

Thermal Properties between SAN and ABS Copolymer Matrices Blended with PTFE Polymer Particle Composites

R. Mahesh Kumar, N. Rajini

Abstract - Styrene Acrylonitrile (SAN) copolymer has styrene with high expanded durability and finds some useful applications. Applications involving replacement of metal by plastics due to light-weight, high quality and firmness attributes were seen. But they are limited as they cannot withstand higher temperature applications. PTFE that finds a perfect filler material has high temperature ability, self-greasing up, high chemical inertness, low friction, corrosion resistance, low outgassing properties. Injection molding process helped addition of copolymers of SAN and ABS to 10% PTFE by weight, 20% PTFE by weight blends and composite samples were prepared successfully using the melt condition. Experimental results show PTFE filler added composites exhibiting improved thermal conductivities and coefficient of linear thermal expansion.

Keywords: Styrene Acrylonitrile (SAN) and Acrylonitrile Butadiene Styrene (ABS) matrices, Polytetrafluoroethylene (PTFE) particle reinforcement, Comparison of Thermal properties and Injection Molding.

I. INTRODUCTION

Utilization of polymer composite-based materials is on the increase [1]. The constantly developing requirement for polymer composite materials brings about the formation of different polymer blends with various compositions, morphologies and properties [2]. Thermal analysis is essential for obtaining better product design and quality control over polymer composite products.

The SAN/PTFE and ABS/PTFE composite samples are manufactured by injection molding machine using plastic molds by heating to melt condition to ensure homogenous mix of PTFE particles. Polymer composites thermal properties also confirmed by examining them by various graphs obtained from the results of TGA.

Styrene-acrylonitrile copolymer has 20 to 30% acrylonitrile content and Chemical Formula is $\{[C_3H_3-N]_n [C_8H_8]_n\}$ with increasing the content helping improvement to toughness and chemical resistance but finding difficulty in the moulding process. In general, the nature of the molecular structure has caused a tendency for SAN resin to be yellow and lose transparency after injection moulding.

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Acrylonitrile Butadiene Styrene (ABS) is an amorphous thermoplastic polymer transparent with the chemical formula $(C_8H_8)_x \cdot (C_4H_6)_y \cdot (C_3H_3N)_z$. The proportions can shift from 40 to 60% styrene, 15 to 35% acrylonitrile and 5 to 30% butadiene. ABS has low melting point and facilitating the use in 3D printing, mannequins, toys, sanitary ware, auto components, sports equipment, and furniture.

Polytetrafluoroethylene (PTFE) is a man made fluoro polymer of tetrafluoroethylene. The chemical formula for PTFE is $n[F_2C=CF_2] \rightarrow -[F_2C-CF_2]_n-$. The thermo plastic polymer, PTFE is white solid at room temperature. Processing procedure for PTFE is difficult, due to high melting temperature (327°C). PTFE is best used in coating non-stick frying pans and other cookware. PTFE plays a vital role in the medical field such as surgical equipment and machinery.

II. MATERIALS AND METHODS

SAN and ABS polymer pellets were procured from SreeMeenakshi Plastics, Madurai, Tamilnadu, India. Powder PTFE polymer in powder procured from M/s. Modoplast Company Pvt. Ltd, Kolkata, West Bengal, India. Average diameter of SAN and ABS pellets were approximately 2mm. The particles sizes of PTFE powder were about 5 to 15 μm . Sample specimens size 200x140x3mm³ polymer mold made from EN8 mild steel plates were procured from Mahesh Plastics, Madurai, Tamilnadu, India.

Samples used in this research work were SAN-1: 100% SAN by weight, SAN-2: with SAN + 10% by weight composition of PTFE powder particle, SAN-3: with SAN + 20% by weight composition of PTFE powder particle, ABS-1: 100% ABS by weight, ABS-2: with ABS + 10% by weight composition of PTFE powder particle and ABS-3: with ABS + 20% by weight composition of PTFE powder particle [3]. Individually SAN pellets, ABS pellets and PTFE powder were pre-dried to moisture free condition at 100°C in vacuum oven for 24 h. Materials as per requirement were taken in six batches with different weight composition, mentioned as SAN-1, SAN-2, SAN-3, ABS-1, ABS-2 and ABS-3 one by one fed into the hopper and molded test plate samples are made [4].



Fig. 1. Specimen SAN-1, SAN-2 and SAN-3

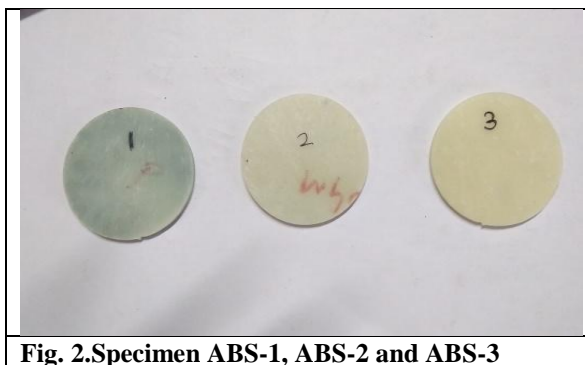


Fig. 2. Specimen ABS-1, ABS-2 and ABS-3

III. THERMAL PROPERTIES

A. Thermal conductivity measurement

Thermal conductivity measurements were conducted under thermal equilibrium conditions. A round shaped molded specimen with 50mm diameter and 3mm thickness as per ASTM E1530 were utilized for thermal conductivity estimates for all samples [5]. Steady state heat was applied from one side of the specimen until thermal equilibrium was achieved. The temperatures of the top and bottom surfaces were estimated with the help of thermocouples. The experiments were conducted in the temperature range of 25 to 90°C.

B. Coefficient of Linear Thermal Expansion (CLTE)

The test specimens with size 90x10x3mm were used for CLTE test. CLTE tests were done according to ASTM D696 at 25 to 90°C utilizing electrical heater. The specimens were heated under steady state from 30 to 90°C and equilibrium was maintained on 90°C for 10 minutes.

C. Thermogravimetric Analysis (TGA)

The thermal degradation behavior of composite samples was examined at King Mokut's University laboratory, Thailand using Mettler – STAR SW 15.00. Powdered samples 10mg were obtained by hacksawing the plate samples of polymer composites used for testing. With a change in mass of the sample as a function of temperature rate 10°C min⁻¹, TGA recorded the thermal degradation

process [6]. The nitrogen gas 60ml min⁻¹ environment was selected for polymer composite sample thermal decomposition with temperature range from 30-700°C.

IV. RESULTS AND DISCUSSION

Comparison values for thermal conductivity and coefficient of linear thermal expansion for different samples are presented in bar chart. The TGA comparison curves are plotted and analyzed.

A. Thermal Conductivity Test Report:

The acquired outcomes showed a comparison of ABS copolymer having twice higher thermal conductivity than SAN copolymer [7]. The write up showed blended PTFE particles having effective thermal conductivity in the light of the fact that PTFE powder established thermal percolation threshold. The blended composites were filled by 10% by wt. PTFE and 20% by wt. PTFE exhibited a better thermal conductivity than base copolymers. Comparison analysis showed, SAN composites exhibiting high thermal conductivity than ABS composites. Thus addition of PTFE proves effective for SAN polymer composite and peak values 0.175 W/mK and 0.162 W/mK were recorded.

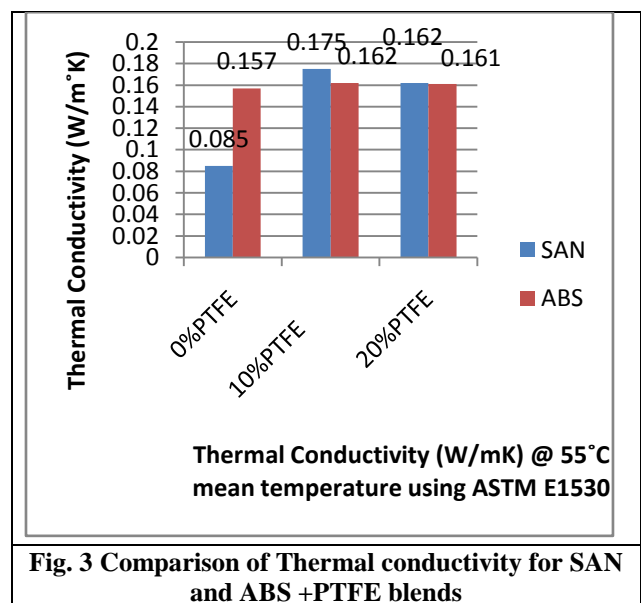


Fig. 3 Comparison of Thermal conductivity for SAN and ABS +PTFE blends

B. Coefficient of Linear Thermal Expansion Test Report

CLTE examination was done as per ASTM standard D-696 between operating temperatures 30-60°C and values /°C were obtained for all samples. Outcomes of the investigation showed SAN copolymer having a low CLTE value compared with ABS copolymer. Similarly the addition of PTFE encouraged the coefficient of linear thermal expansion values. SAN polymer composites filled with 20% wt. PTFE showed an extraordinary high CLTE value (6.66x10⁻⁵) compared to ABS composite of same 20% wt.

PTFE. The experimental estimations of the CLTE values of all samples are displayed in a bar chart.

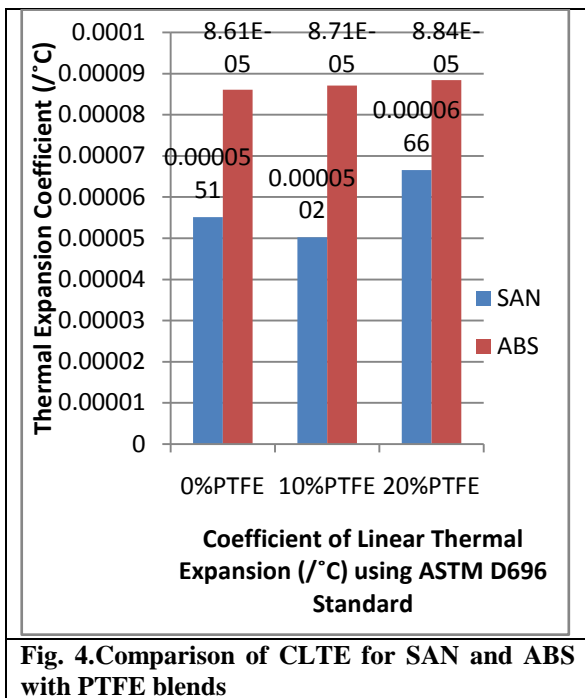


Fig. 4. Comparison of CLTE for SAN and ABS with PTFE blends

C. TGA Test Report

TGA provides quantitative estimation of mass change with time and temperature in polymer composite samples related to transition and thermal degradation [8]. The polybutadiene component of ABS is the weakest part of ABS. A reaction scheme showing some pathways of degradation is shown in Fig. 5. The initial radical came from thermal decomposition of another component in the sample. The results of comparison for SAN and ABS blends are given as graphs.

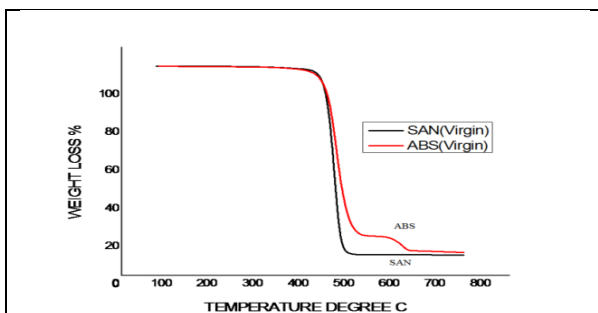


Fig. 5. Primary thermograms of SAN and ABS copolymers

The graph clearly shows an increase in the thermal stability of the copolymers with the addition of PTFE. Particles added 10% by wt. showed increase in thermal stability for ABS copolymer composites and particles added 20% by wt. showed increase in SAN copolymer composites. The high specific area of SAN+20% PTFE provided better interaction between PTFE particle and SAN matrix that tends to increase in interfacial bonding. Also the char content of composites were higher than the copolymer

matrix alone, considering higher thermal stability of PTFE particles than copolymer matrix.

V. CONCLUSIONS

The observations from the results show the display of most extreme thermal conductivity (0.175 W/mK) and 20% by weight composition with 0.162 W/mK by SAN polymer composited blended with 10% weight PTFE. The write up shows PTFE particles consuming more thermal conductivity stuff due to PTFE powder up grading the heat transfer rate [9]. ABS composites blended with (10% Wt.) PTFE particles had good thermal conductivity (0.162 W/mK). Moreover SAN/PTFE particles displayed good thermal properties while related with overall results determined.

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