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Preparation and Characterization of Microwave-absorption of Sarulla North Sumatra Zeolite and Ferric Oxide-filled Polyurethane Nanocomposites

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Abstract

Microwave-absorptive polymeric composite materials are becoming important to protect interference of any communication systems due to the increase in the use of microwave-inducing devices. In this work, the microwave-absorptive polyurethane composites are prepared using natural zeolites of Sarulla North Sumatra and commercial ferric-oxide as fillers. Weight ratio of the natural zeolite to ferric oxide were varied (18:2; 16:4; 14:6; 12:8 and 10:10) by weight. The fillers are prepared using ball milling technique and characterized using Particle Size Analyzer for particle size distribution. The nanocomposites, prepared using in-situ reaction of polyethylene glycol and toluene diisocyanate, is characterized for physical and mechanical properties using tensile strength, thermal properties with TGA techniques, as well as morphological and chemical properties using scanning electron microscopy. Composition and loading of the nanofillers against polyurethane matrices is 20% by weight. Microwave-absorption properties of the nanocomposites is characterized using 8-12 GHz frequency. Tensile strengths of the natural zeolite-ferric oxides polyurethane nanocomposites shows higher values when matrices filled with lower ferric-oxide, which could be due to the nanozeolites have functioned as reinforcement for the polyurethane matrix through polar-polar interaction between the filler surfaces with the matrices. The microwave absorption properties, which investigated by Vector Network Analyzer, of the nanocomposites filled in polyurethane with the ratio of nanozeolite to ferric oxide filler of 12:8 shows reflection loss of – 13.2 dB. This condition was observed at 11.1 GHz.

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1. Introduction

Electromagnetic interference is worsening with the rapid development of wireless communications and circuit devices. The high frequency electromagnetic wave is drawing more attention, due to the explosive growth in the utilization of telecommunication devices in industrial, medical and military application [1,2].

In the past decades, the spinel ferrite have been utilized as the most frequent absorbing materials in various forms. The absorbing characteristics of materials depend on the frequency, layer thickness, complex permittivity (ε_r) and complex permeability (μ_r). All the parameters ε', ε'', μ' and μ'' are found to increase with the increased of ferrite contents and it is found that the absorption properties in the composites are greatly improved with the increasing of ferrite contents in the polymer matrix[4]. But in other side, it will increase the mass of the absorbing materials. Conducting polymer composites with micro/nanostructured have attracted a significant academic and technological attention because of their unique physical properties and potential applications[5-8].

Zeolite mineral is a compound of aluminium silicate hydrate with alkali metal which is group of several types of minerals. Zeolite is aluminosilicate with a framework structure enclosing cavities occupied by a large ions and water molecules, both of which have considerable freedom of movement, permitting ion-exchange and reversible dehydration.

Natural zeolite is natural mineral that composed of crystalline silica (SiO_2) and alumina (Al_2O_3), with cavities of metal ions, which is usually alkali and alkaline or earth metals, and water molecules. Unique characteristic, include very stable with very high adsorption capacity and selectivity and have large active pore structure (microporous) and has a high specific surface area. Natural resources have the potential to be further processed into products that can be used for broad applications, among others, as supporting the catalyst or catalysts, and slow release substances. Zeolite crystal structure of alumina silicate shaped frame (framework) three-dimensional, having cavities and channels as well as containing metal ions such as Na, K, Mg, Ca and Fe as well as water molecules.

Sarulla natural zeolite chemical composition analysis using XRF showed the dominant chemical compounds are SiO_2 and Al_2O_3 as showed in Table 1.

Table 1. Sarulla natural zeolite chemical compositions.

Compound	% wt
Na_2O	1.76
P_2O_5	0.61
MgO	0.12
Al_2O_3	14.19
SiO_2	80.3
K_2O	1.45
CaO	0.14
TiO_2	0.52
Fe_2O_3	0.91

In this paper in-situ reaction of polyethylene glycol and toluene diisocyanate with nanofillers of zeolite and ferric oxide is used to fabricate PU nanocomposites. The effect of alumino silica as the higher compound in natural zeolite combined with ferric oxide as the most frequent absorbing materials were observed as microwave absorption.

2. Experimental

The fillers used for nanocomposite fabrication are natural zeolite and commercial ferric-oxide (γ-Fe_2O_3). The polyurethane matrix used was a commercial type which contains two-part urethane monomers i.e. 60% wt polyethylene glycol and 40% wt toluene diisocyanate.

The PU nanocomposites reinforced with natural zeolite and ferric-oxide were fabricated with in-situ reaction. The activated natural zeolite crushed to the size of 74 μm using planetary ballmill for 10 hours. Natural zeolite and ferric-oxide with ratio of 18:2; 16:4; 14:6; 12:8 and 10:10 by weight were mixed for 4 hours using planetary ballmill. Nanofillers of natural zeolite and ferric oxide is 20 % wt of the Polyurethane. The homogen nanofillers divided into the same ratio and mixed with PPG and TDI for 1 minute. Polyethylene glycol and toluene diisocyanate with nanofillers of zeolite and ferric oxide are using in-situ reaction. Polyurethane, with the sample thickness of 5 mm, is hold and pressed for 30 minutes.