Comparison Of The Effects Of Alkali And Silica On The Tensile Strength Properties Of Epoxy Based Composites

Menderes Koyuncu
Department of Textile, Van Vocational High School,
Yuzuncu Yil University, Van, Turkey
mendereskoyuncu@gmail.com

***Abstract*—Cotton fabrics and fibers is an important renewable, natural reinforcement material for composites. In this study, silica and resin were combined and pressed to form natural fabric composites. The tensile properties of the composites were measured to observe the effect of silica and alkalization. The tensile strength of the treated composites were compared to untreated. The untreated and treated composites has tensile strength of 28 MPa, and 38 Mpa, 33 MPa and 30 Mpa respectively, after 1 h of alkali treatment. Composites of 1% NaOH solution treated fabric showed maximum improvement. Addition of silica leads to an decrease in strength, this can be an explain that for larger silica content, the particles are micron-sized and the composite strength decreases. To conclude, particle size clearly has a significant effect on the tensile strength of particulate-filled polymer composites, which generally decreases with increasing size.**

Keywords—Silica, Tensile Strength, Epoxy - matrix composites, Particle-reinforcement, Natural fibers

I. INTRODUCTION

In recent years, natural fibers have drawn considerable attention as an alternative to synthetic fibers in composite materials. natural fibers have many advantages, such as biodegradability, renewability, wide availability, low density, and low cost, which offer greater opportunities to develop a new class of light weight, environment friendly, structural composites. Natural fiber composites are widely used in many applications, such as automotive and packaging due to their combination of excellent stiffness, strength and low density along with their environmental friendliness[1],[2,][3],4].

However, certain drawbacks of natural fibers such as degradation during processing, poor wettabilty, incompatility with some polymeric matrices and high moisture adsorption make them undesirable for composite applications. Another problem encountered in their use is fiber-matrix adhesion arising due to the incompoatibity between the hydrophilic natural fibers and the hydrophibic polymer matrix. To improve the fiber properties it is necessary to improve the fiber-matrix adhesion and to reduce the moisture content of the fiber. This can be carried out by fiber surface modification by physical or chemical methods[5], [6].

Nowadays industrial and academic research laboratories are focusing much of their efforcts to develop and improve physical, mechanical, and electrical properties of polymer nanocomposites. Their interest to develop such composites is mainly because of the fact that nanoparticles present a high surface-to- volume ratio may induct unique properties to these nanocomposites as compared to macro-scale composites. Many researchers have made studies the effect of silica, clay and other fillers on the polymer based composites. They found that the impact strength of this special silica / clay/ montmorillonite nanocomposite increased up 107% over the neat epoxy resin [7]. The aim of this study was to obtain and evaluate the tensile strength of the composites based on alkaline and silica. Especially, the objective of present paper is to fill the gap and study the effect of addition of silica nanoparticles on epoxy based composites.

II. MATERIALS AND METHODS

A. Materials

The selected reinforcement material of the for this research was cotton fabric and the matrix was selected from epoxy resin group. The ratio between resin and hardener for this study was 2:1 by weight.

B. Evaluation

Firstly, cotton fabrics were immersed in NaOH solution at various concentration and soaking 1h. and after that they were rinsed with tap water until the rinsed solution reached neutral (pH 7). Then, fabrics were dried the cotton fabrics were oven-dried at 60 ^{o}C for 45 min. The composite was manufactured by using hand lay-up technique.

C. Testing

The dimension of scimens used to carry out test adapted from ASTM-D 3039 for tensile testing. All these testing were carried out for untreated and treated cotton fabric reinforcement epoxy composites. Tensile tests were performed using an Instron4411(kN) model testing machine.

Secondly, the silica particles were mixed with epoxy using stirrer for 1h. The resultant mixture was poured over the fabric and compressed and distributed evently until it achieved the thickness of 3.00 mm and 197 mm long 25 mmm wide based on ASTM D 3039 [8]. After than the laminates were pressed in the mold at room temperature for 24h. The tensile strength of the composites were determined using an an Instron4411(kN) model testing machine.

III. RESULTS AND DISCUSSION

A. The tensile strength of untreated and treated cotton fabric reinforced epoxy composites

As seen from Fig.1, the 1%NaOH treated fabric composites improved the tensile strength by 26% compared with the untreated fabric composites. Raising the alkali concentration is expected to have a positive influence on the tensile strength of composite. But this experiment demonstrates that the 5 % alkali concentration in the same conditions does not result in any surplus value compared to the 3% alkali concentrations sample. This can be an indication that the decrease of the strength due to the damage of fabric structure in higher alkali concentration. In previous studies were reported that a very high concentration of alkali solution would certainly damage the fibre and consequently reduce the tensile strength of fibre and also their composites [10],[11].

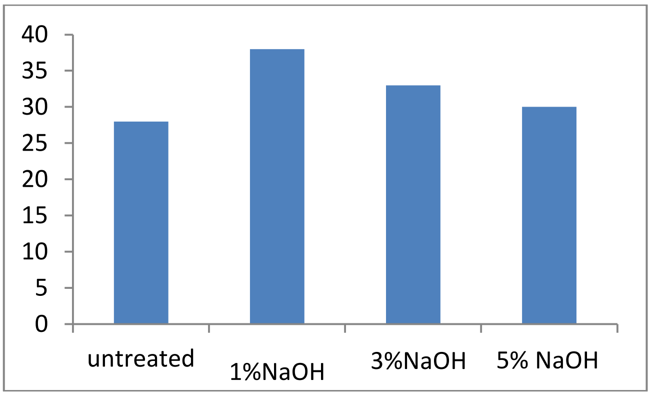

Fig.1 The tensile Strength of Untreated and Treated Cotton Fabric Reinforced Epoxy Composites

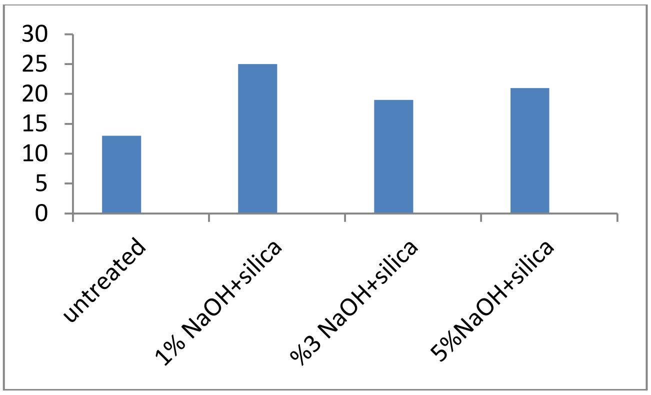

Fig 2. Tensile Strength of Cotton Fabric Reinforced Epoxy Composites Filled with Modified Silica (Particle Size 100 µm)

B. Tensile strength properties of the epoxy-silica composites

The properties of the composites depend upon the method of dispersion of particles, aggregation of particles, and interaction between particles and polymers. The thickness and density of the interphase developed between two constituents depend on the interaction particles and polymer. Interparticle distance also plays an important role in the interphase behaviour and properties of the composites. Tensile properties of the composites are mostly affected by the materials, method, specimen condition and preparetion, and also by percentage of the reinforcement[9]. Silica particles, if not properly mixed with the epoxy, cause voids and inrease level of porosity inside the system.

The effect of particle size on the tensile strength of epoxy composites filled with spherical silica particles with particle contents of 5 wt % shown in Fig 2. It is clearly shown that, for a given particle size (100µm), the composite strength decreases with adding silica. This can be explained by tensile strength decreases with increasing large particle size. Smaller particles have a higher total surface area for a given particle loading. This indicates that the strength increases with increasing surface area of filled particles through a more efficient stress transfer mechanism. However, it is noted that for particles at and larger than 80 nm, the composite strength is reduced with increasing particle loading. For the 10 nm particle composites the trend is reversed [12],[13],[14],[15].

IV. CONCLUSIONS

In this research cotton fabrics were treated with 1%, 3% and 5% sodium hydroxide solution for 1h. The tensile strength of the composites were found to increase after alkali (1% NaOH) treatment due to improved fabric structure.

Specimens with 5wt% and 100 µm particles show approximately 50% decrease in tensile strength compared to unfilled epoxy

None of the reinforced test specimens could compete with neat resin. The epoxy composites showed 2 times higher tensile strength than the specimen reinforced with 5 wt. % of 100 µm particles. At this level of loading the properties of reinforcement dominate and cause brittleness. We expect that these cotton fabrics will be suitable for use as a reinforcement in green composites

REFERENCES

[1] K.Obi Reddy, C. Uma Maheswari, J. Mukul shukla, I. Song, A.Varanda Rajulu, ″Tensile and structural characterization of alkali treated Borasus fruit fine fibers″ Composites: Part B, Vol. 44, 2013, pp. 443-438.

[2] P.Wambua, J. Ivens, L. Verpoest, ″ Natural fibers: can they replace glass in fiber reinforced

plastics″? Compo. Sci Technol, Vol.63. 2003, pp. 1259-64.

[3] SV.Joshi, LT.Drzal, A.K. Mohanty, S. Arora, ″Are natural fiber composites environmentally superior to glass fiber reinforced composites? ″ Composite Part A Vol. 35. 2004, pp. 371-6.

[4] S.M. Sapuan, M.A. Maleque ″Design and fabrication of natural woven fabric reinforced epoxy composite for household telephone stand″ Mater Design, Vol. 26. 2005, pp. 67-71.

[5] D. Sun, ″Investigation the plasma modification of natural fiber fabrics the effect on fabric surface and mechanical properties″ Text. Res.J Vol. 75. 2005, pp. 639-44.

[6] Y. Xie., CAS. Hill, Z. Xiao, H. Militz, C. Mai, ″ Silane coupling agents used for natural fiber/polymer composites a review″. Compos Part A Vol. 41. 2010, pp. 806-19.

[7] S. Sinha Ray, K. Yamada, M. Okamoto, K. Ueda, ″New polylactide-layered silica nanocompoistes. 2. Concurrent improvements of material properties, biodegradability and melt rheology.″ Polymer. Vol. 44. 2003, pp. 857-866.

[8] K. Sever, et al., ″Surface treatments of jute fabric: the influence of surface characteristics on jute fabrics and mechanical properies of jute/ polyester composites″. Industrial crops and Products, Vol.35.2012, pp. 22-30.

[9] J. Jordan, K.I. Jacob, R. Tannenbaum, M.A. Sharaf, I. Jasiuk, ″Experimental trends in polymer nanocomposites - a review″, Mat. Sci. and Eng. A Vol.398. 2005, pp. 1-11.

[10] D. Bachtiar, S.M. Sapuan, M.M. Hamdan, ″The effect of alkaline treatment on tensile properties of sugar palm fibre reinforced epoxy composites, ″ Mater. and Design, Vol. 29. 2008, pp. 1285-1290.

[11] L. Mwaikambo, M. Ansell, ″Chemical modification of hemp, sisal, jute and kapok fibres by alkalisation″ J. Appl Polym. Sci. Vol. 84. 2002, pp. 2222-34.

[12] S. Yun Fu, X-O. Freng, B. Lauke, Y.W. Mai, ″Efects of particle size, particle/matrix interface adhesion and particle loading on mechanical properties of particulate-polymer composites″ Composites part B, Vol.39. 2008, pp. 933-961.

[13] B. Pukanszky, G. Voros, ″Mechanism of interfacial interactions inparticulate filled composites″ Compos Interf. Vol.1. 1993, pp. 411–27.

[14] E. Reynaud, T. Jouen, C. Gauthier, G. Vigier, J. Varlet, ″ Nanofillers in polymeric matrix: a study on silica reinforced PA6″. Polymer, Vol. 42. 2001, pp. 8759–68.

[15] N. Amdouni, H. Sautereau, J.F.Gerard, ″Epoxy composites based on glass-beats. 2. Mechanical-properties″. J. Appl Polym Sci. Vol. 46. 1992, pp. 1723-35.