I J R B A T, Issue (XI) Vol (I) Jan 2023: 68-73

A Double-Blind Peer Reviewed & Refereed Journal

e-ISSN 2347 – 517X

Original Article

INTERNATIONAL JOURNAL OF RESEARCHES IN BIOSCIENCES, AGRICULTURE AND TECHNOLOGY

TEMPERATURE DEPENDENT ELECTRICAL CONDUCTIVITY AND DIELECTRIC PROPERTIES OF FLY ASH COLLECTED FROM THERMAL POWER PLANT

A. D. Dahegaonkar

Department of Physics, N.S. Science and Arts College, Bhadrawati, Dist. Chandrapur, India
Corresponding Email: ajaydahegaonkar@gmail.com

Communicated :10.12.2022 | Revision: 20.01.2023 & 24.01.2023 Accepted: 26.01.2023 | Published: 30.01.2023

ABSTRACT:

Fly ash is finely divided waste obtained during the generation of energy in thermal power plants by burning powdered coal. The recycling of fly ash has become an issue in recent years, as this industrial waste is environmentally and economically important. The conductivity and dielectric permittivity parameters of the pellet measured as a function of temperature. Then, they were analysed how these parameters change depending on varying temperatures. Real and imaginary part of dielectric properties of the fly ash measured in the temperature range of 25–150 °C. Temperature dependence of real and imaginary part of dielectric permittivity suggests that fly ash exhibits strong broadband electrical behaviour. XRD study have performed to determine structural properties of fly ash. SEM analysis has performed to observe the surface morphology of fly ash. Electrical properties of fly ash used to control the conductivity to make it suitable for various applications and the result obtained from dielectric study of fly ash is of greater scientific and technological interest for the fabrication of good quality of capacitor. With utilization of this waste, it is possible to save energy, produce cheaper and protect ecological balance.

Keywords: - Fly ash, Electrical conductivity, Dielectric Properties.

INTRODUCTION :

In India, main source of electrical energy is coal based thermal power plants which contributes 53 % share of total electrical power produced [1-2]. The major problems faced by coal based thermal power plants are the handling and disposal of by-product that is fly ash. This is because of the huge quantity of fly ash produced. The amount of fly ash generated in India is 130 million ton per year [3]. The fly ash disposal problem has assumed such an important issue in the India that the Ministry of Environment and Forests issued a regulation on 14 September 1999 specifying normative levels for progressive utilization of fly ash. It is mandatory for the coal based thermal power plants to utilize 100% of the fly ash produced in a stipulated time horizon [4, 5]. According to Central Electricity Authority Report India has achieved only 63.28% of the target in terms of fly ash Percentage Utilization in the year 2016-17 [6]. Hence, it has decided to work on the utilisation of fly ash. The utilisation of fly ash is itself a big problem. The fly ash generated by the power stations is transported to the ash pond, which takes a large quantity of fertile land for dumping [7]. A huge amount of water is required for transporting the fly ash. The demand and requirement emphasis on application of Fly ash in road embankments, filler, building materials, bricks, in agriculture, in paint industry and many more. The effective use of fly ash it is decided to make an alkali activated fly ash composites which can be converted into some useful in civil construction using these materials such as fillers, tiles etc. with good compressive strength [8]. Electrical conductivity and other electrical parameters are needed to study along with thermal behaviour to develop the material application for frequency base working environment. Thermal conductivity is the heat

http://doi.org/10.29369/ijrbat.2023.010.1.0011

carrying capacity of the materials, which is elementary characteristic of material that conducts heat [9].

After studying the chemical and physical properties of Fly ash from thermal power plants and red mud from aluminum refineries , we found that it should not only be treated as a simple waste which mainly creates environment problem, health problem and reduces fertility of soil [10-14]. Therefore, the scientific communities are devoted to continue the research using industrial wastes to make the useful materials to the society for economic benefits. The one of the useful materials is electrical materials. In the electrical point of view, Insulators have great importance in everyday life as it makes our life easy, safe and shock free. We use varieties of insulators knowingly or unknowingly for different purposes. Electrical pin used in electrical poles is also a same kind of insulator [15-17]. Similarly, dielectrics are also very important for instruments that we use not only in our day-to-day life but also in high value in high technology applications such as defence, microwave, capacitors etc**.** We have invented a tunable material, which has a great application in microwave engineering so it can be used as a phase shifter filter etc. it can also be used in manufacturing radomes. All of these are of high value for defence applications and presently these electronic instruments are not manufacture in India and imported from foreign countries. Hence, it is important to produce developed electronic materials from industrial wastes. Therefore, it will facilitate for the production and development of these appliances in our country. Thus, it will save foreign exchange and promote export potential of the electronic goods. [18].

EXPERIMENTAL:

A fine fresh, clean and pure fly ash powder collected from Thermal Power Station, Chandrapur (M.S.) India. The particle size of this fly ash ranged between 150 nm–120 µm. It was abrasive and refractory in nature. Chemically, the fly ash was silica to an extent of 55–70%, followed by alumina 10–18%, iron oxide 6–20%, and lime magnesia and alkalis varied between 1 and 5% each. It was reported that fly ash generally contains elements like Cu, Pb, Cd, Ag, Mn, Fe, Ti, Na, Mo, S, P, Zn and Cl in different concentrations depending upon the type of coal used. The fly ash powder was compacted into pellet of 10 mm diameter. This pellet was used for the measurement of d.c. conductivity using four-probe method. The dielectric constant (ε) and dielectric loss (ε') was estimated in the by using the formula

$$\varepsilon_r = \frac{Cd}{\varepsilon_o A}$$

Where *C* is the capacitance of the pellet, *d* the thickness the pellet, *A* the cross sectional area of the flat surface of the pellet and ε_o is the constant of permittivity of free space.

The SEM images of fly ash investigated using Field Emission Gun Scanning Electron Microscope. The X-ray diffraction patterns of the samples in this present case were recorded on Philips PW-1700 X-ray diffractometer using CuKα radiation of wavelength 1.544 A^0 Continuous scan of 2 ^{0}/ minimum with accuracy of 0.01.

The characterization by spectroscopic methods is important, as it gives information not only about various molecular-level interactions but also on the type of charge carriers. The variation of conductivity with temperature has studied. Fly ash is a finely divided amorphous powder with the particle size ranging from 150 nm–120 µm. It is abrasive and refractory in nature.

RESULTS AND DISCUSSION:

Scanning Electron Microscopy (SEM):

Fig.1. Shows the SEM images of fly ash as obtained from Thermal Power Station, Chandrapur. From SEM image of pure fly ash that fly ash particles formed a cluster or

http://doi.org/10.29369/ijrbat.2023.010.1.0011

agglomerate among themselves due to strong polarity of hydroxyl groups on fly ash surfaces. Especially the fly ash has well-dispersed nature and spherically shape. The SEM micrograph of fly ash show that these are spherical in nature. Si and Al are the main constituents present in the collected fly ash sample as revealed by the chemical compositional analysis as mentioned.

X-ray Diffraction Spectroscopy (XRD):

Fig. 2 shows the X-ray diffraction pattern of the fly ash the major crystalline phases in the fly ash were quartz and Mullite together with the amorphous component based on an aluminosilicate glass. Fly ash consists of quartz (SiO_2), mullite ($3Al_2O_3$, $2SiO_2$) and hematite (Fe_2O_3) is major crystalline substances in the fly ash. It can be seen that a wide peak in the angle range of 2θ=18° to 23° appears in XRD pattern, which is due to influence of amorphous phase of the fly-ash cenospheres. From the XRD pattern of fly ash cenospheres the diffraction peaks of SiO_2,Fe_2O_3 and Al_2O_3 are clearly seen because the main component of fly ash cenospheres are siliceous oxide, Ferreous oxide and aluminous oxide [39]. Crystalline SiO_2 can be identified as the primary constituent of fly ash from two characteristic peaks at 2Θ=20.9° and 26.6° corresponding to the [100] and [101] reflection planes of quartz in the fly ash. The most intense peak of alumina at 2Θ= 25.6°[012] plane), along with some smaller peaks at 2Θ= 22.6°[101], 35.2°[104], and at 43.4°only the 2Θ= 35.2°[104] and probably of 59.8°[211] Al_2O_3 reflections in the fly ash implies the lower concentration of this phase present in the latter. Mullite ($3Al_2O_3$, 2SiO2) can identified as the third primary constituents from a number of peaks. Moreover, some other metal oxides can identified as the secondary constituents. Iron oxide (Fe_2O_3) peaks at 2Θ= 32.9° [110], and 2Θ= 54.3[211]. Very small amount of calcium oxide (CaO) [peaks at 2Θ= 54.0° and 64.3°] is probably present. Other constituents may also be present in the fly ash sample in negligible amount.

Temperature Dependence D C Conductivity of fly ash :

To study the conduction mechanism of fly ash in pellet form, the DC electrical conductivity was determined by measuring current and voltage in four-probe resistivity set up at different temperatures. Fig. 3(a) shows the variation of conductivity with temperature for the fly ash. Fly ash act as insulator and at room temperature its conductivity is found to be $1.01x10^{-11}$ S/cm which is very low. Fig. 3(b) shows band theory of fly ash and its activation energy was found to be 4.6 eV. In polymers, conduction takes place by the mobility of charge carriers from an occupied site to an unoccupied site. The activation energy exhibits exponential dependence of conductivity on temperature. The defects generally increase with temperature and are independent of temperature at lower temperatures. At higher temperatures, additional defects are created. At lower temperatures, they are frozen. Hence, the conductivity variation with temperature is divided into two regions: (I) pertaining to higher temperature and (II) pertaining to lower temperature [18].

Temperature dependence dielectric constant and dielectric loss of fly ash :

As the temperature of the fly ash increased, there is no desperation in dielectric constant. This is because of tight binding forces between the number of ions or atoms. Moreover, the sample shows value of dielectric constant 6.50 at 100^0C. From the fig.4 It has been observed that variation of ε' and ε" with temperature is nonlinear. This curve shows the existence of relaxation during the change in temperature. The dielectric constant was found continuously increased up to certain temperature and then become saturated as temperature increased this may due to the breakage of chain link and confirms the disordered system. As the

http://doi.org/10.29369/ijrbat.2023.010.1.0011

temperature increases, the dipoles comparatively become free they respond to the applied electric field. Thus, polarization increased and hence dielectric constant increased with increases of temperature [19].

CONCLUSIONS :

In the electrical point of view, insulators have great importance in everyday life. Fly ash act as insulator and at room temperature, its conductivity is very low and its activation energy found to be 4.6 eV the activation energy exhibits exponential dependence of conductivity on temperature. Similarly, dielectrics are also very important for instruments that we use not only in our day-to-day life but also in high value in high technology applications such as defence, microwave, capacitors etc. Fly ash showed dielectric constant of the order of 10, which can be a best suitable material for capacitor fabrication.

REFERENCES:

Ananth Chikkatura ,Ambuj Sagar, Carbon Mitigation in the Indian coal-power sector: Options and Recommendations, Elsavier, Energy Procedia , 1 (2009) 3901-3908.

S K Sahu, T Ohara, G Beig, The role of coal technology in redefining India's climate change agents and other pollutant, Environment Research Letters, 12 (10) (2017) 1-8.

M.Ahmaruzzaman, A review on the utilization of fly ash, Progress in Energy and Combustion Science, 36 (3) (2010) 327-363.

Aakash Dwivedi, Manish Jain, Fly ash- waste management and overview: A review, Recent Research in Science and Technology, 6 (01) (2014) 30-35.

Rakesh kumar Behera, H Xu,, Y Wang, F Ebrahimi, S B Sinnott, A critical assessment of interatomic potentials for ceria with application to its elastic properties, solid state ionics, 181 (11-12) (2010), 551-556.

Report on Fly Ash Generation at Coal/Lignite Based Thermal Power Stations and its Utilization in the Country for the year (2016-17), Central electricity authority, (2017), 1-63.

Manoj Kumar Tiwari, Dr. Samir Bajpai, IRJET, A fly ash utilization a brief review in Indian context, 03 (04) (2016) 949-956.

A Changjan, N Intaravicha, Thermal Conductivity in Soil: Theoretical Approach by 3D Infinite Resistance Grid Model, International Conference on Future Environment and Energy, 150 (2018) 1-5.

S.K.UBALE, a-c Conductivity and dielectric study of ferro electric (leadtitanate) doped zinc-vanadate-borate glass, Indian joirnal of pure and applied physics, 39 (2001) 378-381.

N.S. Pandian, C. Rajasekhar, A. Sridharan, Studies of the Specific Gravity of Some Indian Coal Ashes, Journal of testing and evaluation, 26 (1998) 177-186.

N.S. Pandian, Fly ash characterization with reference to geotechnical applications. Journal of the Indian Institute of Science, 84 (2004) 189-216.

M. Ahmaruzzaman, A review on the utilization of fly ash, Progress in energy and combustion science, 36 (2010) 327-363.

L. Wang, G. Hu, F. Lyu, T. Yue, H. Tang, H. Han, Y. Yang, R. Liu, W. Sun, Application of red mud in wastewater treatment. Minerals, 9 (2019) 1-22

S.Sushil, V.S. Batra, Catalytic applications of red mud, an aluminium industry waste: A review, Applied Catalysis B: Environmental, 81 (2008) 64-77.

C.L. Goldsmith, A. Malczcwski, J.J. Yao, S. Chen, J. Ehmk, D.H. Hinzel, RFMEMS-Based Tunable Filters, International

http://doi.org/10.29369/ijrbat.2023.010.1.0011

Journal of RF and Microwave Computer-Aided Engineering, 9 (1999) , 362.

G. Subramanyam, F.V. Keuls and F. A. Miranda, Novel K-band Tunable Microstrip v-band Pass Filter using Thin Film HTS/Ferroelectric/Dielectric Multilayer Configuration, IEEE MTT-S International Microwave Symposium sponsored by the Institute of Electrical and Electronics Engineers, 8 (1998) 1-8.

A. Tombak, J.P. Maria, F.T. Ayguavives, Z. Jin, G.T. Stauf, A.I. Kingon, A. Mortazawi, Voltage-controlled RF filters employing thin-film barium-strontium-titanate tunable capacitors, IEEE Transactions on Microwave Theory and Techniques, 51 (2003) 462-467.

M.K. Panigrahi , Investigation of Structural, Morphological, Resistivity of Novel Electrical Insulator: Industrial Wastes Bull. Sci. Res. 3(1) (2021), 51-58 [19] Ye Yaping , Zeng Xiaoqiang, Qian Weilan, Wang Mingwen-Y. Yaping et al. Synthesis of pure zeolites from supersaturated silicon and aluminum alkali extracts from fused coal fly ash- / Fuel 87 (2008) 1880–1886

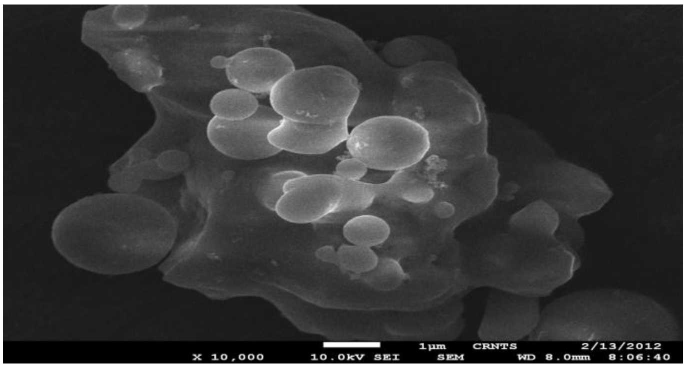

Fig .1 SEM image of fly ash

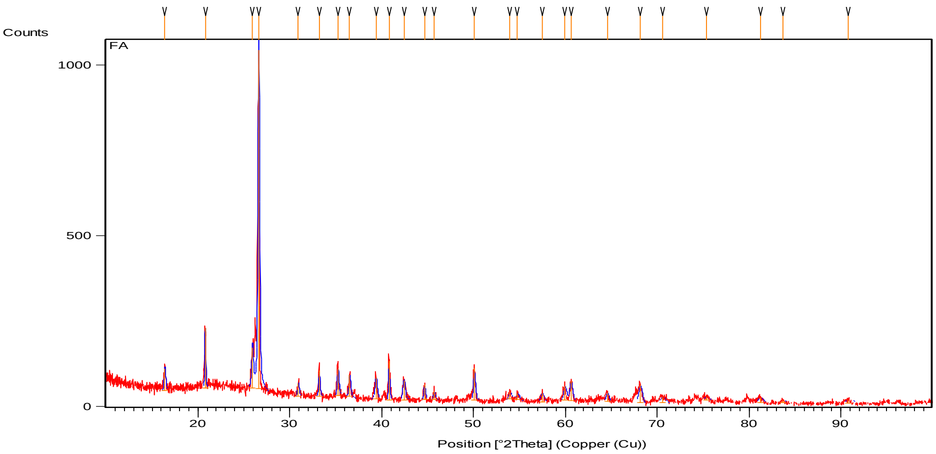

Fig.2 XRD of Fly Ash

http://doi.org/10.29369/ijrbat.2023.010.1.0011

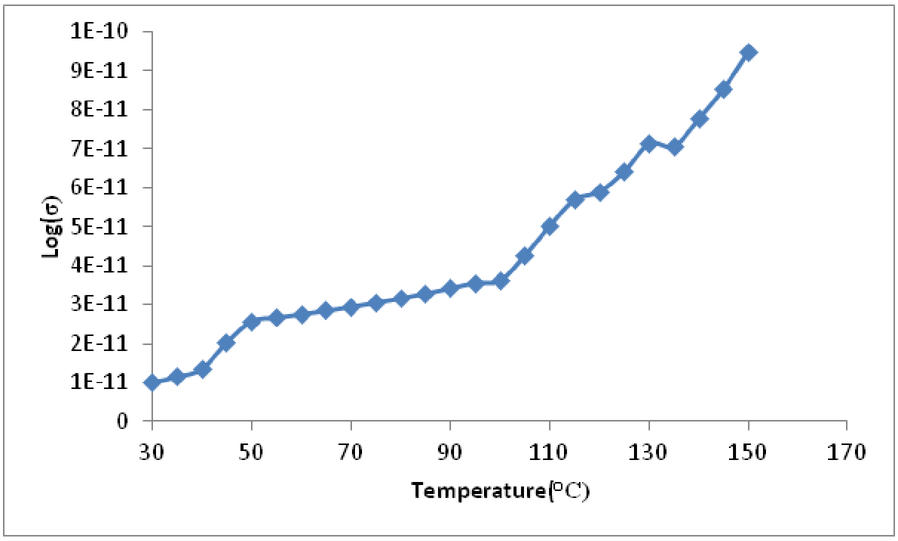

Fig. 3(a) Plot of conductivity of FA with temperature.

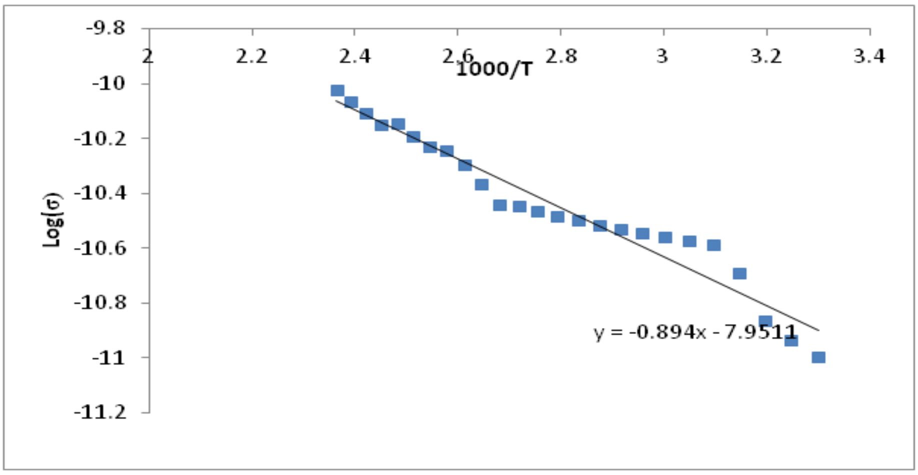

Fig. 3 (b) plot of logσ Vs 1000/T of Fly Ash (Band theory)

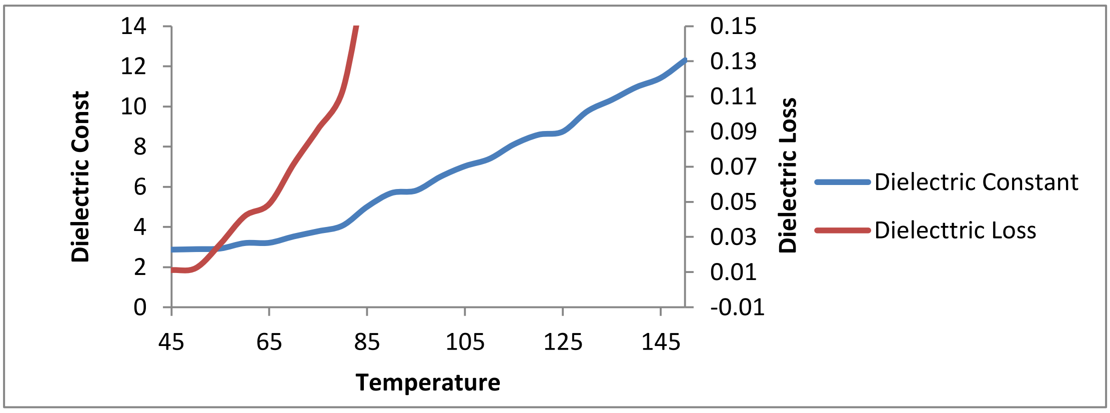

Fig.4 Dielectric constant and dielectric loss of fly ash

http://doi.org/10.29369/ijrbat.2023.010.1.0011