International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.9, No.12, pp 565-569, 2016

Effect of Modified Bentonite – Titanium Dioxide as Filler on Mechanical Properties and Water Absorption of Unsaturated Polyester Resin (UPR) Composite

Iriany, Kenrick*, Alvian and Maulida

Department of Chemical Engineering, University of Sumatera Utara, Jalan Almamater, Kampus USU Medan 20155, North Sumatra, Indonesia

Abstract : Research about the usage of modified bentonite– titanium dioxide as filler in unsaturated polyester resin has been done to evaluate the best composition of modified bentonite as filler on the mechanical properties of polyester composites. The bentonites used were modified with Cetyltrimethylammonium Bromide (CTAB) surfactant with various concentrations of 0,05, 0,1, and 0,15M and Titanium Dioxide (TiO_2). In this research, unsaturated polyester resin was mixed with modified bentonite with the filler composition of 5%, 10%, 15%, and 20% of the weight of the composite and molded with hand lay-up method. The FTIR characterization result showed that the bond between matrix and the filler produced only interfacial bonding between the matrix and the filler. Result of testing the mechanical properties indicated that, the maximum impact strength has been obtained on the composition of 5% filler with 0,1M of surfactant concentration with the value of 9420,9 J/m^2. On the test of water absorption, the water absorption capacity increased along with the increased of filler composition.
Keywords: Bentonite, CTAB, hand lay-up, unsaturated polyester resin.

Introduction

Unsaturated polyester resin (UPR) is considered one of the most important classes of thermosetting polymers and is widely use in various fields, including automotive, chemical, electrical, and other engineering applications. Unsaturated polyester resins are widely used because of their high corrosion resistance and good mechanical and thermal properties. However, in many applications they have one major disadvantage, that is low toughness[1]. Over the years bentoniteshave been used for the preparation of polymer-clay composites in order to improved the mechanical properties of polymer composites. The surface of bentonite is hydrophilic, and therefore has to be modified to ensure good dispersion in mostly hydrophobic commercial polymers[2]. One of the most common method of bentonite modification is cation exchange using organic modifier[3].

Titanium dioxide (TiO_2) is one of the material with a lot of advantage such as chemically stable, harmless, can be used within high photocatalytic activiy and able to improved the mechanical properties of composites[4]. Since the research of titanium dioxide as filler for composite has not been well known while it has a lot of potential, it is necessary to conduct further research on the effect of titanium dioxide as filler on mechanical properties of composite.

In this research we try to prepare bentonites modified with cetyltrimethylammonium bromide (CTAB) and treated the modified bentonite with titanium dioxide before being used as filler of unsaturated polyester resin.

Experimental

Materials

The unsaturated polyester resin (UPR) and methyl ethyl ketone peroxide as catalyst were obtained fromJustus Kimia Raya, Medan,North Sumatera Indonesia. Bentonites, titanium dioxide (TiO_2), and cetyltrimethylammonium bromide (CTAB) were acquired from Rudang Jaya, Medan, Indonesia.

Preparation of Modified Bentonite

Bentonites were mixed into various concentration of CTAB solution (0,05;0,1 and 0,15 molar) and stirred for 5 hours at 50 ^oC with ratio of 200 ml CTAB for every 10 grams bentonite. After that, the mixture was filtered and washed with 500 ml of methanol and water solution with ratio of 1:1. Then, the mixture was dried for 6 hours at 80^{o}C inside an oven.

Five grams of modified bentonite were mixed with 4 grams of TiO_2 and 15ml ethanol and stirred for 5 hours. After that, the mixture were filtered and dried for 5 hours at 120^{o}C. Then, the mixture were calcinated for 5 hours at 400 – 500^{o}C.

For the composite preparation, unsaturated polyester resin was first added with methyl ethyl ketone peroxide (MEKP) as catalysts before mixed with modified bentonite with ratio of 95:5; 90:10; 85:15; 80:20% (wt/wt). The mixtures were then poured into molds and dried for 24 hours.

Results and Discussion

FT-IR Spectra

The FTIR spectra of pure polyester resin and polyester composite are shown in Fig. 1. It is observed that the absorption band between pure polyester resin and polyester composite showed at 1053, 1315, 1708 and 3020 cm^{-1} [5]. The absorption band at 1053 cm^{-1} which corresponds to the stretching vibration of C-O bond of ether, becomes more intense, apparently because of the reaction between polyester and -O- bond of modified bentonite. The band at 1315 cm^{-1} results fromincreased C=O bond of ester. The absorption band at 1708,93 cm^{-1} shown huge difference between the composite and pure polyester resin corresponds to the stretching vibration of O-H bond of carboxyl, becomes more intense due to reaction of polyester and –OH bond of modified bentonite, thus resulting in the enhancement of the mechanical strength of the polyester/bentonite composite. The band at 3020 cm^{-1} which is the characteristic of C-H alkane stretching. This confirms that the modified bentonite have been intercalated into the polyester matrix.

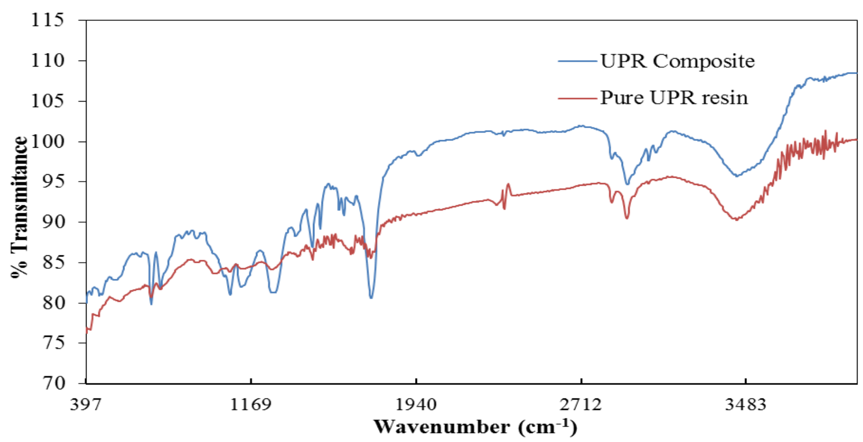

Figure 1.FTIR spectra of pure UPR resin and UPR composite

Mechanical Analysis

Figure 2 shows the elongation at break of pure UPR resin and UPR composite. It is shown thatvalue of elongation at break started to decreased along with increased of clay content. It may due to at higher clay content,the stiffness of the compositesincreased significantly which may cause less strain between the matrix and filler. Another reason may be aglomeration of clay occured and caused the composites became more brittle[6].

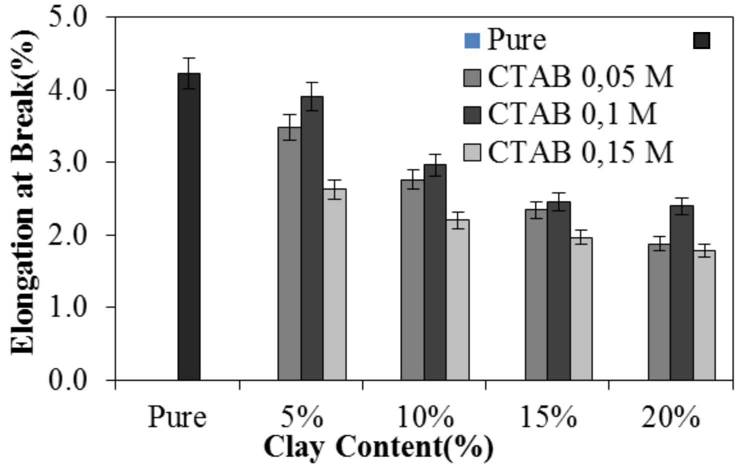

Figure 2. Elongation at break of pure UPR resin and UPR composite

The impact strength of composites is shown in figure 3. There is an increase in impact strength value of polyester compositescompared to pure unsaturated polyester resin. The greatest increase of the impact strength, by as much as 50% was observed for the polyester resin filled with 5 wt% of modified bentonite. This means the addition of titanium dioxide on bentonite evidently improved the impact strength of polyester composite.Above the 5% clay content, the impact strength starts to decrease with filler content increase. It may be caused by agglomeration and decrease of interaction between the matrix and clay[7]. Another reason may be due to the presence of porosity in the composites. During processing of composites at high clay contents, it was observed that the viscosity of the resin increases significantly. So the entrapped air during shear mixing finds very difficult to escape out of the matrix system and remains as micropores after curing[8].

It is also observed that the impact strength of composites increased along with increased concentration of CTAB on the same amount of clay content. However, the addition of CTAB concentration of more than 0,1M will result in a decrease of impact strength. It may be due to the constancy of surface tension lowerd by surfactant although surfactant concentration was increased, which is called critical micelle concentration.

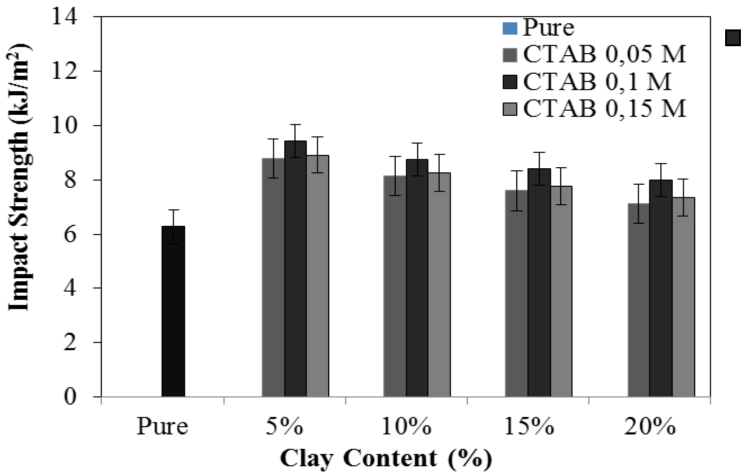

Figure 3. Impact strength of pure UPR resin and UPR composite

Water absorption test

Figure 4-6shown the water absorption result for pure polyester resin and polyester composites. Different specimens were weighed and immersed in water at room temperature for 120 hour. During this period, the specimens' weight difference was recorded at different times. As shown in figure, the ability of composite to absorb water is low and it increases with increasing bentonite content.

The increase of water absorption is due to the fact of the bentonite itself is water rich, and, thus,absorbs more water than nearly all the polymer used as matrix, leading to an increase in the water content of composites[9].On the other hand, several authorssuggested that claylayers dispersed at the nanometerscale in the matrix can decrease the mean free path ofwater molecules to pass through the nanocompositenetwork compared to the pure matrix,which leads tolower water absorption[10,11]. So, it is difficult to predict the effect of bentonite incorporation to the water absorption behavior of polymeric matrices.

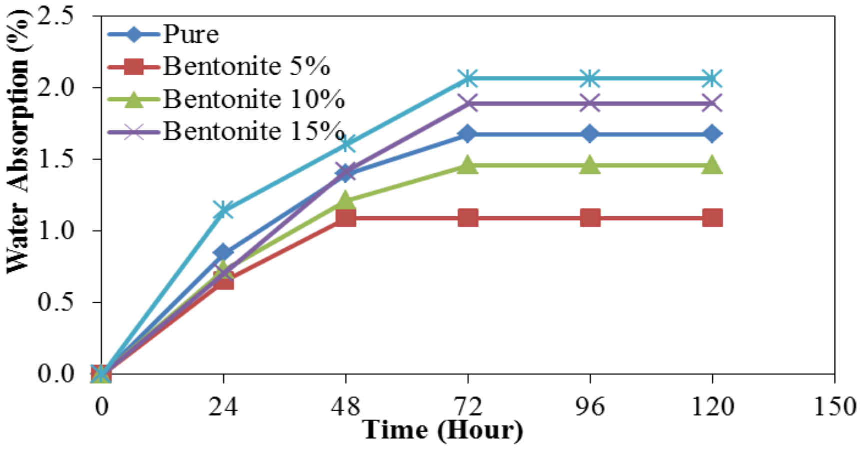

Figure 4. Water absorption of pure unsaturated polyester resin and modified bentonite-polyester composite with for surfactant concentration of 0,05M

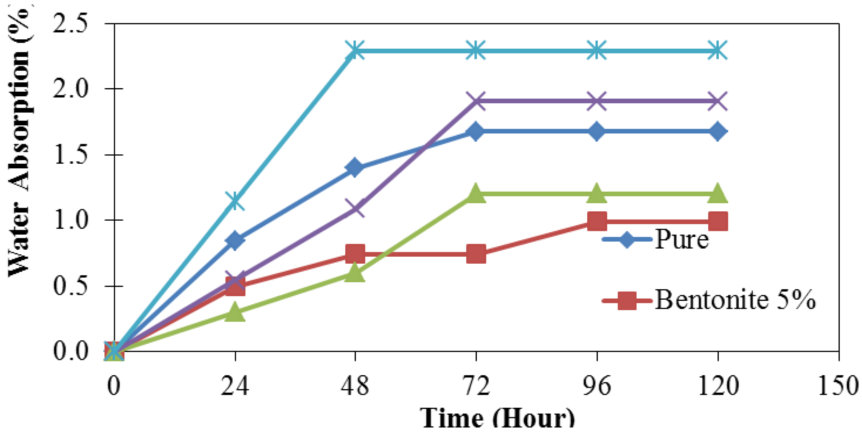

Figure 5. Water absorption of pure unsaturated polyester resin and modified bentonite-polyester composite with for surfactant concentration of 0,1M

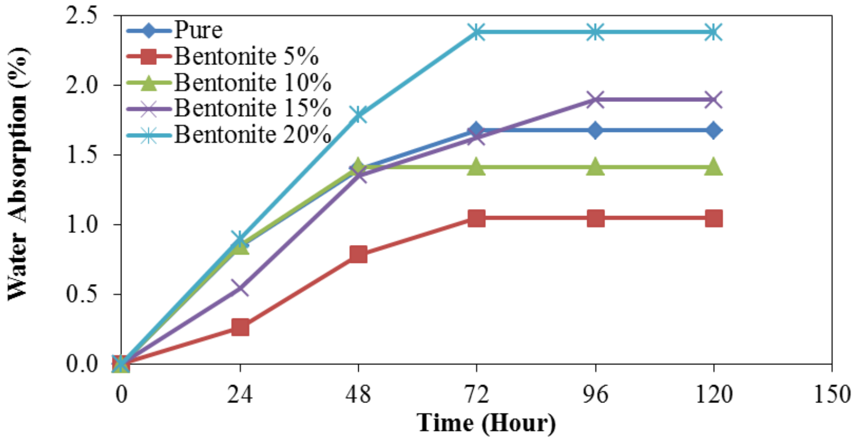

Figure 6. Water absorption of pure unsaturated polyester resin and modified bentonite-polyester composite with for surfactant concentration of 0,05M

Conclusion

Unsaturated polyester/bentonite composites were obtained. The bentonite used were chemically modified by cation exchange reactions with cetyltrimethylammonium bromide and then reacted with titanium dioxide in order to increased the mechanical properties of the composites. The proposed chemical modification of bentonite with titanium dioxide seems to be adequate to improve the impact strength of the polyester matrix, which is vety important for several applications. On the other hand, the composites containing bentonite content less than 10% might reduced the water absorption of the composites. Further addition of bentonite in the matrix might instead increased the water absorption.

References:

1. Husaini and Kusmono. Kekuatan Tarik Komposit Hibrid Unsaturated Polyester/Clay/SeratGlas. Universitas Gajah Mada. 2012
2. Juliani, Evi. AktivasiBentonitAlamSebagaiBahanPengisiPadaKompositPolietilen/High Density Polyethyline (HDPE) Untuk BahanTeknik.Universitas Sumatera Utara. 2013.
3. Rosyadi, Iim Imron., Ahmad Mudzakir, Budiman Anwar. Preparasi dan Karakterisasi Bentonit Termodifikasi Surfaktan Kationik Fatty Imidazolinium. J. Sains Tek. Kim., 2010,1: 112-120.
4. Olesky, Mariusz.,Heneczkowski, Maciej., Galina, Henryk. Thixotropic Compositions: Unsaturated Polyester Resins/Modified Bentonites. Faculty of Chemistry, Rzeszow University of Technology. 2007
5. Pavia, D.L., Lampman, G.M., Kriz, G.S.*Introduction To Spectroscopy : A Guide for Students of Organic Chemistry*. Brooks/Cole Thomson Learning. Singapore. 2001
6. Chitraningrum, Nadya.Sifat Mekanik dan Termal Pada Bahan Nanokomposit Epoxy-Clay Tapanuli. Universitas Indonesia, Depok, 2008.
7. Sanemuang P. and Pumchusak J. Toughening Of Epoxy By Silane-Treated Nanotitanium Dioxide. The Malaysian Journal of Analytical Sciences, 2014,18: 478-484.
8. Motawie M.A., AhmedN.M., ElMesallamy S.M., SadekE.M., Kandile N.G. Unsaturated Polyesters / Layered Silicate Nanocomposites: Synthesis and Characterization. *IOSR Journal of Applied Chemistry*,2014, 7: 34-43.
9. Jdayil, Basim-Abu, Kaml Al-Malah, Ranya Sawalha. Study on Bentonie- Unsaturated Polyester Composite Materials. Journal of Reinforced Plastics and Composites. 2002, 21(17).
10. Liu X., Wu Q., Berglund L.A., Fan J. and Qi, Z. Polyamide 6-Clay Nanocomposites/Polypropylene-Grafted-Maleic Anhydride Alloys. J.Polymer, 2001,42: 8235–8239.
11. Ward W.J., Gaines G.L., Alger M.M. and Stanley, T.J. Gas Barrier Improvement Using Vermiculite And Mica In Polymer Films. Journal of Membrane Science, 1991, 55:173–80.

*****