Comparison between chemically treated sisal fiber with Al_2O_3 and Fe_2O_3: -it's dielectric loss

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Abstract

Aluminum oxide and iron oxide synthesized through sintering route. The present research work deals with ferrite and aluminum composite prepared using chemical reactions. Aluminum nitrate, ferric nitrate and ammonium chloride doped with sisal fiber has been prepared. The comparative studies of aluminum oxide and iron oxide were examined through dielectric measurement.

Key words: - Al_2O_3, Fe_2O_3, sintering method, tanδ

Introduction

The crystalline structure of $LiAlO_2$ depends mainly on the preparation methods. Many researches prepared $LiAlO_2$ with difAlrent structures. V.R. Galakhov et al. prepared α-$LiAlO_2$ with Fm-3m space group by using solid state reaction and M. Tabuchi et al. prepared α-$LiAlO_2$ with Fm3m space group by hydrothermal synthesis [1-3]. Similarly, β-$LiAlO_2$, γ- $LiAlO_2$ and layered $LiAlO_2$ are prepared by hydrothermal synthesis and other methods. Corrugated $LiAlO_2$ and Goethite type $LiAlO_2$ are prepared by ion exchange method. In comparison with the conventional solid phase synthesis methods, hydrothermal method is one of the simplest and best methods to prepare lithium based cathode materials [4-7]. In case of the electrical properties of the oxides, grain boundaries play an important role. The measurement of conductivity and permittivity shows dispersion behavior which offers an opportunity to gain some information of ionic migration process. Considering the significance, the electrical conductivity studies on various lithium-based oxides such as $LiCoO_2$, $LiCeO_2$, $LiSmO_2$, Li2SnO_3, Li2MnO_3, $LiMn_2O_4$, and Li2V_2O_5, and others have been reported in the literature [8-11].

However, to the best of our knowledge, there are meager reports on electrical and dielectric properties of $LiAlO_2$. A detailed study on the temperature and frequency depended electrical properties is necessary to understand the conduction mechanism in $LiAlO_2$ for effective utilization as cathode material in the fabrication of lithium ion batteries. In the oxides of aluminum a-Al_20_3 is the most stable compound. For the non-existence of Al++ ions a-Al_20_3 has higher electrical resistivity than other oxides of aluminum such as Al_30_4, AlO, and Aluminates. It has been reported, however, that at the temperature above 1200°C there is the possibility of the appearance of Al++ ions in a-Al_20_3. When the oxides contain Aluminum ions, the hopping of electrons between Aluminum and aluminum ions gives rise to higher conductivity. Thus for samples possessing both the conductive and less-conductive phases the Maxwell-Wagner interfacial polarizations are observed. With the surface modified by the use of mild reducing condition of sintering Hirbon reported the interfacial polarization in the sintered compacts of a-Al_20_3. On the other hand, in a-Al203 containing other ions of different valences such as Ti" ions polarizations due to permanent dipoles of Al++_Al+++ induced by Ti+4 ions were observed at very low temperature [12-15]

$LiFeO_2$ has various crystalline structures such as α- $LiFeO_2$, β-$LiFeO_2$, γ-$LiFeO_2$, Layered $LiFeO_2$, Corrugated $LiFeO_2$, Goethite type $LiFeO_2$ etc. The crystalline structure of $LiFeO_2$ depends mainly on the preparation methods. Many researches prepared $LiFeO_2$ with different structures. V.R. Galakhov et al. prepared α-$LiFeO_2$ with Fm-3m space group by using solid state reaction and M. Tabuchi et al. prepared α-$LiFeO_2$ with Fm3m space group by hydrothermal synthesis [16-18]. Similarly, β-$LiFeO_2$, γ- $LiFeO_2$ and layered $LiFeO_2$ are prepared by hydrothermal synthesis and other methods. Corrugated $LiFeO_2$ and Goethite type $LiFeO_2$ are prepared by ion exchange method. In comparison with the conventional solid phase synthesis methods, hydrothermal method is one of the simplest and best methods to prepare lithium based cathode materials [19-22]. In case of the electrical properties of the oxides, grain boundaries play an important role. The measurement of conductivity and permittivity shows dispersion behavior which offers an opportunity to gain some information of ionic migration process. Considering the significance, the electrical conductivity studies on various lithium-based oxides such as $LiCoO_2$, $LiCeO_2$, $LiSmO_2$, Li_2SnO_3, Li_2MnO_3, $LiMn_2O_4$, and $Li_2V_2O_5$, and others have been reported in the literature [23-26]. However, to the best of our knowledge, there are meager reports on electrical and dielectric properties of $LiFeO_2$. A detailed study on the temperature and frequency depended electrical properties is necessary to understand the conduction mechanism in $LiFeO_2$ for effective utilization as cathode material in the fabrication of lithium ion batteries.

Material and method

Chemical treatment of fiber

Ferric Nitrate (Fe $(NO_3)_3.9H_2O$) and ammonium chloride (NH_4Cl) was taken in the ratio 10:4 in 500 *ml* of distilled water. The mixture was stirred till a homogenous solution was obtained. In this mixture 10g of sisal fiber was added and then 1:1 solution of NH_4OH (liquid ammonia) was added to it then left the solution for one hour. Again the mixture thus obtained was dried and then annealed in muffle furnace at 1000°C and kept it at that temperature for 15 min.

The reaction may take place in this way

$2Fe\ (NO_3)_3.9H_2O + 3NH_4Cl + 3NH_4OH + \text{Fiber} \rightarrow \mathbf{Fe_2O_3: fiber} + 6NH_4NO_3 + 3HOCl + 18H_2O$

When ferric nitrate reacts with ammonium chloride and ammonium hydroxide along with sisal fiber at 1000°C with ammonium nitrate and HO-Cl (hypoclorous acid) decomposed at such high temperature and only ferric oxide is left.

Aluminum Nitrate (Al $(NO_3)_3.9H_2O$) and ammonium chloride (NH_4Cl) was taken in the ratio 10:4 in 500 *ml* of distilled water. The mixture was stirred till a homogenous solution was obtained. In this mixture 10g of sisal fiber was added and then 1:1 solution of NH_4OH (liquid ammonia) was added to it then left the solution for one hour. Again the mixture thus obtained was dried and then annealed in muffle furnace at 1000^{o}C and kept it at that temperature for 15 min.

The reaction may take place in this way

2Al $(NO_3)_3.9H_2O$ +3NH_4Cl+3NH_4OH+ Fiber→ **Al_2O_3: fiber** + 6NH_4NO_3 + 3HOCl + 18H_2O

When aluminum nitrate reacts with ammonium chloride and ammonium hydroxide along with sisal fiber at 1000^{o}C with ammonium nitrate and HO-Cl (hypoclorous acid) decomposed at such high temperature and only aluminum oxide is left.

2.2 Nature and structure of sample after firing

The material formed was found to in solid crystals in physical appearance. The sample appeared in powder form and it is like Cole in color. The material formed was found to in soft crystal in physical appearance. The sample appeared in powder form and it is like pale cream in color.

Result and discussion

The electrical properties of the insulating material Al_2O_3 and Fe_2O_3 composite were measured by impedance analyzer these dielectric measurement of Al_2O_3 and Fe_2O_3 composite doped with sisal fiber shown in figures. In the Fig 1-3 represents the graph between frequency and tanδ for Al_2O_3 and in the Fig 4-6 represents the graph between frequency and tanδ Fe_2O_3 respectivelly.

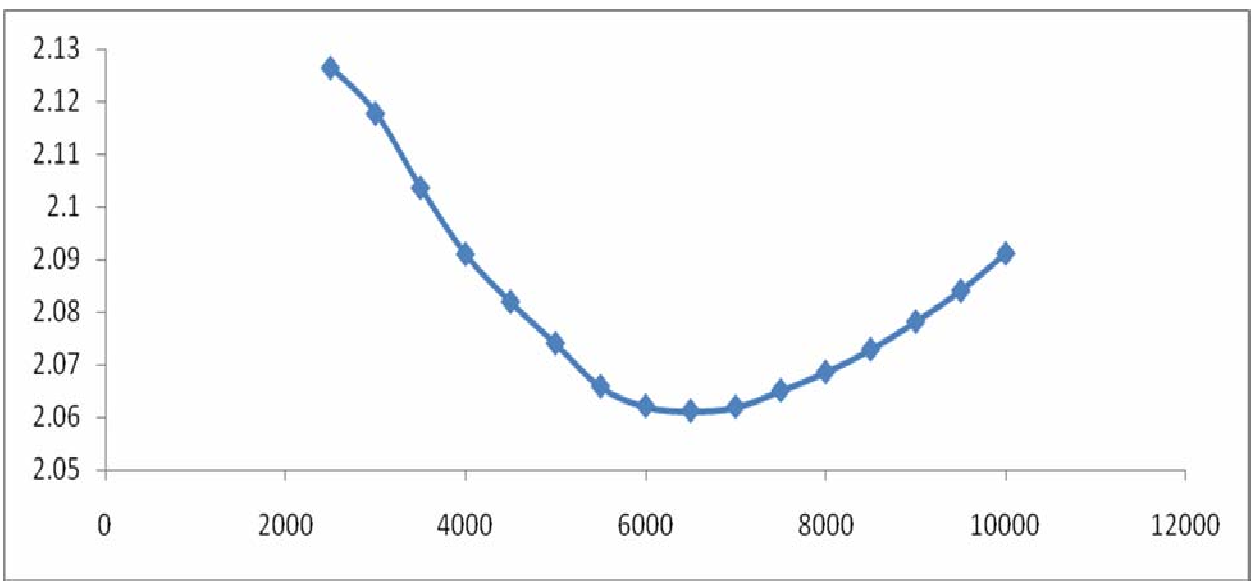

Fig 1

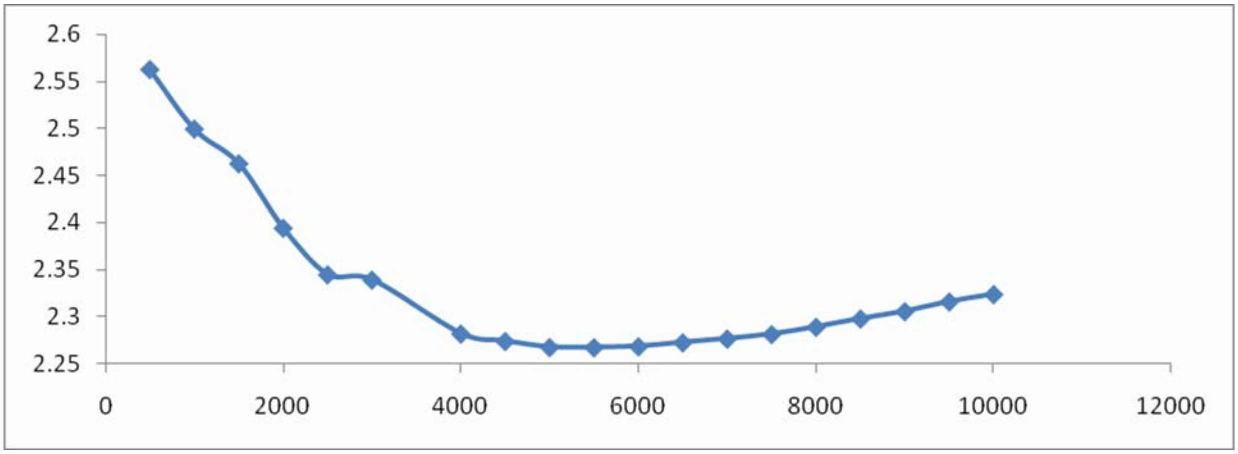

Fig 2

The dielectric constant ε and loss tanδ of Al_2O_3 at room temperature 30^oC are measured to be 1.9 to 1.3 respectively and are found to decrease with the increase in the frequency. The value of ε and tanδ are found to different with each other. In fig 1 the variation of dielectric constant at different frequencies with room temperature 30^oC for Al_2O_3 is shows that it decreases considerably with increase in frequency.

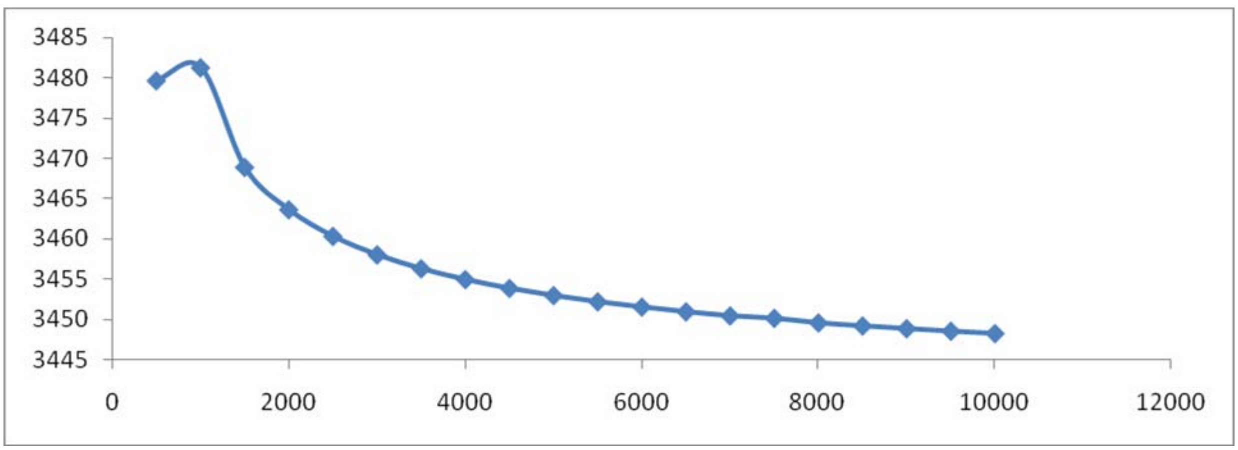

Fig 3

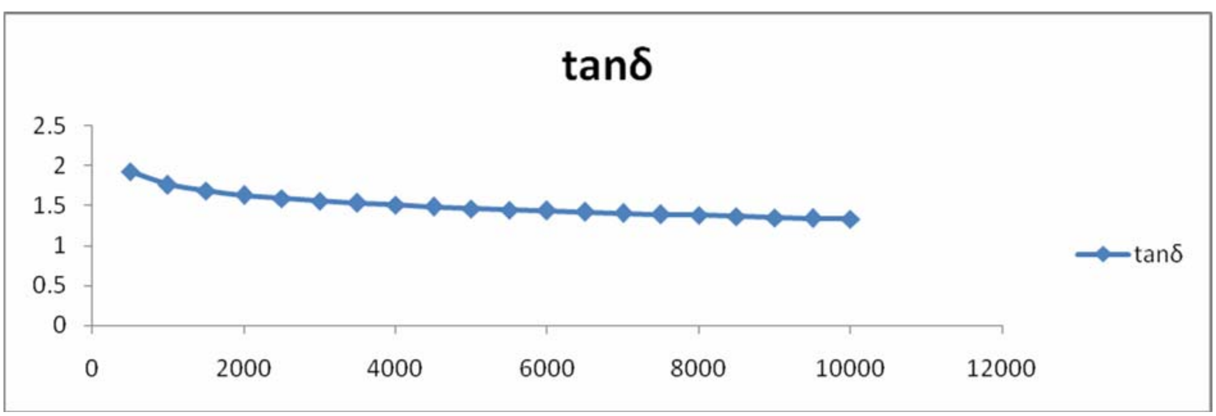

Fig 4

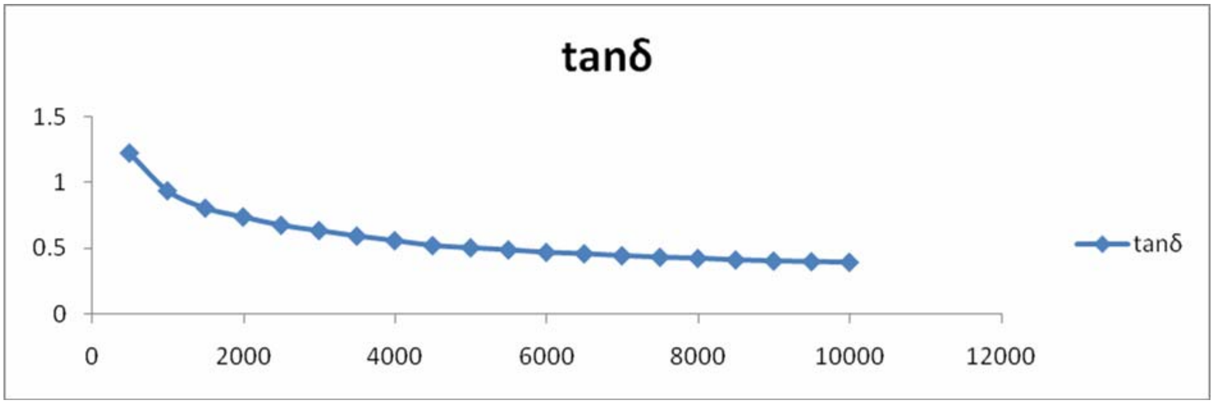

Fig 5

This dielectric dispersion is attributed to the Maxwell and Wagner type of interfacial polarization in agreement with Koop's phenomenological theory [30]. Since polarization decreases with increasing frequency and reaches constant values, a decrease in dielectric constant with frequency is observed.

At lower frequencies, dielectric loss tanδ is large and it decreases with increasing frequency. The tanδ is the energy dissipation in the dielectric system, which is proportional to the imaginary part of the dielectric constant. An increase in loss factor at higher frequencies may be due to the series resistance of the electrodes, leads, etc [31-33].

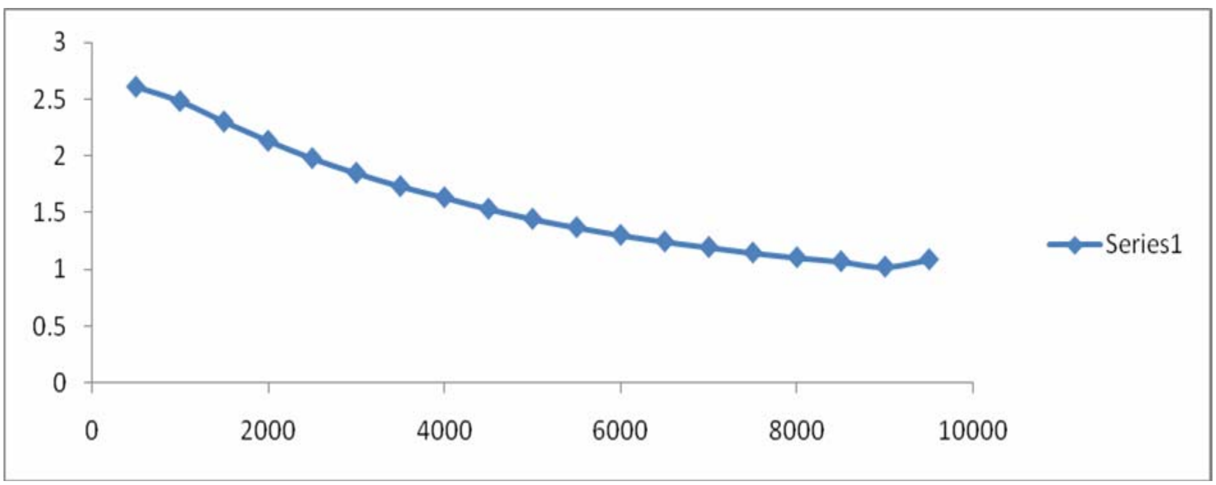

Fig 6

Conclusion

The effect of chemical homogeneity, fine grain structure, particle size and shape of the Alumina and ferrite samples are understood to affect the properties of dielectric behavior. The presence of moisture, cellulose, hemicelluloses, lignin and pectin also contribute towards changes in dielectric properties

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