Topography of Fiber Reinforced Composite Resin Polyethylene and the Nature Fiber of Bagasse

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***Abstract*–Bagasse is a residual of sugarcane which has experienced five times of extortion. Bagasse has been researched and it can be used as a fiber for material outside the field of dentistry. Fiber that most often used in dentistry is an Ultra High Molecular Weight Polyethylene fiber (UHMWPE). Most often fiber used as reinforcement is composite resin. The purpose of this study was to see the difference of topography of synthetic polyethylene fiber with bagasse that is used as a reinforcement of composite resin. The specimen of this study was 2 groups of rectangle bar with measurement 25x2x2 mm. The group was divided based on the type of fiber. It was Ultra High Molecular Weight Polyethylene fiber (UHMWPE) and nature bagasse fiber. Both of them were combined with composite resin. The UHMWPE fiber and bagasse fiber were put in the composite resin then the topography was seen using scanning electron microscopy (SEM) and optic microscopy. The result of this study showed that the difference of plait pattern gives influence toward the flexural strength of FRC with diameter filament was about 4-14 µm. The crack between composite resin with synthetic and natural fiber in the current part indicated an imperfect adhesive. The conclusion of the study was there were differences of topography in nature bagasse fiber and the polyethylene fiber reviewed from diameter, adhesive, and porous.**

Keywords–baggase, topography, SEM, natural fiber, polyethylene fiber, FRC

I. INTRODUCTION

Bagasse is the fiber of residual sugarcane which has experienced five times extortion [1]. Bagasse produced from one-time extraction is 35-40% of the total weight of sugarcane in the extraction [2]. Bagasse is excellent for reducing industrial waste such as fiber reinforced composites in shipbuilding, particle board, mortar and tread brake [3,4]. Utilization of waste bagasse has not developed in dentistry, while fiber amplifiers are often used primarily as reinforcement of composite resin.

Fiber reinforced composite resin often used in dentistry in the manufacture of denture bridges, removable denture, splinting, temporary prosthesis, orthodontic and endodontic treatment [5]. Fiber reinforced composite resin that commonly used in dentistry is Ultra High Molecular Weight Polyethylene (UHMWPE) fiber. In terms of form, UHMWPE fiber has a silk-like shape (strands) and multidimensional which has a webbing-like shape (woven) or braid (braided) [5]. The properties of UHMWPE fiber are strong, low-density (0.97 gr/cm3), easily binds with composite and acrylic resin, and translucent (high aesthetic). The weakness of UHMWPE fiber is the fact that they are expensive and their synthetics requires a chemical process [6].

Based on the background above, the researchers tried to substitute bagasse with a woven shape as a polyethylene substitute used to reinforced composite resins in terms of the topography of both fibers. Evaluation of topography was done to compare both fibers, particularly by diameter, porous, and adhesion.

II. MATERIALS AND METHODS

Specimens used in this study was 25x2x2 mm rectangular bar, which was divided into two groups: fiber reinforced composite added with UHMWPE fiber (FRC + PE) and fiber reinforced composite added with bagasse (FRC + B). The available mold was smeared by thin silicon oil as a separator medium. Inserting the composite resin (Filtek Z350 nanofiller) polyethylene fiber and bagasse fiber that has been prepared wetted by Alpha Bond Light adhesive and placed above the composite resin as well as in curing using LED light curing for 20 seconds with dividing radiation into four parts. Put back composite resin until it fills the mold, then placed on a glass slide and then be given n ½ kg load on it for 5 minutes. Curing back the resin composites for 20 seconds in 4 different parts. Specimens are then released and tested using Olympus brand of an optical microscope and FEI brand of Scanning Electron Microscopy (SEM), type: Inspect-S50.

A. Bagasse preparation

The non-synthetic fiber of bagasse obtained from five times of sugarcane mill. Bagasse soaked with hot water (80^o) for 1 hour. Soaking is done to reduce sugars in the bagasse to create a stronger bond with the adhesive material [7,8]. Bagasse then combed to obtain fiber. Diameter of fiber equalized in diameter ranges between 0,05-0,1 mm. The chosen fiber then is woven with a mat pattern (plain-woven).

B. UHMWPE fiber preparation

Materials used were UHMWPE Ribbon with ribbon-shape and leno weave woven pattern. Fiber with the length of 22 cm and a width of 2 mm cut with special scissors in accordance with the length of the mold 25 mm.

TABLE I. COMPOSITION OF NANOFILLER RESIN COMPOSITES, FRC UHMWPE, BAGASSE AND ADHESION MATERIALS

Material	Type	Composition	Product
Nanofiller Composite Resin	Filtek Z350TM XT color A3	Matrix: Bis-GMA[a], UDMA[b], Bis-EMA[c], PEGDMA[d] and small amount of TEGDMA[e]; Filler: 20 nm Si and 4-11 nm Zr	3M ESPE
Fiber Reinforced Composite Resin	UHMWPE Ribbond THM Leno-weave	Fiber fabricated by cold plasma with a woven pattern of "lock-stitch"	Ribbond, Inc
Bagasse fiber	Saccharum officinarum	Cellulose, hemicellulose, and lignin	
Bonding Agent	Alpha Bond Light	Bis-GMA, TEDMA[f], 2,6 DI, Urethan, B 200 P, Benzyl dimethyl ketal, Canforquinone and Quantacure EHA	DFL Industria

[a.] Bis-GMA: Bisphenol A-glycidil methacrylate
[b.] UDMA: urethane dimethacrylate
[c.] Bis-EMA: Bisphenol A-ethoxylated dimethacrylate
[d.] PEGDMA: Polyethylene Glycidyl Methacrylate
[e.] TEGDMA: tryethylene glycol dimethacrylate
[f.] TEDMA: triethylene dimethacrylate

III. RESULTS

This study was conducted to look at the topography of composite resin using polyethylene fiber and composite resin that uses bagasse fiber. Initial observations were made on bagasse and UHMWPE fiber which has not been formed into a specimen using an optical microscope with a magnification of 5x and results can be seen in Figure 1A and 1B. Results of the topography showed that fiber made from bagasse has irregular webbing and has a greater density than UHMWPE fiber. The distance between the fibers of bagasse is 500µm while the UHMWPE fiber is 80µm.

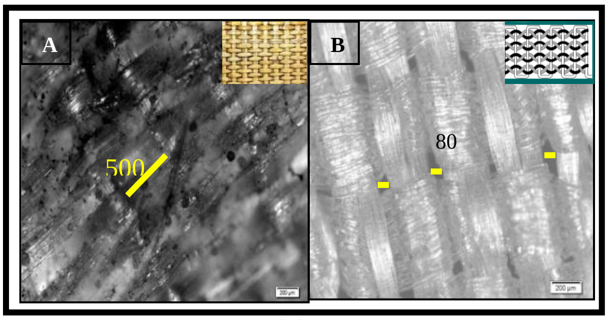

Figure 1. Overview density of fiber (A) Bagasse (B) UHMWPE ribbond (microscope Mag.5X).

Besides the difference in woven patterns, the diameter of a synthetic fiber and natural fiber of bagasse also showed a large difference. Figure 2A showed that the diameter of filaments that make polyethylene fiber ranged between 9-12 µm. Combination of these filaments will make bundle size about 97.25 µm. Unlike the natural fiber of bagasse, the fiber diameter was about 55-71 µm (Figure 2B).

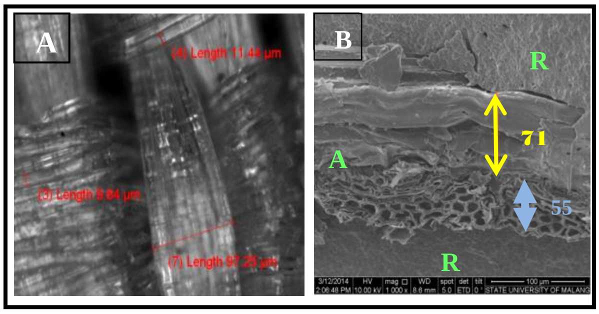

Figure 2. Difference of diameter between fiber polyethylene and bagasse fiber. (A) Fiber polyethylene ribbond (Leno-Weave) (B) Bagasse fiber.

Results from Scanning Electron Microscopy (SEM) overview showed the combined specimen between nanofiller composite resin with bagasse fiber and composite resin combined with polyethylene fiber. Picture of the specimens cross-sectional showed the structure, porous and adhesive from both fibers. The picture can be seen in Figure 3 and 4.

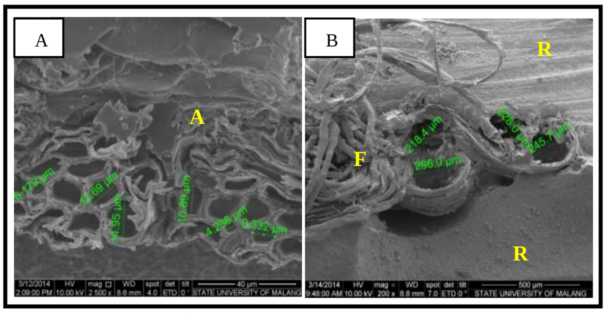

Figure 3. Overview of combination between (A) Composite resin with bagasse fiber (Mag. 2500x) and (B) Composite resin with Polyethylene fiber (Mag.200x)

Overview of SEM with 2500x magnifications showed that the structure of fiber bagasse was irregular and hollow with different sizes. The size of the results was ranged from 4-15 μm (Figure 3A). Polyethylene fibers also showed cavities with varying sizes ranging from 218-245 μm (Figure 3B). SEM picture of the specimen between composite resin and fiber bagasse showed that there was a gap between bagasse fiber and composite resin (red arrows) (Figure 4A). SEM picture with different magnification (500x) also showed that there was a gap between polyethylene fiber and the composite resin is shown in Figure 4B (yellow arrow).

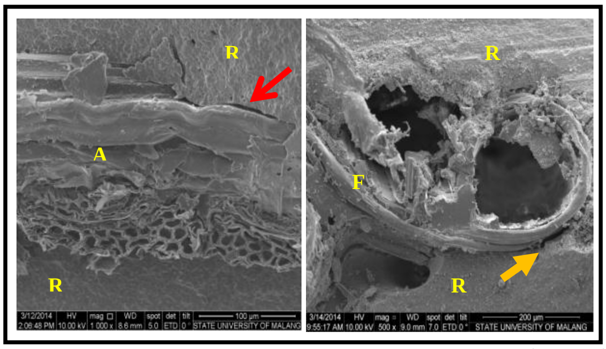

Figure 4. There is a gap between composite resin with fibers of bagasse (Mag. 1000x) (A) and composite resin with polyethylene fiber (magnification 500x) (B).

IV. DISCUSSION

The study produced a topography overview of the composite resin with polyethylene fiber and composite resin with natural fibers of bagasse. Topographical observation is made to see the quality of material terms of woven pattern, porous, adhesion and diameter of polyethylene fiber and bagasse fiber [9]. Topography observed using an optical microscope was to see the pattern of woven from the natural fiber of bagasse and synthetic polyethylene fiber, while the porous and adhesion that formed was observed using SEM.

The results showed that the pattern of woven polyethylene fiber and bagasse fiber were different. Woven bagasse fiber composed of several long fibers (longitudinal position) and short fiber (transverse position) which was superimposed and up-down forming an angle of 90o. This woven pattern called plain woven pattern that resembles a mat woven (Figure 1A). Polyethylene fiber showed a pattern of woven leno weave woven pattern that intertwined rotates past the lock cross stitch (Figure 1B). Results of this study showed a different pattern from both of fiber thus affecting the flexural strength of FRC. Vistasp et al study also showed differences in flexural strength on different woven pattern fiber, leno weave pattern (191 MPa), unidirectional (247 MPa) and braided (224 MPa) [10].

These different woven patterns affect the distance between one fiber to another fiber. Measurement of this study showed that the distance between the two bagasse fiber length of 500 μm, while the distance between the polyethylene fiber is much smaller than 80 μm (Figure 1). The distance between the polyethylene fibers was smaller than the fibers of bagasse can be assumed to give polyethylene fiber a higher density level than bagasse fiber, so that the flexural strength also higher.

Polyethylene fiber is composed of thousands of filaments which have a size ranging between 5-15 μm. Measurement in this study showed polyethylene fiber filament size ranging between 9.84 to 11.44 μm. Bagasse filaments fiber ranging between 4-15 μm (Figure 3A). Size of the polyethylene fiber filament and bagasse are still included in the ranging size of the filaments making the FRC. Combination of fiber filaments forms a bundle fiber with a difference of diameter. Polyethylene fiber diameter size in this study showed a yield of 97.25 μm (Figure 2A). The results showed a greater than Jonathan research that is 30 μm. This is assumed to be due to differences in the brand of the fiber [11]. This study uses a polyethylene ribbon fiber, but in Jonathan study did not mention the brand used. The diameter of bagasse fiber diameter in this study was around 55-71 μm (Figure 2B). The diameter of polyethylene fiber is greater than the fiber of bagasse. The larger the diameter of the fiber can improve the flexural strength of FRC.

Cross section of bagasse fiber showed an irregular shaped with globular structure and have different sizes (Figure 3A). Cavities on bagasse fiber are small pieces and much in amounts. The globular limited by cell walls that are inherent among other globular. One globular can be assumed to be the filament of bagasse fiber. Unlike the polyethylene fiber, the cavity formed only one by one with varying sizes, 218-286 μm (Figure 3B). Cavities are formed on polyethylene fiber only be a separation between polyethylene fiber with each other. The cavity believed to formed because of the longitudinal fiber that is cut off, thus leaving the fiber cross which envelops the lengthwise fiber. This cause the presence of cavities in the polyethylene fiber.

Besides diameter and density of the fiber, the adhesion between fiber and composite resin affects the value of flexural strength of the composite resin. The effectiveness of fiber as a reinforcement would be good if they can receive mechanical force from the polymer matrix to themselves. The ability of the attachment between the fiber with the matrix of composite resin can be influenced by the type of composite resin, the bonding material used and the water content of the fiber. This study used a composite resin Filtek Z350TM XT (3M ESPE), while the bonding material used is alpha bond light (DFL Industria).

Different products allow unfit between the matrix of composite resin and bonding agents. Bonding alpha bond material containing ethanol, which takes a longer time to dissolve than another solvent. In addition, bagasse is used in this study was not done drying process to remove water content, so that the water content contained enables deposited and form a cavity. Combination of composite resin with bagasse showed a gap formed between bagasse fiber and composite resin (Figure 4A). Gap formed on bagasse fiber is smaller than the gap formed in combination with polyethylene composite resin fiber. The combination of composite resin with polyethylene fiber showed a larger and widespread gap (Figure 4B). The formation of this gap is assumed for the content of ethanol in the bonding material. Ethanol has the disadvantage that it takes longer to evaporate. Martha cit Ellakwa research states that theoretically bonding material containing solvents can interact with the fiber and cause a gap that occurs when receiving a load mechanics [12].

Based on the results of research that performed on the composite resin Filtek Z350TM XT combined with polyethylene fiber (ribbons) and natural fiber of bagasse can be concluded as follows:

- Bagasse fiber diameter was 55-71 µm whereas polyethylene fiber was 97.25 µm, size of bagasse fiber filament ranges between 4-14 µm while the polyethylene fiber ranges between 9-12 µm.
- Bagasse fiber has the smallest filament with a size of 4-15 µm.
- The topography of bagasse and polyethylene fibers are reviewed from a woven pattern, diameter, porous and fiber attachment to the composite resin, showing the difference.
- From the size of sugar cane fiber filaments approaching synthetic fiber filaments, sugarcane fibers can still be used to reinforced composite resin.

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