A COMPARATIVE STUDY ON VEHICULAR TYRE RUBBER AND AIRCRAFT TYRE RUBBER: A REVIEW BASED ON SEM EDS AND XRD ANALYSIS

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ABSTRACT

In recent years the wastage of rubber waste material is tremendously increased because of the high usage of rubberized materials. It is understood that rubber materials are user-friendly but not eco-friendly because of its non-degradable nature. Often waste rubber from the tyre is being disposed of through land filling or by incineration process which is causing a serious threat to the environment. Hence, it is necessary to utilize the waste rubber from the tyre with suitable technical manner. A number of research works are being carried out to reuse the vehicular tyre rubber waste. In the present work, an attempt has been made to study the characteristic properties of Vehicular and Aircraft tyre rubber waste through Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Spectrometry (EDS / EDX) and X-ray diffraction (XRD) analysis. It is found that the aircraft rubber waste contains less percentage of siliceous more material than normal vehicular tyre rubber waste.

KEYWORDS: Tyre Rubber Powder, Scanning Electron Microscopy, Energy Dispersive Spectrometry & X-Ray Diffraction

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INTRODUCTION

In the present era industrialization and consumerism tremendously increased the usage of polymers like rubberized materials¹⁻¹⁵. Advancement in the construction of roads and vehicles is on the priority as automobiles became a necessary part of life. This additional development and requirements increased the urban heat and generation of rubber tyre waste². Apart from the economic growth, the amount of garbage generated by these materials causing pollution to the environment is high. Most of the tyre rubber waste is being sent to landfills, or on worse conditions to the open dumps, which raises a concern for the air pollution and social unrest³. The open dumping of scrap tyres involved a substantial space presents terrible nature to the eye and causes potential health and environmental hazards⁴. Scrap tyres contain oily chemicals that are easily set on fire which releases hazardous chemicals into the air, water, and soil⁵. This is hard to quench and costly to clean up⁶. The best approach for solving the generated tyre rubber waste issue would be recycling and reusing of waste material produced¹⁶. Tyre rubber waste is neither categorized as solid waste or hazardous waste. For the most part, it is considered as industrial or trade waste and thus there is no particular law or regulation which governs waste tyre management⁴⁻¹⁷.

Considering the environmental importance, the treatment and disposal of tyre waste have become the need of the hour, but the mixed composition of tyre waste is the major problem⁷. The Crystallinity of rubber materials has an

influence on their physical and chemical properties, and the measurement of the crystallinity is one of the important characterizations to know the material properties⁸⁻⁹. Several methods for crystallinity measurements emerged and the technique of X-ray diffraction is one of the best methods. X-ray diffraction (XRD) is one of the most important non-destructive tools to analyze all kinds of matter ranging from fluids to powders and crystals¹⁰⁻²¹. However, since polymers like rubber do not consist of clear two phases, crystalline, and amorphous regions, it is difficult to calculate the accurate crystallinity values of rubberized materials¹⁸. On the other hand, it is sometimes necessary to trace the crystallinity changes of rubberized materials, which are subjected to chemical or thermal treatments, because the changes of the ultra-structure of rubberized materials have directly and indirectly influenced on physical properties of rubberized materials¹¹.

The analysis of scanning electron microscopy (SEM) is a supplementary technique to observe the morphological changes during the different aging process. The result shows the larger crystal size, increased crystallinity and more regular morphology of the material with increased aging time¹²⁻¹⁹. Energy-dispersive X-ray spectroscopy (EDS or EDX) is an analytical technique used for the elemental analysis or chemical characterization of a sample¹³⁻¹⁴. Its characterization capabilities are due in large part to the fundamental principle that each element has a unique atomic structure allowing a unique set of peaks on its electromagnetic emission spectrum²⁰. EDS can be used to determine the composition of the sample to estimate the relative abundance. The accuracy of the analysis is mostly influenced by the nature of the sample. Hence, in this paper, an effort has been made to characterize the chemical composition of the vehicular tyre rubber and aircraft tyre rubber by performing the SEM, EDS and XRD analysis and presented the results.

EXPERIMENTATION

The vehicular tyre rubber waste is collected from Visakhapatnam and the Aircraft tyre rubber waste is collected from the Runway. The runway is being deposited by the rubber because of the Impact load of large Aircraft and environmental changes. As the part of runway maintenance work, the deposited rubber is removing using Track Jet. The cleaning performance of the Track Jet is up to 800meter square per hour, the pressure is up to 2000bar with the Rotor speed of 863 revolutions per minute. The speed of the Track Jet Engine is 1805 revolutions per minute and the speed of Track Jet is 379 meters per hour. The collected rubber from Track Jet is dumped in the yard from where the sample is collected for the present study.

Figure 1: Runway with Deposited Rubber

Figure 2: Collecting Rubber using Track Jet

Figure 3: Dumped Rubber in the Yard

Figure 4: Collected Rubber dried in Sunlight

The Vehicular & Aircraft tyre rubber waste was cleaned and washed thoroughly with distilled water. It is dried in an oven at 100 °C for 120minutes. The obtained product was treated with 30% Hydrogen peroxide (H₂O₂) for 15 to 20 min to oxidize adhering organic impurities. Then the sample was placed in the oven for 24hrs at 60 °C. The material was washed with deionized water several times to remove H₂O₂ and dried at 110 °C for 120 min in the oven. The dried Rubber sample was collected for further tests.

Figure 5: Pictures Showing the Process of Cleaning the Tyre Rubber Waste

A portion of the tyre rubber waste material sample was sent to Andhra University (AU), Andhra Pradesh, to characterize the chemical composition by performing the Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Spectrometry (EDS / EDX) and X-ray Diffraction (XRD) analysis.

SEM Analysis

Vehicular Tyre Rubber

Figure 6: SEM analysis at 200µm and 60× Magnification

Figure 7: SEM analysis at 200µm and 95× Magnification

Figure 8: SEM Analysis at 50µm and 330× Magnification

Figure 9: SEM Analysis at 20µm and 650× Magnification

Figure 10: SEM Analysis at 20µm and 850× Magnification

From the SEM analysis of vehicular tyre rubber waste, it was observed that the particles are non-uniformly distributed and unevenly spread. The pictures of SEM clearly, show the presence of minute chemical compositions with minimum agglomeration. The surface of the particle is rough compared to aircraft tyre rubber waste. Hence, from this analysis, it can be concluded that the presence of chemical composition of Vehicular tyre rubber waste is relatively less compared to Aircraft rubber tyre waste.

Aircraft Tyre Rubber

Figure 11: SEM Analysis at 500µm and 50× Magnification

Figure 12: SEM Analysis at 200µm and 80× Magnification

Figure 13: SEM Analysis at 100µm and 200× Magnification

Figure 14: SEM Analysis at 50µm and 300× Magnification

Figure 15: SEM analysis at 20µm and 600× Magnification

Figure 16: SEM analysis at 10µm and 1000× Magnification

The SEM analysis of Aircraft tyre rubber waste also confirms the non-uniform distribution and uneven spread of particles as seen in the Vehicular tyre rubber waste. The pictures of SEM show more chemical composition and high agglomeration compared to vehicular tyre rubber waste. High agglomeration may be due to the presence of more chemical particles in the sample which justifies Aircraft tyre rubber waste contains more chemicals compared to Vehicular tyre rubber waste.

Aircraft Tyre Rubber After Purification

Figure 17: SEM Analysis at 100µm and 160× Magnification

Figure 18: SEM Analysis at 50µm and 270× Magnification

Figure 19: SEM Analysis at 50µm and 450× Magnification

Figure 20: SEM Analysis at 20µm and 750× Magnification

Figure 21: SEM Analysis at 10µm and 1200× Magnification

The SEM analysis shows the presence of the less chemical composition in purified aircraft tyre rubber compared to non-purified aircraft tyre rubber waste. The surface of the particle is as smooth as Aircraft tyre rubber with minimum agglomeration. From this analysis, it was observed that some chemicals were removed during the process of purification.

DISPERSIVE X-RAY SPECTROMETRY (EDS / EDX) Analysis

Vehicular Tyre Rubber

The EDS results of Vehicular tyre rubber waste exhibits the presence of Silicon Oxide (37.17%), Sulphur Oxide (27.70%) and Zinc Oxide (37.13%) in the given sample. Hence, the SEM analysis for the presence of less chemical composition and minimum agglomeration is further supported by the EDS results.

Aircraft Tyre Rubber

Different compositions of Oxygen (64.7%), Silicon Oxide (17.61%), Potassium Oxide (3.4%), Calcium Oxide (2.38%), Ferrous Oxide (4.29%) and Molybdenum Oxide (7.61%) are found to be present in the given sample of Aircraft tyre rubber waste. This study also supports the SEM analysis of Aircraft tyre rubber waste in concluding the presence of more chemical composition with high agglomeration when compared to Vehicular tyre rubber.

Purified Aircraft Tyre Rubber waste

The purified Aircraft tyre rubber sample contains Oxygen (46.15%), Silicon Oxide (35.14%), Sulphur Oxide (5.5%), Potassium Oxide (5.26%) and Ferrous Oxide (7.94%). From this result, it can be observed that some chemical compositions were removed during the purification process.

X-RAY DIFFRACTION

Graph 1: XRD for Vehicular Tyre Rubber

Graph 2: XRD for Aircraft Tyre Rubber

Graph 3: XRD for Aircraft Tyre Rubber after Purification

The figures illustrate typical X-ray diffraction patterns for Vehicular and Aircraft tyre rubber waste. The sinusoidal representation of the peaks in the graph shows the variations of chemical composition of different samples. The XRD authenticates the results of SEM and EDS analysis. Even though the peaks of non-purified and Purified Aircraft tyre rubber waste look similar, a minute change can be observed in the purified sample due to the removal of chemicals in the purification process.

CONCLUSIONS

The chemical composition, regular morphology, particle size and agglomeration of Vehicular and Aircraft tyre rubber waste was observed clearly with different aging times in the present study. The analysis of above parameters shows the minimum correlation between the samples of Vehicular and Aircraft. Purification of tyre rubber waste results in the removal of some chemical compositions. The siliceous material is less and oxygen is present in the Aircraft tyre rubber waste and siliceous material is more and absence of oxygen was observed in the Vehicular tyre rubber waste.

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