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ScienceDirect

Energy Procedia 119 (2017) 670–679

Energy Procedia

www.elsevier.com/locate/procedia

International Conference on Technologies and Materials for Renewable Energy, Environment and Sustainability, TMREES17, 21-24 April 2017, Beirut Lebanon

Study characteristics of (epoxy–bentonite doped) composite materials

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Abstract

Procedures for preparing ceramic compounds with consisted of bentonite (80 wt %), alumina (10wt %) and silica (10wt %) were examined by solid state reaction technique. The thermal treatment of ceramic sample was studied by X-ray diffraction analysis. The influence of the content of the cordierite and mullite on the gained phase's properties of ceramic compounds specimens was analyzed. We found good insulator with mullite (73.33 wt%) and cordierite (50.10 wt%).The optimum achieved consequences are: Get a ceramic product without any distortion in the it form with the additives under sintered temperature (1250ºC) and gave the maximum diametrical Strength (σD) to 90 MPa. The best results of the break down voltage (24.8Kv) and dielectric strength (8.3Kv/mm). These results allow us to use the ceramic body in energy storage applications. As a second step: the ceramic product was re-grinded and it mixed in different ratio (5, 10, 15 and 20%) with polymer (epoxy) to prepare composites. Some of the physical properties of the product have been tested. The optimal results have been showed for all properties: electrical at the (5and10%) ratio, mechanical the ratio (20%) only and excellent thermal insulation. Depending on the Composite results can be used in the required electrical insulators industry (voltage bushings applications).

Peer-review under responsibility of the Euro-Mediterranean Institute for Sustainable Development (EUMISD).

Keywords: epoxy, Vicker hardness, Young modulus, yield strength, Tensile Strength, Dielectric Constant, Thermal conductivity Introduction.

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10.1016/j.egypro.2017.07.094

1. Introduction

Composite materials have exceptional thermal and electrical properties as a result of their components, which are superior to all other known structural materials in specific strength and hardness, high-temperature strength, fatigue strength, and other properties [1-4]. So, they have been widely applied in various fields due to their properties. Composite materials have comprised at least two elements with significantly different physical or chemical properties that, when mixed together, achieve a material with characteristics unique structural properties such as heat resistance, stiffness, strength, and other properties [1]. Ceramic has a very important position among Composite materials due to the characteristic properties of many industrial and structural applications. It's art and science of making heat-resistant solid materials and made up of compounds formed from metallic and non-metallic elements of inorganic [2-4]. It can be configured by the application of heat, and sometimes heat and pressure [2]. The past few decades have seen outstanding technological developments, which included the discovery of new types of ceramic compounds and specific specifications and methods of production better [5, 6]. In addition, the large developments in the requirements of high-temperature systems have all resulted in the production of modern ceramic materials [4, 6]. Ceramic is generally characterized by different qualities such as brittle, intrinsically transparent, hard, non-magnetic, electrical and thermal isolative, refractory, wear-resistant, chemically stable and oxidation-resistant [3].Generally, polymers are extremely flexible, good chemical stability; therefor polymers are considered substitutes to ceramic materials and insulator materials. But the main drawback in polymers are that they have less thermal stability than ceramic materials, limiting wider applications.in addition , the dielectric constant is less than ceramic materials. To improve insulation properties for polymers can be designed by introducing polarized groups into polymer chains, thereby increasing free size by stimulating porosity as well as polymerization. Dielectric constant can be increased effectively by producing composites (CCP) from polymer with ceramic filler [7]. Fillers non-active Industrial (clays and ceramic) used to reduce the cost of composite materials and improve the Mechanical properties of materials. Due to the disparity between the mechanical properties of polymeric materials and fillers [8]. Dielectric constant (ζr) defined as [9]:

$$\zeta r = \zeta'' / \zeta_o \ldots.(1)$$

Where ζ'' is the permittivity of the dielectric material. Dielectric constant on the frequency of the electric field applied depends [9].

$$\sigma_{a.c} = w\, \zeta'' \zeta_o) \ldots. (2)$$

The purpose of the present work is to study the important properties such as; mechanical, electrical and thermal properties of the Epoxy–Ceramic Composite (CCP) with the aim obtain composite materials with excellent characteristics, as well as to determine the possibility of using this (CCP) as high voltage bushings applications and lightweight.

2. Experimental.

For the purpose of this study, work includes a two-step:

First step: In this study were used calcium-bentonite clay (non-activate) defined as basic material. Alumina ($Al2O3$) and Silica ($SiO2$) with a high purity of 99.98% provided by Merck, it was calcined ($Al2O3$) at 1200°C for1h using furnace (carbolite type) to get a full conversion to alpha-phase (α- $Al2O3$). As shown in Figure.1

The ceramic specimen was prepared by using magnetic stirrer and wet mixing method, at temperature 60ºC, mixing process continue for 13h to get slurry to insure homogeneity, then that mixture dried at 80ºC. The mixture was molded (0.3 cm in thickness, 2.5 cm in diameter) then compacted to 100MPa for 60 sec by using steel die and hydraulic press. The specimen was thermally treated at 1250 ° C for two hours, as shown in Figure.2