



Data Article

Dataset on tribological, characterization and thermal properties of Silicon carbide reinforced polyamide composites for industrial applications



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ABSTRACT

This dataset comprises the characterizations, tribological and thermal properties of Silicon carbide (SiC) reinforced Nylon 6 (N6) or Polyamide 6 composites. The dataset illustrates the tribological properties such as coefficient of friction, wear and it also describes the characterizations and thermal stability of polyamide composites by varying the weight percentages from 5 - 30wt.%. The composites samples were fabricated by injection moulding method. The tribological, characterization and thermal behaviors were determined by wear test, characterizations were carried out by Scanning Electron Microscope (SEM) and Fourier Transform Infrared (FTIR), Thermal stability, degradation performed by Thermogravimetric Analysis (TGA) and Derivative Thermogravimetry (DTG) of the polyamide composites. The dataset helps the readers to understand the significant characteristics of the SiC reinforced N6 composites. However, it is revealed that the addition of SiC can enhance the N6 properties. The preparation of N6 polymer composites findings were useful with

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good tribological (highly wear resistive) and thermal stability characteristics. This composite can be used for high impact stress parts of gears application.

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Specifications table

Subject	Materials Engineering, Composite Materials
Specific subject area	Tribology, Thermal degradation, Polymer and ceramic composites
Type of data	Text file, Tables, Images, Figures and graphs
How data were acquired	Tribometer (TR-20LE-PHM-400), Thermogravimetric Analyzer (EXSTAR TG/DTA 6300 TG) Scanning Electron Microscopy (SEM) on a JEOL equipment model JSM-5300LV with 10kV, FTIR Spectrometer Shimadzu (8400S Model) spectrometer, in the range of 400 and 4000 cm-1 with a maximum resolution of 0.85 cm-1.
Data format	Raw and Analyzed
Parameters for data collection	Tribological, characterization and thermal properties of composite material
Description of data collection	Tribological behavior was carried out by wear test and graphs were plotted the corresponding values. Characterizations were performed by SEM and FTIR analysis that images were generated as per given input. Thermal stability and degradation were observed by TGA and DTA then the image was generated as per temperature input.
Data source location	CMR Institute of Technology, Hyderabad.
Data accessibility	https://data.mendeley.com/datasets/47k6jswwg7/draft#file-eeb25e21-f31a-4dfb-bb7a-3e26c7e68611

Value of the data

- The data is valued because it comprises significant information regarding how different density of different materials are reinforced polyamide composites.
- These data involved the interlink between SiC and N6 Tribological properties compared with SiC /N6 composites and results are plotted.
- These data comprised two different materials such as metallic materials and non-metallic materials.
- SEM data is useful for evaluating various materials for surface fractures, flaws and contaminants. FTIR data can be applied various phases of the materials lifecycle and failure analysis.
- The data presented herein may be used to develop different ceramic materials reinforced polyamides for high temperature and high strength applications.

1. Data Description

The dataset presented herein were obtained from the tribological tests of various percentages of SiC reinforced N6 composites. This data presents in this article constituted of polyamide composites. All the data's (tables, Figures and images) are presented by experiments. This data is made up of polyamide composites in this article. Fig. 1 reveals the raw materials a) N6 and b) SiC, Fig. 2 displays the Preparation proces of SiC/N6 composites, Fig. 3 displays fabricated raw N6 and polymer composite specimens, Fig. 4 shows the Variations of coefficient friction for N6 and N6 composites, Fig. 5 Variations of wear rate for N6 and N6 composites, Fig. 6 describes the SEM images of before and after worn sufaces of of N6 and N6 composites.

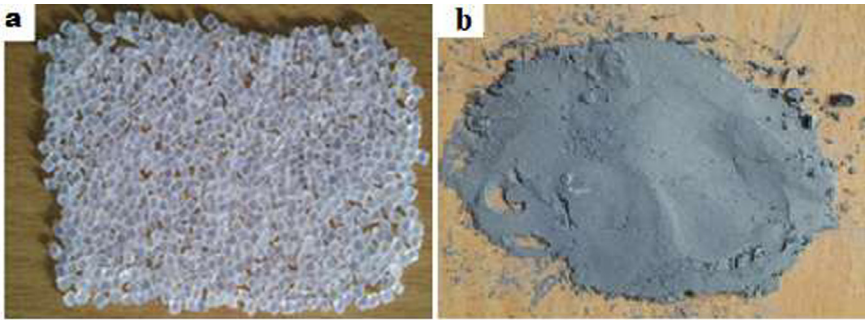


Fig. 1. a. Nylon 6 (N6) and b) Silicon Carbide (SiC)

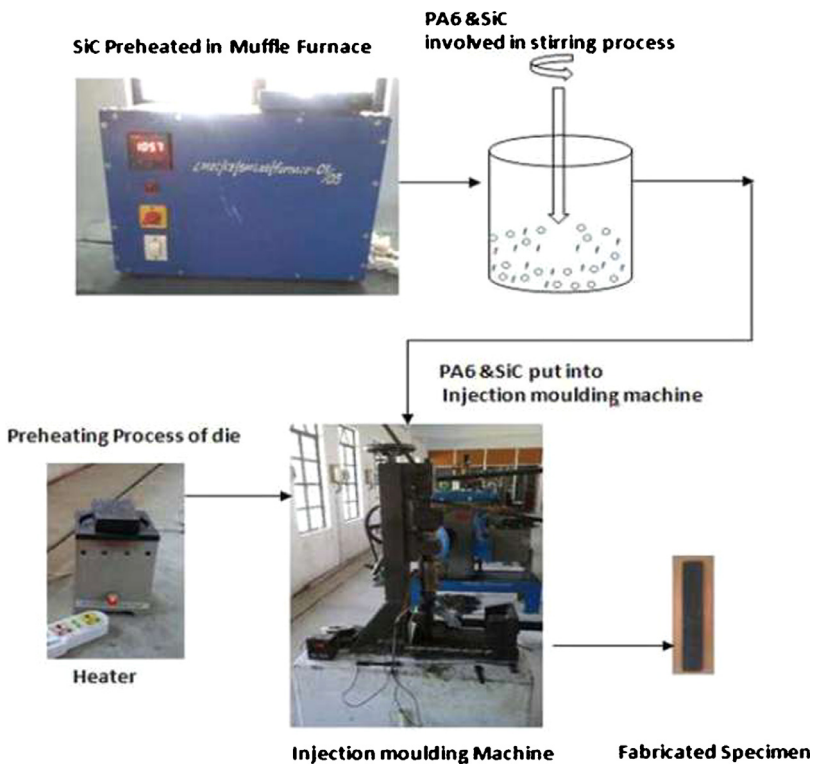


Fig. 2. Preparation process of SiC/N6 composites

Fig. 7. represents the TGA and DTA of 20 wt. % SiC / N6 specimen and **Fig. 8.** describes the FTIR spectroscopy of 20wt. % SiC / N6 specimen. **Table 1** describes the designation of specimens and **Table 2** represents the tribological testing conditions of N6 and composite specimens. In this work, Each composition of tested with 3 specimens and the average values are taken.

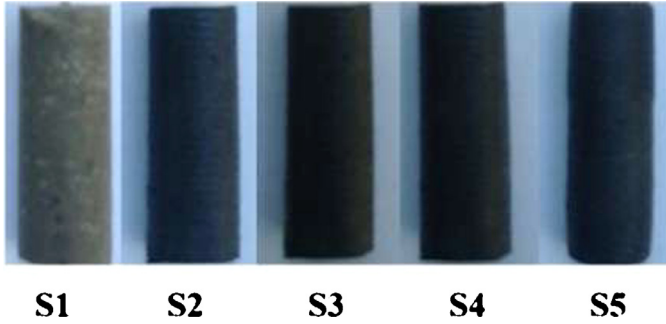


Fig. 3. Fabricated N6 and N6 composite specimens

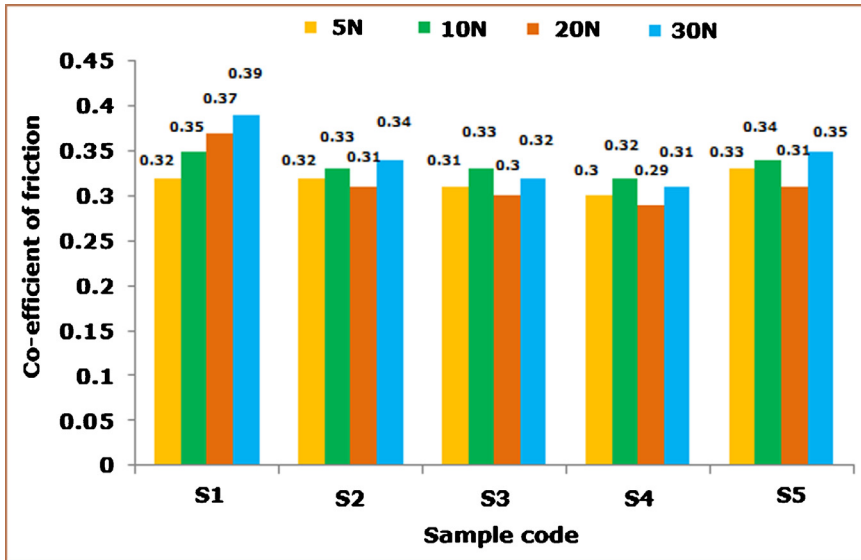


Fig. 4. Variations of coefficient friction for N6 and N6 composites

Table 1 Designation of composite specimen.

Specimen code	N6 wt.(%)	SiC wt.(%)	Remarks
S1	100	–	Pure N6
S2	95	5	SiC reinforced N6 specimen
S3	90	10	
S4	80	20	
S5	70	30	

2. Experimental Design, Materials, and Methods

2.1. Materials

In this work, N6 is purchased as pellets of size 3 mm. The test specimens are prepared using an injection molding machine with maximum chamber capacity of 150g. The muffle furnace was used for pre heating the SiC particles. Purchased N6 and SiC as shown in Fig. 1

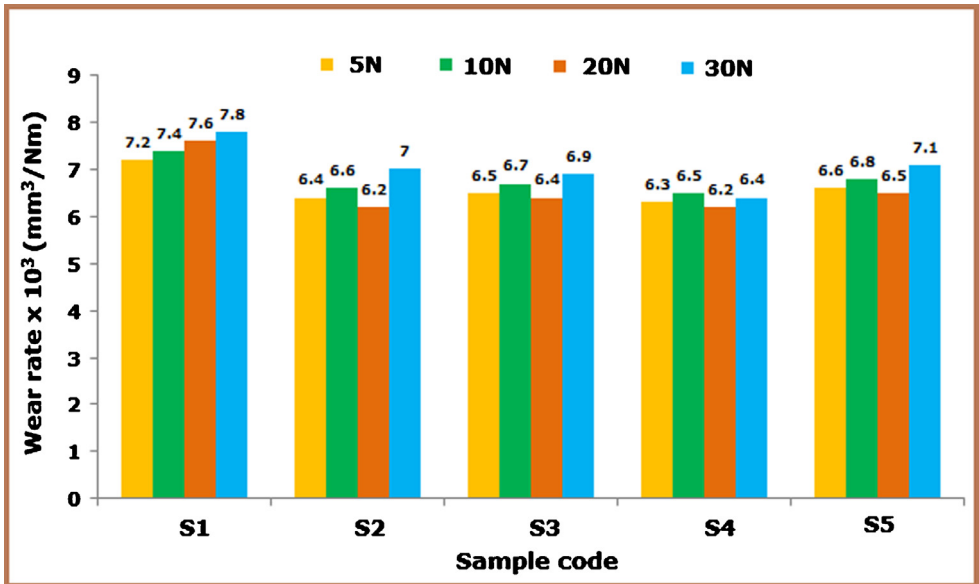


Fig. 5. Variations of wear rate for N6 and N6 composites

Table 2

Tribological testing conditions of SiC reinforced N6 composites.

Constraints	Testing Conditions
Load	5,10,20 and 30 N
Disc Material	EN31 Steel
Speed	1000 – 2000rpm
Pin Materials	Pure N6 (S1) SiC reinforced N6 (S2 – S5)
Condition of Surface	Dry friction
Track diameter	100mm
Sliding distance	1000m

2.2. Preparation of composites

SiC have high melting point and hence, they debonding with N6 directly. Therefore, fillers are preheated below the melting temperatures. Here, the fillers are preheated below the melting temperatures through muffle furnace for SiC up to 1800°C, respectively. In general, the melting temperature of N6 is 220°C and if it is suddenly blended with fillers it will burn. Hence, after reaching the temperature of 1800°C, the SiC particles are cooled at atmospheric temperature for 40 to 50 minutes.

The cooled fillers are blended with N6 pellets by stirring process. The blended material is melted up to the temperature up to 220°C in the injection moulding machine [1]. In this temperature, N6 melts and reaches liquid state. The liquid N6 is passed from injection moulding to 75°C preheated die [2]. Here, the preheating of die is helpful for free flow of composite materials. The composite specimens are prepared with various proportions of weight percentages. Preparation process of SiC/N6 composites as shown in Fig. 2 [3]. The specimen code used for representing fabricated test specimens of N6 and N6 composites were listed in Table 1.

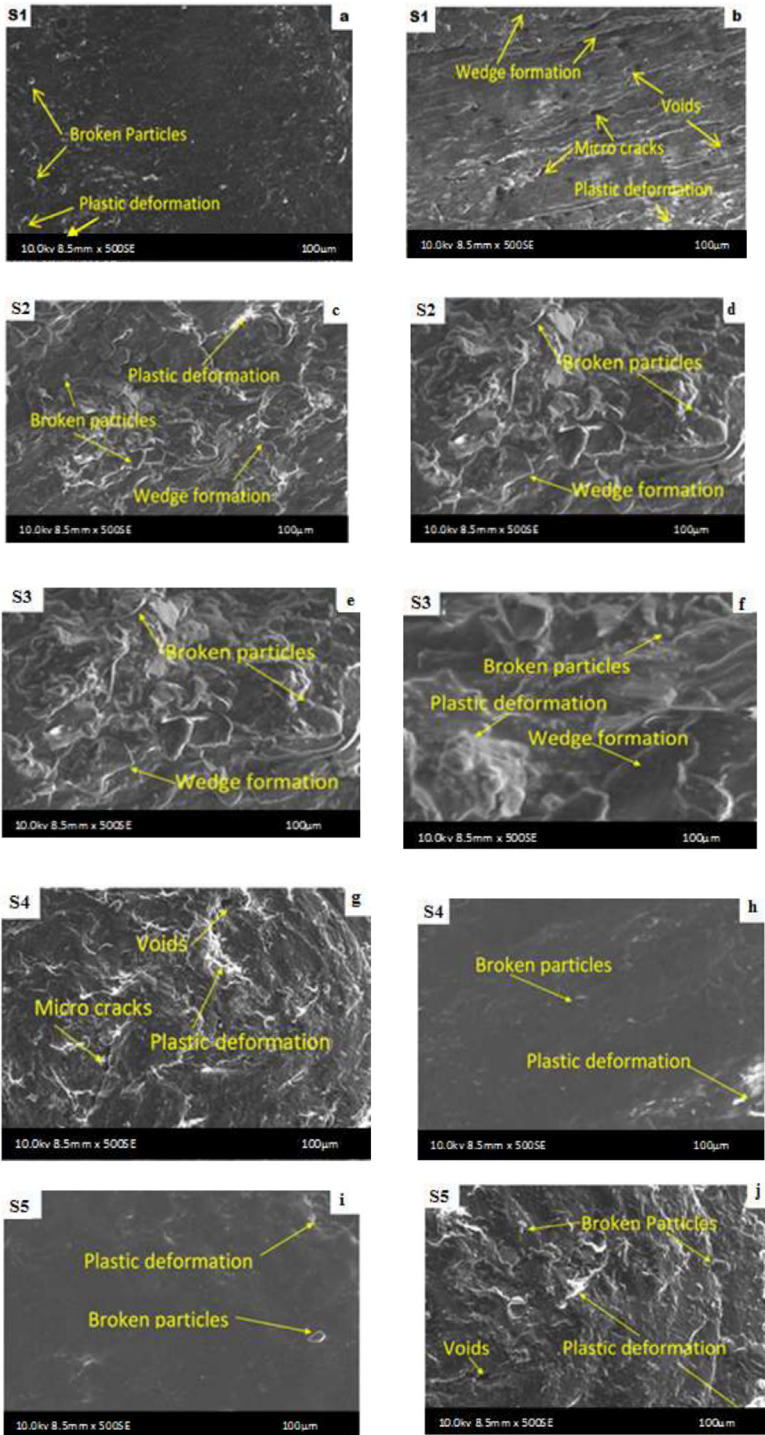


Fig. 6. SEM images of before (a,c,e,g and i) and after (b,d,f,h and j) worn surfaces of N6 and N6 composites

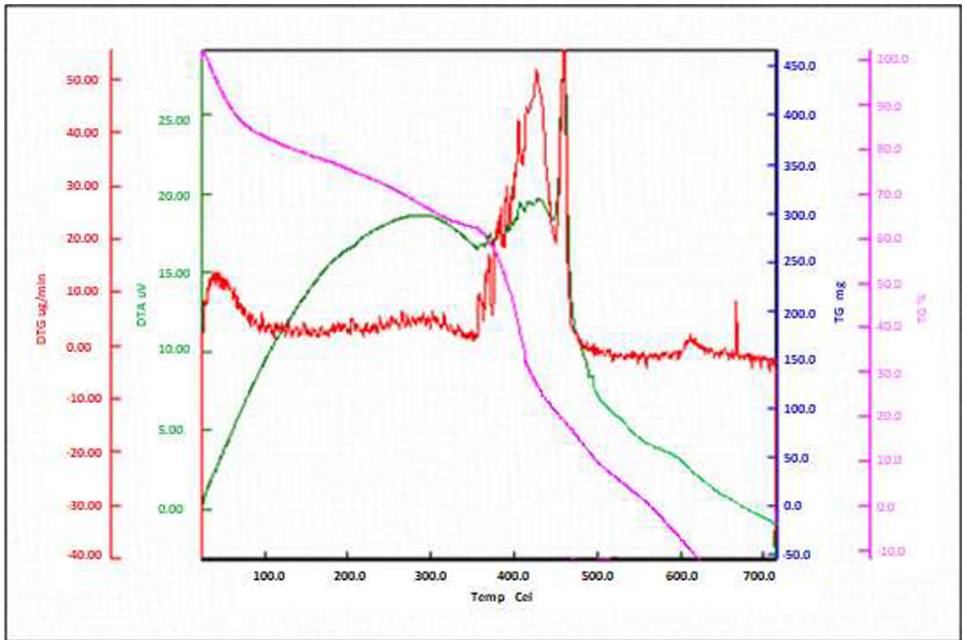


Fig. 7. TGA of 20 wt. % SiC / N6 specimen

2.3. Tribological test

The dry sliding wear characteristics of the composite were analyzed by using a pin-on – disc test apparatus as per ASTM G99 standard. The specifications of pin-on – disc are as follows; Disc rotation speed 200 – 2000 rpm., normal load 0 – 200 N, frictional force 0 – 200N and wear measurement range 0 - 1200 μ m. The size of test specimen is 12 mm diameter and 30 mm length. The surfaces of both the specimen and the disc are cleaned with a soft paper soaked in acetone before the test. The disc material of the pin –on disc tribometer is EN-31 plain carbon steel. The testing speed is kept in the range of 1000, 1500 and 2000 rpm. Then, the load is applied in the range of 5, 10, 20 and 30N. The friction and wear characteristics of 5 specimens are tested by pin on disc tribometer under different dry friction conditions. The environmental condition in the laboratory is 28° C and 44% relative humidity. Here, the following constraints and the test conditions as shown in Table 2. are utilized as a part of the pin on disc testing machine.

2.4. Co-efficient friction on N6 and N6 composites

Fig. 4 reveals the variations of frictional co-efficient of N6 and SiC reinforced N6 composites with varying loads. Pure N6 (S1) exhibits high Co-efficient friction Such as 0.32,0.35,0.37& 0.42 by varying 5,10,20 and 30N loads. It was obvious that the friction coefficient increases initially to a higher value due to the fresh abrasive material and as the process continues it to nearly remain same for the entire test period.

2.5. Wear rate on N6 and N6 composites

The specimen surface was measured by using a precision electronic balance with an accuracy of ± 0.01 mg. During initial tests, the surfaces of both the specimens and the steel coun-

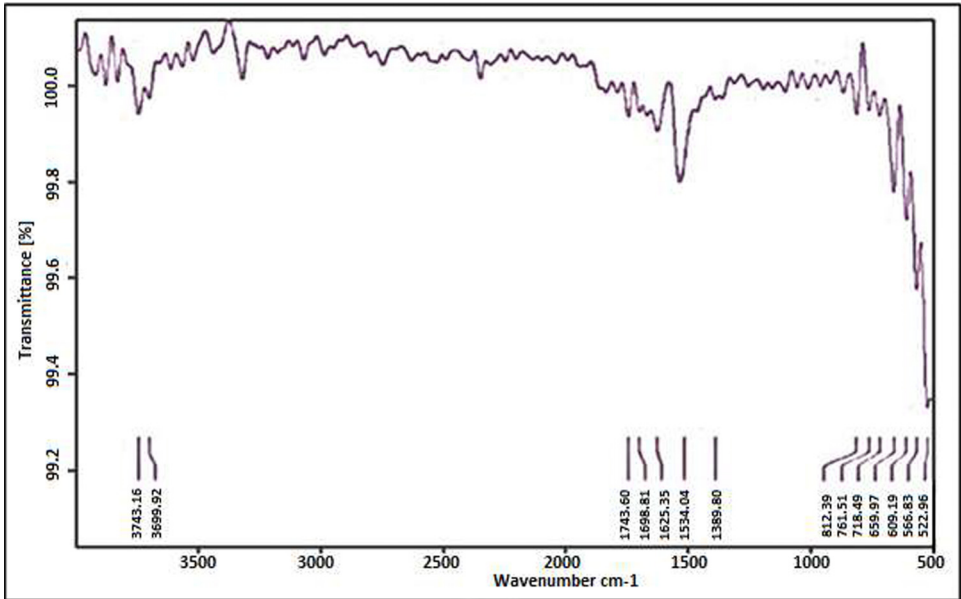


Fig. 8. FTIR spectroscopy of 20 wt. % SiC / N6 specimen

terparts were rough due to the strong interconnections between the surfaces resulting in a high friction coefficient. As the wear process continued, the rough profiles of the steel counterparts and the specimens were smoothed. Moreover, there is an increase in sliding velocity, the friction heat is much more, additional wear debris adheres on the specimen. Fig. 5 shows the wear characteristics of N6 and SiC reinforced N6 composites under 5, 10, 20 and 30N load [4,5].

2.6. Scanning Electron Microscope (SEM) of SiC / N6 composites

The SEM images of the specimens were obtained by using SEM. The surfaces of the N6 and N6 composites of before worn and after worn images are represented in Fig. 6. Fig. 6 (S1.a) and Fig. 6 (S1.b) reveal the morphological images of before and after worn surfaces of pure N6 test specimens. In Fig. 6 (S2.c) and, Fig. 6 (S2.d), 5 wt.% of SiC particles are consistently scattered on N6. SiC shows the broken particles and the wedge formations are made less compared to pure N6. Broken particles and wedge development were not exposed on the surface of N6 with 5 wt.% SiC. Fig. 6 (S3.e) shows the broken particles, plastic deformation and wedge formation of N6 with 10 wt.% SiC. Fig. 6 (S3.f) shows the voids development, plastic disfigurement and micro cracks of N6 with 10 wt.% because of SiC particles are not evenly distributed on the N6. Fig. 6 (S4.g) shows the broken particles and plastic deformation. The proper blending of SiC with N6 shows very less plastic distortion and broken particles on the image. Fig. 6 (S4.h) demonstrates the picture of 20 wt.% SiC.

This picture obviously depicts the uniform dissemination of SiC particles in N6. In the meantime, plastic distortion and broken particles are formed on the worn surface before testing of the specimen. After testing, worn surface of 20 wt.% SiC reveals the plastic distortion and broken particles arrangement on the surface of N6 (Fig. 6(S4.h)). Fig. 6 (S5.i) demonstrates the voids development, plastic deformation and broken particles of N6 with 30 wt.% SiC. micro cracks and broken particles are formed on the after worn surface of N6 with 30 wt.% SiC. It is seen

that the dispersion condition of SiC in the N6 polymer matrix is reasonably uniform in the 30 wt.%.

2.7. Thermal Properties of 20 wt.% SiC reinforced N6 composites

For optimum 20 wt.% SiC reinforced N6 composites, Thermal degradation were determined by the Thermogravimetric analysis (TGA) and Differential Thermal Analysis (DTA) thermogram as shown in Fig. 7. As expected, the two stages of degradation are evident in both the profiles which correspond to temperature regions of different constituents like moisture evaporation (upto 100°C) and degradation of the material of SiC (100–550°C). The depolymerization of SiC usually occurs between 500 and 580°C. The initial peak of SiC reinforced N6 composites was found at 93°C which obviously represents the loss of moisture and other volatiles at the first degradation.

The degradation trends in nitrogen environment for SiC/ N6 – 20 wt.% composite is similar, but the residues left behind after decomposition are different. While the residue left is about 0% in the case of N6, it is found to be SiC 20 wt.% composite under nitrogen. The TGA 20 wt.% loss temperature, char yield and maximum decomposition temperature (Tmax) for the SiC/N6 composites under nitrogen environments. The onset temperature for degradation is 17°C. The onset temperature for degradation remained almost unchanged for 20 wt.% SiC with higher polyamide loading. These findings were related to morphological observations that show exfoliated structure only for 20 wt.% SiC, and distinct polyamide agglomerations in this composite with higher SiC loadings.

It is observed between room temperature and 100°C. The next peak which is obtained around 585°C which denotes DTA degradation of SiC and the prominent peak appears at the temperature corresponding to the maximum degradation rate. Moreover, SiC reinforced with N6 composites increases the degradation temperature (550°C to 620°C) due to retaining and improving the structural order to minimizing the amorphous content. A greater crystalline structure essentially requires a higher degradation temperature which is clear in optimal SiC with N6 composites. The DTG curve shows the decomposition temperature of SiC composite material value which is above 580°C.

This work proposes that only exfoliated polymer composites exhibit improved thermal stability. Agglomerated SiC particles do not significantly affect the thermal stability of the polymer matrix.

The work suggests that the SiC with an optimized N6 concentration can be a promising reinforcing material in the design of new generation composites with specific applications requiring high wear resistance and high thermal stability [6].

2.8. Fourier transform infrared (FTIR) analysis for SiC / N6 composites

In Fig. 8, the curve indicates that the main characteristic bands of doped 20 wt. % SiC and N6 appear in FTIR spectrum. From the Fig. 8, it is observed that the peak at the wave number 522.96 cm^{-1} shows the presence of the C-Br whereas the peak at 812 cm^{-1} shows the presence of C-H (Alkene). The peaks at 1389.80 cm^{-1} and 1743.40 cm^{-1} represent the presence of C-F and C= O, respectively. The peaks attained in the spectrum at 3699.92 cm^{-1} and 3743.16 cm^{-1} prove the presence of O-H stretch free bonding.

These observations suggest that SiC/N6-based composites most likely degrade via unzipping depolymerization leading to the evolution of cyclic monomer and random chain cleavage through amide pyrolysis. When this pyrolysis reaction involves adjacent amide groups, 5-hexenamide is formed. This molecule might be responsible for the absorption bands at 1625 and 1534, 1389, 812.39 cm^{-1} . The amide group can also react at high temperature with water that trapped in the polymer and therefore produce volatile carboxylic acid compounds detected in

FTIR at 1743 cm^{-1} . The decarboxylation of this acid leads to CO_2 emission (3699.92–3743.16 cm^{-1}).

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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