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Effect of Salt Fog Spray and Ultraviolet Exposure on the Fracture Surface Morphology of Fiber Reinforced Polymer Composites

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Fiber reinforced polymer composite (FRPC) materials are superior to other conventional materials because of their high strength to weight ratio, corrosion resistance, and moisture resistance [1]. Therefore, FRPC materials are preferred in many high-end applications such as marine, automobile, aerospace, and advanced sporting goods [2]. Epoxy polymer resins are preferred as matrix material over other polymers in many high-end applications. Nanoparticles as a secondary reinforcement tend to improve the mechanical and thermal properties of matrix material as well as improve the interfacial bond between fiber and matrix [3]. Various organic and inorganic nanoparticles have been investigated by many researchers [4]. Even a small percentage of nanoparticle addition significantly influences mechanical properties of FRPC materials [5]. The degradation of FRPC materials depends on the nature of the environment and the unique responses of the constituents [6]. A great deal of research has been focused on the durability of FRPC materials that are subjected to extreme environmental conditions such as ultraviolet radiation (UV), seawater, salt-fog spray, or a combination of both. Not only the matrix and reinforcement but also the interphase/interface undergo changes during their service life under these environments.

This study investigated the effect of UV radiation and salt fog spray on the fracture surface morphology of nanoclay infused FRPC materials. Composite samples were fabricated using carbon fibers and SC-15 epoxy, modified with montmorillonite nanoclay (MMT) as a binary reinforcement. Eight grams of MMT and 400 grams of SC-15 resin (2 weight % MMT in epoxy resin), were dried in an oven for 2 hours at 100°C. Specifically, the nanoparticles mixed with 301.54 grams of part A were magnetically stirred at 350 rpm and 40°C for 3 hours. Then, 90.46 grams of part B were added to the mixture that was further mechanically stirred at 800 rpm for 10 minutes. Fabrication of FRPC samples was done using the 8-inch carbon fiber mat as reinforcement and SC 15 reinforced with 2 wt. % MMT as the matrix. Layers of carbon fiber mats were wet with the hardener mixed resin mixture to fabricate composite laminates using a combination of hand layup and compression mold methods. Flexural properties were investigated using MTS testing equipment. The testing equipment was run under displacement control mode with a crosshead speed of 1.2 mm/min at room temperature. UV and salt fog spray conditioning were performed on the samples for 1, 2, 3, and 4 week periods. The conditioned samples were tested and compared with unconditioned samples. Fractured samples were investigated using a scanning electron microscope (SEM). Surfaces of failed samples were initially sputtered with thin layer of gold-palladium under vacuum prior to SEM imaging.

The results indicated that UV and salt fog spray conditioning affects the flexural properties of FRPC materials. Flexural strength and modulus decreased with longer UV exposure. The control samples showed flexural strength of 256 MPa and modulus of 24 GPa. However, after 4 weeks of UV exposure, the samples showed 6.37% and 12.54% decrease in flexural strength and modulus, respectively. The micrographs also revealed the detrimental effect of UV conditioning. Figure 1 represents the comparison of the micrographs of controlled and 4 week UV conditioned samples. After 4 weeks UV exposure, a large amount of matrix was washed away from fibers (Figure 1). Therefore, it can be inferred that UV conditioning affects the flexural properties of FRPC materials by fiber and matrix debonding.

Salt-fog spray conditioning also affects the flexural properties of FRPCs. After 4 weeks salt-fog spray conditioning, the samples showed 9.7% and 17.33% decrease in flexural strength and modulus, respectively. Figure 2 represents the comparison of the micrographs of control and 4 week salt-fog spray conditioned samples. After 4 weeks of salt-fog spray exposure, a large amount of matrix was washed away from fibers (Figure 2).

UV radiation and salt-fog spray affect the mechanical properties of FPRC materials by reducing the cohesiveness between the fiber and matrix interface/interphase. This result must be considered when designing any FRPC materials for real life applications.

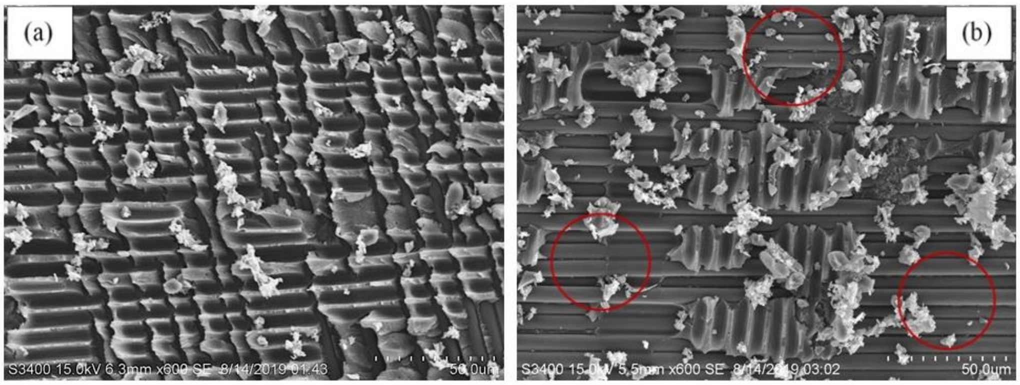

Figure 1. Micrographs of the fracture samples (a) Control vs (b) UV conditioned samples

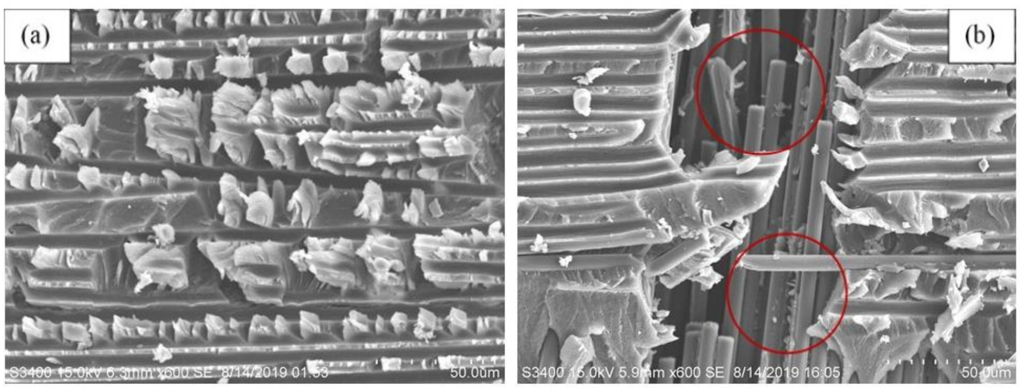

Figure 2. Micrographs of the fracture samples (a) Control vs (b) Salt-fog Spray conditioned sample

References

[1] J. Arbaoui, M. Tarfaoui, and A. El Malki Alaoui, “Mechanical behavior and damage kinetics of woven E-glass/vinylester laminate composites under high strain rate dynamic compressive loading: Experimental and numerical investigation,” *Int. J. Impact Eng.*, vol. 87, pp. 44–54, Jan. 2016, doi: 10.1016/j.ijimpeng.2015.06.026.

[2] D. Nguyen, V. Voznyuk, M. S. Bin Abdullah, D. Kim, and P. Y. Kwon, “Tool Wear of Superhard Ceramic Coated Tools in Drilling of CFRP/Ti Stacks,” in *Volume 2: Processes; Materials*, Erie, Pennsylvania, USA, 2019, p. V002T03A089, doi: 10.1115/MSEC2019-2843.

[3] S. K. Hasan, S. Zainuddin, J. Tanthongsack, M. Hosur, and L. Allen, “A study of poly (3-hydroxybutyrate-co-3-hydroxyvalerate) biofilms’ thermal and biodegradable properties reinforced with halloysite nanotubes,” *J. Compos. Mater.*, p. 002199831876324, Mar. 2018, doi: 10.1177/0021998318763246.

[4] M. A. Ahsan, M. Hosur, S. H. Tareq, and S. M. K. Hasan, "Quasi-static compression characterization of binary nanoclay/graphene reinforced carbon/epoxy composites subjected to seawater conditioning," *Mater. Res. Express*, vol. 7, no. 1, p. 015033, Jan. 2020, doi: 10.1088/2053-1591/ab62fb.
[5] M. E. Islam, T. H. Mahdi, M. V. Hosur, and S. Jeelani, "Characterization of Carbon Fiber Reinforced Epoxy Composites Modified with Nanoclay and Carbon Nanotubes," *Procedia Eng.*, vol. 105, pp. 821–828, 2015, doi: 10.1016/j.proeng.2015.05.078.
[6] M. S. Tareq, S. Zainuddin, E. Woodside, and F. Syed, "Investigation of the flexural and thermomechanical properties of nanoclay/graphene reinforced carbon fiber epoxy composites," *J. Mater. Res.*, pp. 1–10, Oct. 2019, doi: 10.1557/jmr.2019.302.