, S. Azizi, A. Fatehi, Enhancement of mechanical and thermal properties of polycaprolactone/chitosan blend by calcium carbonate nanoparticles, Int. J. Mol. Sci. Vol.13, No.4, 2012, pp. 4508-4522.
18. A. Leszczynska, J. Njuguna, K. Pielichowski, J.R. Banerjee, Polymer/ montmorillonite nanocomposites with improved thermal properties: Part I. Factors influencing thermal stability and mechanisms of thermal stability improvement, Thermochim. Acta Vol.453, No.2, 2007, pp.75-96.
19. Nelkon M, Parker P. Advanced level physics. 3rd ed. London: Heinman; 1988, pp.336–8.
20. Lees’ Conductivity Apparatus (Electrical Method) LL44-590I.S. 1122/7302. Wembley, Middlesex, UK: Griffin & George Ltd.

21. Yamsaengsung, W., Sombatsompop, N., (2009). Effect of chemical blowing agent on cell structure and mechanical properties of EPDM foam, and peel strength and thermal conductivity of wood/NR composite-EPDM foam laminates.Compos.Part B: Eng. Vol.40, pp.594-600.
22. Al-Homoud, M.S., 2005, Performance characteristics and practical applications ofcommon building thermal insulation materials. Build. Environ.Vol.40, pp.353-366.

*****