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Low Frequency Dielectric Response of Modified Fly Ash Zeolite

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ABSTRACT

In Thermal power stations for generation of electricity, coal is burnt on large scale so that the coal fly ash is produced on large scale in India. In this paper, the modified zeolite A synthesized using fly ash is used for studying the dielectric properties. The zeolite is modified by ion exchanging so as to form Co-A type zeolite. The samples were tested for dielectric constant (ε′), dielectric loss (ε′′), electrical conductivity (ε_{ac}). The dielectric properties depend upon the percentage of encapsulated metal cations. This cost effective zeolite reported in this work provides a new path to fabricate highly sensitive materials for dielectric applications from hazardous solid waste fly ash.

Keywords: Fly ash, Zeolite Co-A, dielectric properties.

INTRODUCTION

Zeolites are alumino silicates and their applications in many disciplines are well known. Synthesis of zeolites using coal fly ash is a best alternative to utilize this hazardous solid waste. Since coal fly ash includes a large amount of silica and alumina, they are easily converted into zeolite by hydrothermal treatment in an alkaline solution [1, 2]. Fly ash is a fine grained powder, which is mainly composed of spherical glassy particles, produced during the combustion of pulverized coal. Many researchers have been synthesized zeolite A from fly ash [3]. Nowadays, a novel application of zeolite in electronics is necessary [4]. This paper reports the dielectric effects on zeolite Co-A synthesized from coal fly ash.

METHODOLOGY

The starting material was fly ash obtained from thermal power station, Parali Vaijnath, Maharashtra (India). The fly ash zeolite A synthesized using fly ash based on previous study [5] is used. The zeolite A thus formed is ion exchanged with 1 M solution of NH_4NO_3 at 80^0C for 12 h. This process was repeated thrice so as to get proper ion exchange. The product was filtered, air dried at 60^0C for 24 hr and then calcined at 450^0C so that the NH_4-A is decomposed into H- A i.e.protonic form then the zeolite which when ion exchanged with 0.1M, 0.2M and 0.3M solution of cobalt nitrate [Co $(NO_3)_2$.nH_2O], so as to obtain the **$Na_{(1-x)}$ Co_x A** zeolite where x = 0.1, 0.2, 0.3M.

Characterization:
The physical properties of coal fly ash and synthesized products were measured as follows. The chemical composition fly ash was determined by using a X-ray Fluorescence Spectroscopy. The chemical composition was analyzed using X-ray fluorescence analysis equipment (Phillips PW -2404). The sample phases were characterized by X-ray diffraction (XRD) using a (Philips PW 3710) diffractometer with Cu- K□ radiation (1.5496Å).

Dielectric Measurement:
The samples of Na-A and Co- A zeolite were compressed to form pellet of 10 mm diameter and 1 mm thickness. The pellets were heated to 300^0C to obtain a hard solid sintered material. The pellets were polished with silver paste for good electrical contact. The electrical conductivity was measured in the frequency range 20Hz–1MHz at room temperature 25^0C using LCR-meter (HP-4284A).

RESULTS AND DISCUSSION

1. XRF:
The elemental composition analysis by XRF in Table 1 indicated that coal fly ash contained large quantities of silica and alumina which are the two main components in zeolite. The chemical analysis of the fly ash used as the starting material in this work showed it to be a high-silica ash with the mole ratio of SiO_2: Al_2O_3 = 5.127: 1.

Table1. Chemical composition of fly ash

Oxides	% wt	Mol/100 g of fly ash
SiO_2	70.23%	1.169
Al_2O_3	23.27%	0.228
Fe_2O_3	4.38%	0.027
MgO	1.26%	0.031
Na_2O	0.42	0.0067
LOI	0.44%	-

2. XRD:
The X-ray diffraction pattern of fly ash based zeolite H–A and its exchanged form Co-A is shown in fig.1. The d values are compared with the standard [6]. The peaks located in the region of 7° < 2θ < 34.1° are representative peaks of a typical H-A zeolite. The peaks at 2θ = 36.8° is representative peak of a cobalt [7]. As can be seen in Figure 1, the intensity of peaks corresponding to H-A zeolite decreased, whereas, the intensity of peaks corresponding to cobalt increased on increasing the cobalt loading on H-A zeolite.

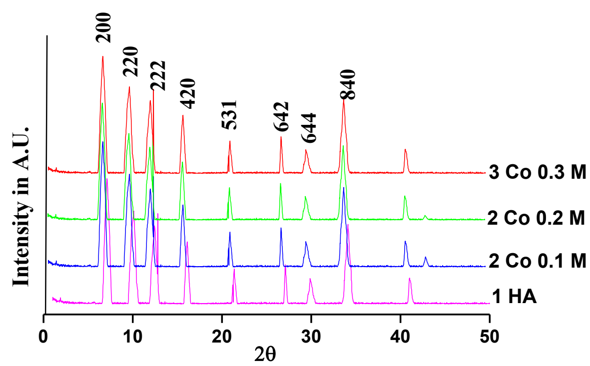

Figure 1. X-ray diffraction patterns of H-A/Co-A zeolite.

The intensity ratios (I/I_m) were calculated by considering peak intensities (I) at 2θ = 7.1^0 for A zeolite. The XRD for Co-A were found to be similar to that of original H-A sample, indicating that there is no structural changes occur after ion exchange with Cobalt nitrate [8].

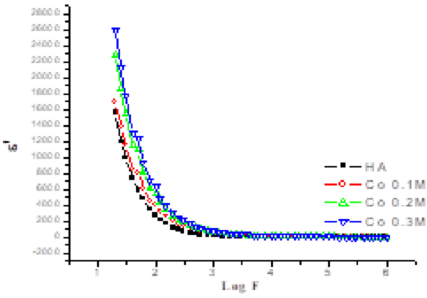

Figure 2.Variation of dielectric constant (ε') with log f

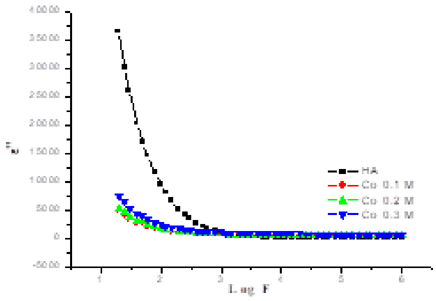

Fig.3 Variation of dielectric loss (ε'') with Log F

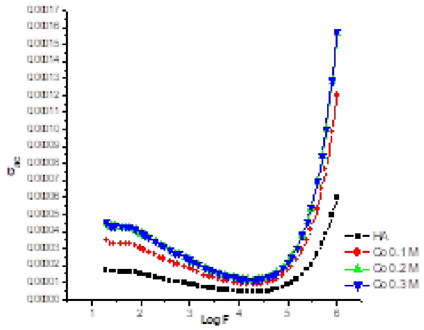

Fig4 Variation of ac conductivity (σ_{ac}) with Log F

3. Dielectric Measurement:

The variation of dielectric constant (ε'), dielectric loss (ε''), ac conductivity (σ) with log f for H -A and Co-A zeolites are shown in figure 2, 3, and 4. In Figure 2, the permittivity (ε') of zeolite HA was found to decrease with an increase in frequency. This characteristic gives the increase of the permittivity at low frequency. The low dielectric constant of zeolites (ε') suggests, however, that such processes in the zeolite channels should involve concerted action rather than strong charge separation.

In fig.3 the variation of dielectric loss (ε'') with frequency at room temperature is shown. This dielectric loss is frequency dependent and also influenced by water content of the zeolite [9]. The loss is in lowest frequency region and has been frequently observed in zeolites is supposed to be due to a dc ionic conductivity loss and grain boundary effect [10].

In fig. 4 the variation of ac conductivity (σ) with frequency at room temperature is shown. The conductivity increases with increase in frequency. The conductivity of zeolite HA is less than Co -A, as the conductivity depends on the cation size and the channels within the zeolites structure.

CONCLUSION

Zeolite A is successfully synthesized from solid waste material fly ash and it shows no structural change after modification with cobalt. The zeolite A and Co-A shows good response for dielectric applications.

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Conflicts of interest: The authors stated that no conflicts of interest.

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