EFFECT OF SULFURIC ACID ON THE BEHAVIOR OF A COMPOSITE BASED POLYMER REINFORCED WITH GLASS FIBERS

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Abstract: *In this work, an experimental study was conducted with the objective of achieving a microscopic characterization of samples aged of wastewater and sewer pipes HDPE reinforced with glass fibers in a H_2SO_4 solution with different concentrations, using the Microscope scanning electron (SEM). The microscopic results show that degradation at the fiber / matrix interface worsens as the increase of the concentration of H_2SO_4.*

Keywords: composites, HDPE, interface, aging, sulfuric acid.

I- INTRODUCTION

The deterioration of materials used in wastewater pipes is a major problem [1-7], due to the presence of effluents rich in sulfur compounds which decompose under anaerobic conditions, under the effect of sulfate-reducing bacteria causing the release of hydrogen sulfide. The latter, by undergoing the action of the sulfur-oxidizing bacteria gives rise to the formation of sulfuric acid. Among materials families that suffer from this problem to different degrees, there are cement materials and those based polymer [5]. For example, concrete is considered unable to maintain their physical and chemical properties especially when exposed to chemically aggressive environments (presence of H_2S) [8].

The composite material (PEHDRFV) is increasingly used in wastewater pipes, due to its features that provide excellent corrosion resistance [5, 9], tensile, impact and fatigue [9], and low thermal expansion [10]. It is now possible to provide a reliable and representative durability of composite materials by subjecting them to accelerated tests conducted under laboratory control [5, 11].

The moist environment act a term long on composite materials. Its aggressive action present in many forms that can be of biological origin [5, 12], chemical, physical and mechanical, causing an alteration of said materials and causing a fall their mechanical characteristics over time. The most penalizing parameters appear to be the water-polymer interactions (water diffusion in the composite structures). Degradation begins with a composite physical aging, resulting from the diffusion of water at the fiber-matrix interface [5.13], followed by a chemical aging [5, 14]. The aim of this study is to follow the damage composite wastewater pipes samples HDPE / Fiberglass when entering into contact with a sulfuric environment at different concentrations.

II- MATERIAL AND METHOD

II-1. Material and immersion conditions

The material used is a composite HDPE / Glass fiber manufactured according to the filament winding method, the matrix is a thermoplastic polymer great diffusion. It is part of the polyolefin family .The main qualities of HDPE: resilience even at low temperatures, chemical resistance, low water sensitivity, impermeability to water vapor, excellent electrical properties, make it a material of choice in the most varied applications such as extrusion blow molding, injection of the most diverse articles, film extrusion, tube and pipe [15]. The reinforcement is composed of continuous E-glass fibers and cut according to ASTM D 578-99 and the filler consists of high-grade silica sand. The used composite contains 30% fiber, 35% resin and 35% of silica sand.

In this test we have placed composite specimens (HDPE / GRP) size 20×40×8mm^3 in H_2SO_4 at different concentrations. The cutting of the specimens is performed longitudinally in the direction of randomly arranged fibers (Mat), from a wastewater pipes (Ø400mm × 300mm). Samples are immersed in different concentrations 30, 50, 70, 80 and 90% H_2SO_4.

III- RESULTS AND DISCUSSION

In the first place, we made micro structural observations using scanning electron microscope (SEM) on a specimen in a virgin state (Figure 1), later on aged specimens during 300 days of duration in sulfuric acid (H_2SO_4) at various concentrations (figures 2, 3, 4, 5 and 6).

Regarding the sample in the virgin state, the observation demonstrates good adhesion between the fibers and the matrix (Figure 1), the fibers being coated with a resin layer [16, 17].

After immersion in the sulfuric acid solution for a duration of 300 days, we have seen a loss of cohesion at the interface between the polyester resin and glass fibers (Figure 2), which results from a double attack ,one being the result of coming into contact between the chemical compositions of glass fibers (SiO_2, CaO, Al_2O_3, MgO) and sulfates $SO4^{-2}$, while the other is the result of the reaction between the main molecule of the polyester (ester, ...) and acid protons H^+ [18-21]

The first etching is crystals on the side surfaces of the fibers (Figures 2 and 6). The second attack results in a degradation chain end, which generates the protonation of the oxygen atom of the carbonyl of the ester function, followed by interaction with water, producing an equivalent amount of the hydroxyl functional group and the carboxylic acid [20].

Electron micrographs of the composite specimens (HDPE / GRF) immersed in 50%, 70% and 80% H_2SO_4 helped to highlight the deterioration of the interface fiber / matrix (Figures 3, 4 and 5) . The attack of the sulfuric acid generated during aging, separation between the glass fibers and the HDPE resin, creating impressions fibers on the matrix (Figures 3 and 4)[22]. This observation proves that the interface is degraded along the side surfaces of the fiber, causing a loss of cohesion between the fibers and the resin HDPE [23].

Therefore, all the samples immersed in the sulfuric acid solution in a degraded at the interface fiber / matrix, which creates free zones for solvent. The debonding phenomenon of the interface fiber / matrix becomes more important in view of the aging time and elevation of the sulfuric acid percentage. This confirms that the solvent is aggressively penetrating more easily by the spaces created at the interface fiber/matrix [20, 24].

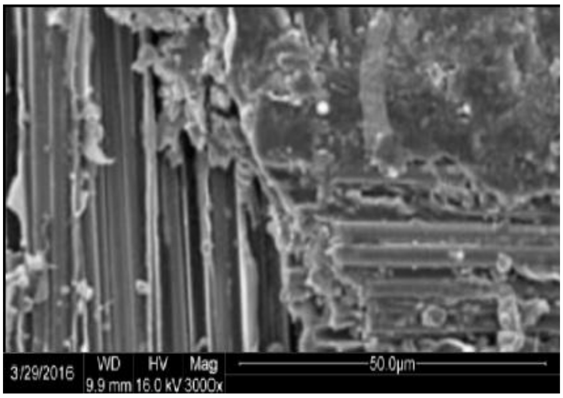
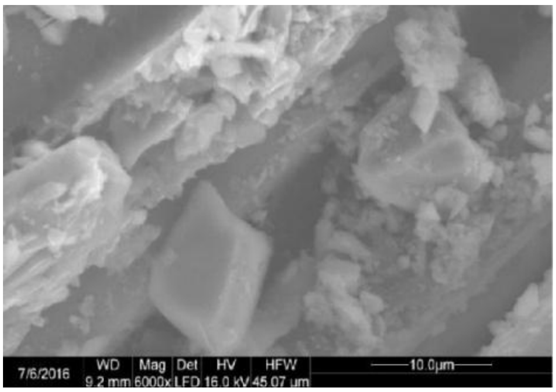


Figure 1. Electron micrographs sample in a virgin state.



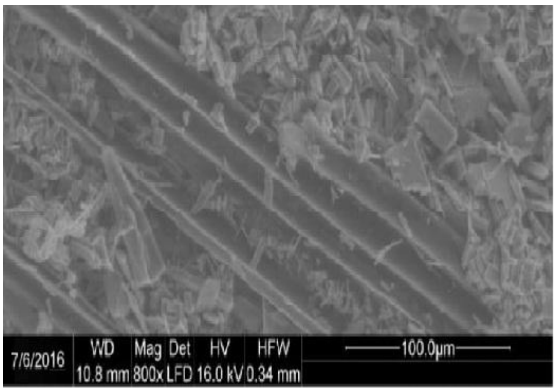
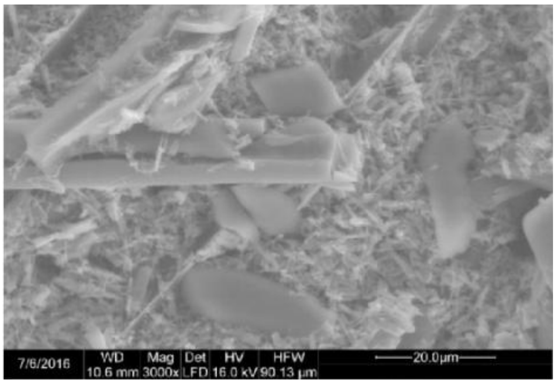


Figure 2. Electron micrographs of a sample degraded for 300 days in 30% H2SO4

Figure 3. Electron micrographs of a sample degraded for 300 days in 50% H_2SO_4



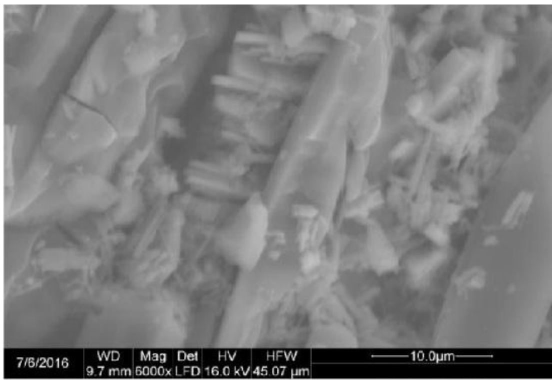


Figure 4. Electron micrographs of a sample degraded for 300 days in 70% H_2SO_4

Figure 5. Electron micrographs of a sample degraded for 300 days in 80% H_2SO_4

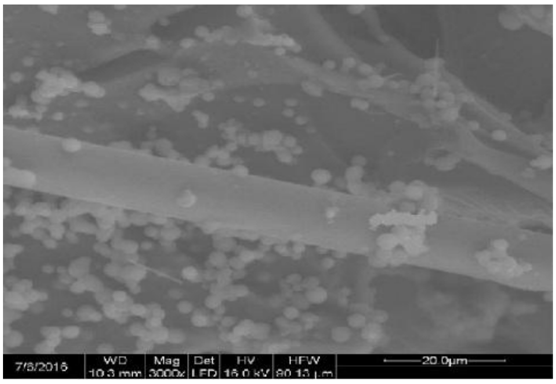


Figure 6. Electron micrographs of a sample degraded for 300 days in 90% H_2SO_4

VI- CONCLUSIONS

As they age at sulfuric acid different concentrations, the fiber /matrix interface deterioration of composite (HDPE / glass fiber) has been demonstrated. The attack of the sulfuric acid generates a separation of glass fibers with the HDPE resin, producing fibers prints on the resin. Microscopic observations by SEM show that over the sulfuric acid concentration increases, the degradation of the fiber /matrix interface worsens.

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