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Electrical Properties of Fly Ash Zeolite Cu-Beta

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ABSTRACT: In India Fly ash is produced on large manner in thermal power plants for production of electricity. This byproduct produces pollution and it is hazardous to human life. This fly ash contains silica and aluminium which is important in synthesis of microporous material like zeolite beta. As synthesized fly ash based zeolite beta is ion exchanged and characterized for its novel electrical applications as d. c. resistivity, Dielectric constant. The resistivity and dielectric constant changes with change in temperature. The dielectric measurements were taken in the frequency range 1KHz-1MHz. The temperature range used was 30^{o}C to 300^{o}C.

Keywords: Fly ash; Dielectric constant; Zeolite.

INTRODUCTION: In India Coal is the main source for the production of electricity. A large amount of fly ash is generated by the coal based thermal power stations. The authority handles ash utilization activities like its use in cement or concrete, fly ash bricks, filling of open cast mines and making roads etc. This ash is enriched with alumina and silica hence the ash material can be used as a source material for synthesizing novel useful materials like zeolites by using simple low cost process [1]. In the present paper it is demonstrated that the use of fly ash as a source material for synthesis of zeolite beta. Generally the zeolite synthesis is carried out by conventional hydrothermal method which is time and energy consuming process [2].The zeolite synthesis is carried out by microwave assisted hydrothermal method as it offers many distinct advantages over conventional synthesis, they include rapid heating, homogenous nucleation, fast super saturation by the rapid dissolution of precipitated gels and eventually a shorter crystallization time compared to conventional auto clave heating [3]. Recent studies show the role of microwave in zeolite is important to understand the properties of zeolites such as the movements of extra frame work cations .The movements of cations can be easily estimated using the conductivity and dielectric measurements [4-5].The dielectric properties of zeolites are important to study the catalytic applications. However, there is no detailed work on the variation of dielectric constant and loss with applied temperature. In the present work, resistivity and dielectric properties of fly ash based zeolites beta over a range of frequency are studied.

MATERIALS AND METHODS:

Preparation of Cu-beta zeolite: The zeolite Na-beta synthesized in a system with the gel composition 1.97 Na_2O:1.00K_2O:12.5(TEA) $_2O$: Al_2O3: 50SiO_2: 750 H_2O:2.9HCl thus formed is ion exchanged with 1 M solution of NH_4NO_3 at 80^{0}C for 12 h. This process was repeated thrice so as to get proper ion exchange. The product was filtered, air dried at 50^{0}C for 24 hr and then calcined at 450^{0}C so that the NH_4–beta is decomposed into H- beta i.e. protonic form which when ion exchanged with 0.1, 0.2 and 0.3M solution of copper nitrate [Cu $(NO_3)_2$.xH_2O], the Cu-beta samples were air dried.

Electrical Measurements: The samples of Na-beta and Cu- beta zeolite were compressed to form pellet of 10 mm diameter and 1 mm thickness. The pellets were heated to 300^{0}C to obtain a hard solid sintered material. The pellets were polished with silver paste for good electrical contact. D.C. resistivity of all samples was measured using two-probe method. The pellet was held between two electrodes in the temperature-controlled furnace. The d.c. resistivity values were measured at different temperatures in the step of 10 K. The relation between resistivity and temperature may be expressed as

$$\rho = \rho_0 \exp\left(\frac{\Delta E}{kT}\right) \quad (1)$$

Where, ρ_o is the pre-exponential factor with the dimensions of Ω cm, k is the Boltzmann constant, ΔE is the activation energy, and T is the absolute temperature.

The Dielectric parameters were measured in the frequency range 1KHz–1MHz for temperature 30^0C to 300^0C using LCR-meter (HP-4284A).

RESULTS AND DISCUSSION:

D. C. Resistivity Measurement:

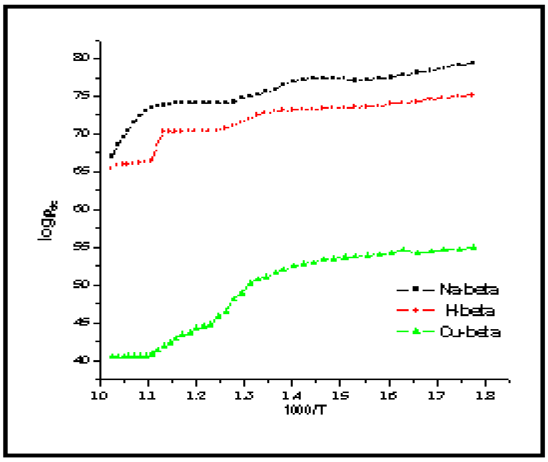

Figure 1: Variation of log dc resistivity of Na-beta, H-beta and Cu-beta with temperature inverse.

Comparison of variation of log dc resistivity of Na-beta, H-beta and Cu-beta with temperature inverse as shown in Fig.1. It is observed that for all the samples resistivity decreases with increasing temperature indicating the semi conducting nature of the samples. The temperature dependence of resistivity found to follow the Arrhenius equation.

The conduction mechanism of zeolites involves exchange of electrons between the ions of the same elements present in more than one valence state and distributed randomly over crystallographic lattice sites. The decrease in resistivity with increase in temperature is due to the increase in drift mobility of the charge carriers. Also conduction in zeolites is attributed to hopping of electrons from $Cu^{3+}$to Cu^{2+} at elevated temperatures. The mobile cations in zeolite are exchangeable and are weakly bound to the adjacent atoms than the framework ions [6].

Dielectric Measurement: The variation of dielectric constant (ε') is shown in figure 2.The dielectric constant decreases with increase in temperature This effect should indicate an increasing of the hopping frequency of the charge carriers with temperature[7]

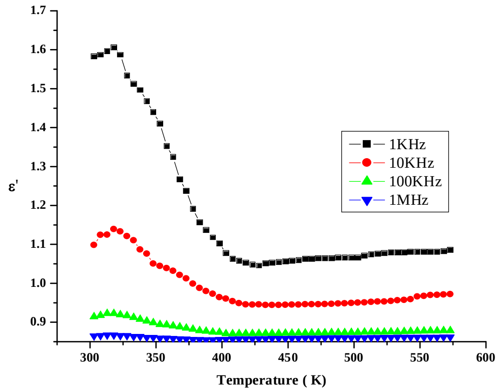

Figure 2: Variation of dielectric constant as a function of temperature.

CONCLUSION: The abnormalities in electrical conduction of Na and cu-beta zeolite is due to their different activation energies, which can be explained by three factors affecting the moving cation, coulombic attraction, coulombic repulsion. The dielectric behavior of zeolite is strongly affected by the presence of various molecular and ionic species.

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