Studies on the effects of high-energy electron beam irradiation on the Mechanical properties of Magnesium hydroxide filled HDPE/Mg(OH)2/TCA-27 composites .

Dr. Nabil Abdullah Noman Alkadasi abc [*]

Abstract

The effect of irradiation electron beam at dose of 150 kGy,on the mechanical properties of high density polyethylene (HDPE) mixed with various amounts of magnesium hydroxide (Mg(OH)2) composites as filler have been studied here. It has been found that the high-energy electron beam irradiation has much effect on the mechanical properties of the HDPE/Mg(OH)2/TCA-27 composites. The tensile strength and elastic modulus are increased greater than the unirradiated ones. Meanwhile, the increasing content of the Mg(OH)2 in composites . The structure of the SEM of the unirradiated HDPE/Mg(OH)2/TCA-27 shows poorly mechanical properties of composites which are compared to irradiated ones. The Comparison of properties of composites filled with irradiated and unirradiated Magnesium hydroxide establishes than irradiated of Magnesium hydroxide which imparts better reinforcing properties than unirradiated filler of composites. The properties under consideration are tensile strength, (%) elongation at break , elastic modulus, hardness . Tensile strength is

*Faculty of Education and Sciencesa , Engineering College b and Applied Sciences Collegec aDepartment of chemistry , Al-bida'a ,University , Yemen b

Department of Civil Engineering , Mechanics ,Thamar ,University

Department of chemistry, Thamar University , P.O. Box : 39189, , Yemen

Details of Corresponding author : Tel;00967-713082516, Fax:00967-6-509572.

E-mail : nalkadasi@yahoo.com **;** samnoman@rediffmail.com

improved by 6.67% , elastic modulus is improved by 42.86%, while hardness is improved by 0.85%, at (0.37) volume fraction .

Keywords: electron beam irradiation, cross-linking, mechanical properties, Mg(OH)2, HDPE, TCA-27, composites

Introduction

Dental caries is a process that may take place on any tooth surface in the oral cavity where a microbial biofilm (dental plaque) is allowed to develop over a period (Nilchian, 2005).

Dental caries is a chronic non-communicable disease (Hujoel, 2009) and continues to be a major public health problem. It may also be the source of considerable pain and suffering for many. It is one of the few chronic diseases which effected also children, and its management represents a large proportion of the health resources worldwide (Petersen, 2003; Petersen, 2004).

The tooth is most susceptible to plaque stagnation during eruption because at this time the occlusal surface is below the line of the arch and easily missed with the toothbrush. (Pickard et al., 2003). The brush and fluoride toothpaste have no access inside pits and fissures, where chewing forces food to be trapped where accumulation of the bacteria. Occlusal caries accounts for between 80 and 90 percent of caries in children; teeth at highest risk for carious lesions are the first and second permanent molars. Two factors are considered important for plaque accumulation and caries initiation on occlusal surfaces are the stage of eruption-functional status and tooth specific anatomy (Hellwig et al., 2003).

Introduction

Many investigations have been reported on the irradiation of polymers and polymer composites and its effect on chemical structure and physical properties[1]. High-energy electron beam irradiation cross-linking of polymers has been carried out in a wide range of fields, for example, the production of heat shrinkable polyethylene films and tubes. Also, cross-linked polymers have been used in hot water piping installation, in wire and cable industries[2-6]. Radiation cross-linking of HDPE can improve the blends' mechanical properties and thermal stability[7-10].

In the previous paper[11-13], the effects of high-energy electron beam irradiation on the mechanical properties of HDPE/$Mg(OH)_2$/TCA-27 composites with various of $Mg(OH)_2$ composites, have been reported . The high-energy electron beam irradiation has much effect on the mechanical properties of the HDPE/$Mg(OH)_2$/TCA-27 composites, And the tensile strength and elastic modulus increase greater than the unirradiated ones. The present study reports an investigation of the effects of a high-energy electron beam on the compound of HDPE with various contents of $Mg(OH)_2$ composites. The properties under consideration are tensile strength,(%) elongation at break, elastic modulus, hardness . Tensile strength is improved by 6.67%, and elastic modulus is improved by 42.86%, while hardness is improved by 0.85%, at (0.37) volume fraction.

EXPERIMENT :-

Materials :

High-density polyethylene (HDPE, 5502#, MFR=0.35g/10min) was taken from Daelim, Korea. The filler magnesium hydroxide ($Mg(OH)_2$, average particle size=2μm) was obtained from Dalian Yatai Science and Technology New Material Co.Ltd. , China.

Physical parameters of high-density polyethylene, constituents of Magnesium oxide,and titanate coupling agent are reported in the following tables 1, 2 and 3 respectively.

Table 1. General Characteristics of High Density Polyethylene

Trade Name	**HDPE, 5502 , Daelim, Korea**
Appearance	White
Specific Gravity (g/cm3)	0.96
Melt index (g/10 min)	0.05-0.8

Table 2 . Physical Properties of Magnesium hydroxide.

Molecular formula	**Mg(OH)2**
Molecular Weight	58.3
Purity	95%
Whiteness	90%
Colour	White
Average Particle Size (μm)	2
Specific Gravity (g/cm3)	2.4
Moisture Content (%)	0.5
pH	7-8

Table 3. Physical Characterization of Titanate Coupling Agents (TCA – 27)

Chemical Name	**A multiplex monoalkoxy titanate which has the dispersion as phosphate ester and coupling property as titanate.**
Typical purity	99 %
Physical form	Liquid
Color	Deep brown dope
Density (g/cm3)	(GB4472-84) D20 About 1.05
Flash point (0c)	Ts (Open)105
Diopter Coefficient	ND25 1472+0.002
Viscosity (cp)	(GB265-70) 20 About 400mm/s
pH	2.5+ 0.5
Solubility	Isopropyl alcohol, Xylene, Toluene, DOP, Mineral oil, MEK

Preparation of HDPE/Mg(OH)2/TCA-27 Composites:

HDPE/$Mg(OH)_2$/TCA-27 composites were prepared via melt compounding at 160^{o}C in ThermoHaake-rheomixer with a rotation speed of 60 rpm, and the mixing time was 6 min for each sample. The mixed samples were transferred to a mold and preheated at 180^{o}C for 15 min, then they were pressed at 20MPa and then successively cooled to room temperature while maintaining the pressure to obtain the composites sheets for further measurements. Before mixing, all the components were dried in vacuum oven at 80^{o}C for at least 12 h.

Table 4 . Compounding Recipe For HDPE/Mg(OH)2 /TCA-27

Volume Fraction of HDPE/Mg (OH)2/TCA-27	HDPE (Wt – g)	Mg(OH)2 (Wt – g)
(Non filler)	50	0.0
0.04	45	5
0.09	40	10
0.14	35	15
0.21	30	20
0.28	25	25
0.37	20	30
0.48	15	35
Curing Time of Composites	15 min	
Curing Temp. of Composites	180 o C	

Scanning Electron Microscopy (SEM):

The SEM micrographs of samples were observed by the JEOL JSM-5510 scanning electron microscope. The samples were chosen after the tensile test. The content of HDPE/$Mg(OH)_2$ /TCA-27 was 0.48 volume fraction. The tensile fractured surface of the irradiated and un-irradiated samples was coated with a thin layer of gold to avoid electrostatic charging during examination. Photographs of representative areas of the sample were taken at 5000X magnifications.

Particle Size Analysis:

Surface area is a major parameter in connection with filler-matrix interaction for reinforcing purposes. The finer the particle size, the higher is the surface area and higher the reinforcement. The details regarding particle size distribution of the $Mg(OH)_2$ used in the study are given in figure 1. The data were used to find out the mean particle size, which turned out to be 2 μm. The analysis is done on particle size analysis, instrument, China.

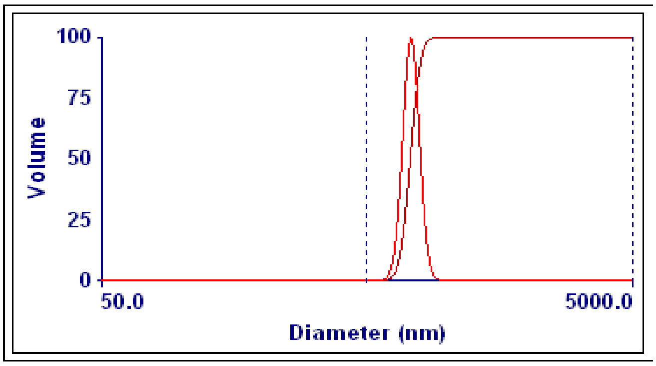

Fig.1. Particle Size Distribution of $Mg(OH)_2$

Measurement of Mechanical Properties:

Mechanical properties such as tensile strength, elongation at break ,elastic modulus were determined by subjecting dumbbell shaped specimens (in confirmation with ASTM D– 638) to a universal testing machine (Shenzhen Reger Instrument Co. Ltd, China). The sheets from which specimens were cut had been conditioned for 24 hours prior to subjecting to universal testing machine (100 kg load cell), at a crosshead speed of 50 mm / min. Hardness was measured by the Machine – LX –A ,produced by Shanghai, Liuzhong- meterage , factory.

Results and Discussion:

The Magnesium hydroxide composites showed improvement in the mechanical properties and the mechanical adhesion due to magnesium hydroxide as filler to this composites.

Tensile strength:

The dependence of the tensile strength on volume fraction of magnesium hydroxide is presented in fig 2. It is seen that on increasing the volume fraction of (both irradiated and un-irradiated) magnesium hydroxide, the tensile strength increases up to a certain value at 0.04 volume fraction and declines .The peak values of tensile strength of the composites correspond to 25.2 MPa and 21.9 MPa for irradiated and unirradiated Magnesium hydroxide composites respectively. It is noteworthy that the tensile strength of composites filled with irradiated Magnesium hydroxide 0.04 volume fraction is 6.67% higher than that of unirradiated Magnesium hydroxide composites.

Modulus at (%) elongations at break:

For unirradiated fillers, general magnitudes of elongation at break were much higher than the irradiated fillers as shown Fig 3. while the former (composites with unirradiated magnesium hydroxide) showed increase in tensile strength at low loadings and decrease subsequently at high loadings, no much discernible change was observed for composites filled with irradiated filler.

Hardness:

Fig 4 shows the dependence of hardness on concentration of irradiated and un-irradiated filler in HDPE/EVA. It is seen that, hardness of both irradiated and un-irradiated HDPE/Mg(OH)2/TCA-27 composite increased on increasing the concentrations of fillers, with a constant rate of increment for composites containing irradiated and un-irradiated filler (separately) as evidenced by constant and identical slopes of the lines (figure 4). The hardness of irradiated magnesium hydroxide at 0.37 volume fraction is about 1.01 times higher than that of un-irradiated magnesium hydroxide .The rate of increment in the property with increasing volume fraction of the filler.

Elastics Modulus:

Fig 5. shows the dependence of elastic modulus on concentration of filler in HDPE depending upon irradiation. It is seen that, elastic modulus of both irradiated and un-irradiated HDPE/$Mg(OH)_2$/TCA-27 composites increase linearly depending on increasing the concentrations of fillers. The elastic modulus of irradiated magnesium hydroxide at 0.37 volume fraction is about 1.43 times which is higher than that of unirradiated magnesium hydroxide. The rate of increment in the property with increases with volume fraction of the filler.

SEM of Composites:

The SEM photomicrographs of filler magnesium hydroxide and HDPE are shown in Fig.6 (a – b). It is clear from these photographs that unirradiated magnesium hydroxide and HDPE show tendency to form agglomerates. SEM of HDPE/$Mg(OH)_2$ /TCA-27 Composites are shown in fig.6 (c – d). Unirradiated composites fracture shows non-adhesive appearance and formation of agglomerates while irradiated composites show a very uniform distribution, regular, adhesive appearance indicating further enhancement in polymer–filler attachment.

Conclusions:

1. The Magnesium hydroxide- HDPE/TCA-27 composites exposed to electron beam irradiated shows higher values of tensile strength than that of unirradiated.
2. The irradiated magnesium hydroxide - HDPE/TCA-27 composites show higher values of Elastic modulus than that of unirradiated composites .

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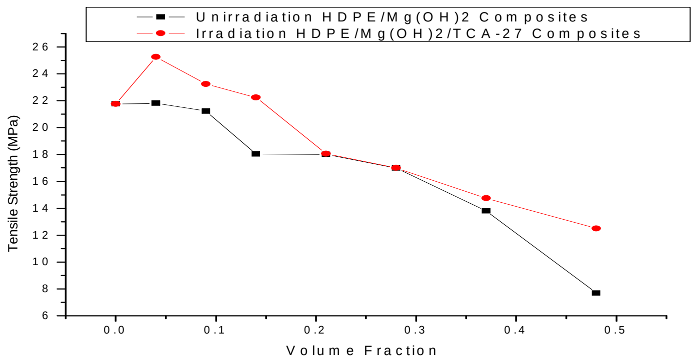

Figure 2: Tensile Strength as a Function Volume Fraction of HDPE/Mg(OH)2/TCA-27 Composites.

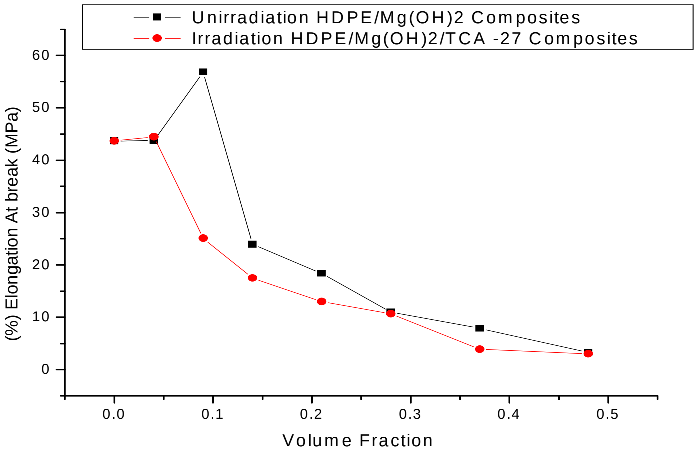

Figure 3 : (%) Elongation at Break as a Function Volume Fraction of HDPE/Mg(OH)2/TCA-27 Composites .

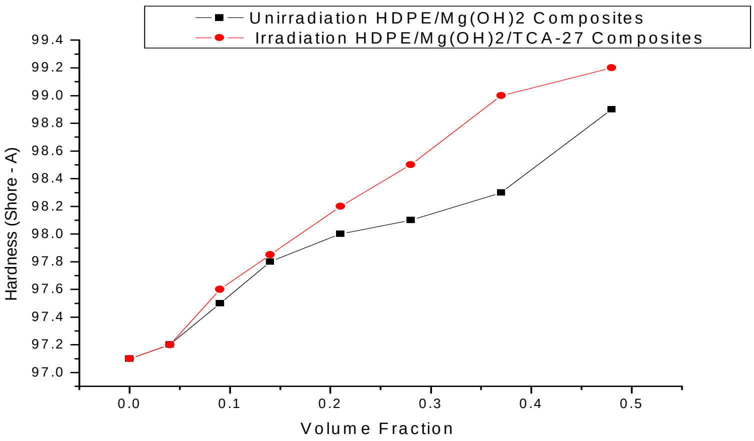

Figure 4 : Hardness as a Function Volume Fraction of $HDPE/Mg(OH)_2/TCA-27$ Composites.

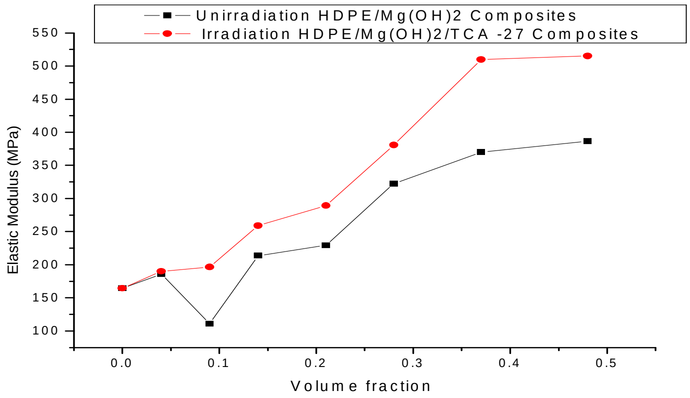

Figure 5 : Elastic Modulus as a Function Volume Fraction of HDPE/Mg$(OH)_2$/TCA-27 Composites.

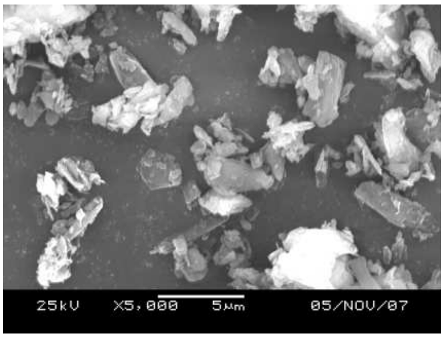

Fig .6 (a) : SEM of Mg(OH)2 Powder (2?m) .

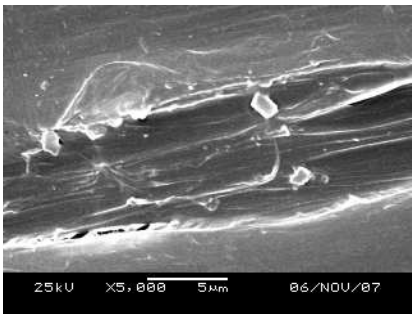

Fig .6 (b): SEM of HDPE .

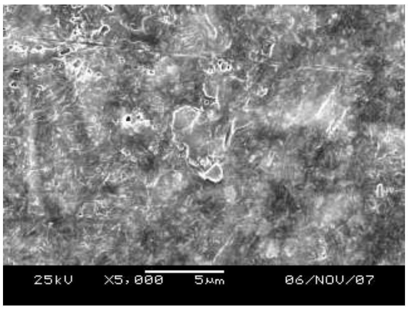

Fig .6 (c). Unirradiated HDPE/$Mg(OH)_2$

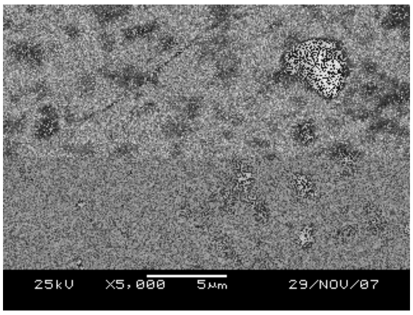

Fig .6 (d). Irradiated HDPE/Mg(OH)2/TCA-27