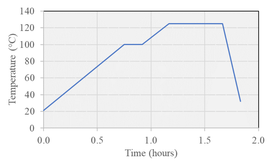
EFFECT OF CONSOLIDATION PROCESS ON TENSILE STRENGTH OF UHMWPE FIBERS EXTRACTED FROM COMPOSITE PANELS

Dr. Ahmad Abu Obaid[1], Dr. Sagar M. Doshi[1], Dr. Joseph M. Deitzel[1] and Professor John W. Gillespie, Jr.[1]

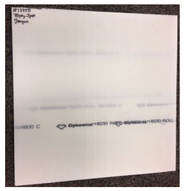
University of Delaware | Center for Composite Materials[1]

Introduction

- UHMWPE fibers exhibit excellent strength, toughness, chemical resistance, impact resistance. These fibers have many applications, however, processing of composites of these fibers can affect the strength of fiber.
- Evaluated materials: Dyneema®SK99 fibers, HB210 sheet consisting of four unidirectional layers (0/90/0/90) of SK99 fibers impregnated thermoplastic resin.
- The panel evaluated in this effort consists of 75 HB210 sheets, where the consolidation parameters were: Ramp to 100°C/290 psi for 10 minutes followed by125°C under 20.7 MPa (3 ksi) for 30 minutes.



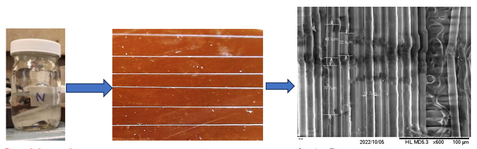
Processing temperature profile applied



Consolidated HB210 composite panel

Extraction of fibers Procedure

- A strip was cut from the center of panels. The was then soaked in THF 20 days , enabling us to separate the sublayers (top, middle and bottom).
- Then, the filaments were extracted from these sublayers after 7 days of soaking in THF. Also, fibers from unprocessed HB210 sheets were extracted.
- It was ensured that extraction procedure did not induce any microdamage mod observed by the fiber.



Soaking the sublayers for 7 days

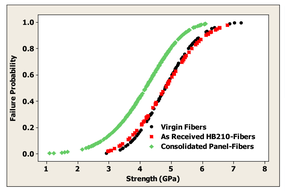
Low mag. of extracted fibers from the sublayers

SEM of extracted fibers from consolidated panel

Tensile Testing

- Micro-mechanical test frame equipped with a 5 N load cell was used. Tests were performed applying a gauge length of 25 mm and a cross-head speed of 5 mm/min.
- Tests were conducted on virgin fibers, fibers extracted from the panel and from unprocessed HB210.
- Failure probability-Strength (CDF curves) were generated.

Failure Probability Distributions

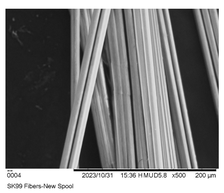


Fiber	Strength at 50% Probability (Gpa)
Virgin Fibers	4.81
As Received HB210-Fibers	4.81
Consolidated Panel-Fibers	4.15

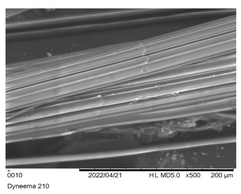
- SK99 fibers and fibers extracted from unprocessed HB210 show identical CDF curves, validating that the THF procedure did not induce damage to fiber. At 50% probability, relative to virgin fibers, the average reduction in strength values extracted fibers is ~15%.

SEM Images for Damage Modes

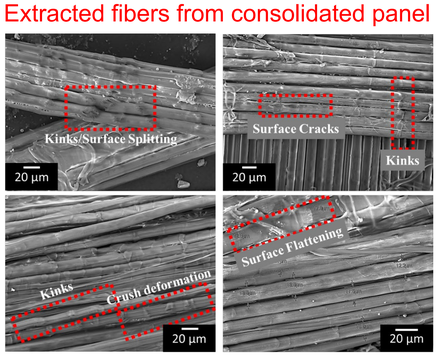
Virgin Fibers



Fibers from unprocessed HB210



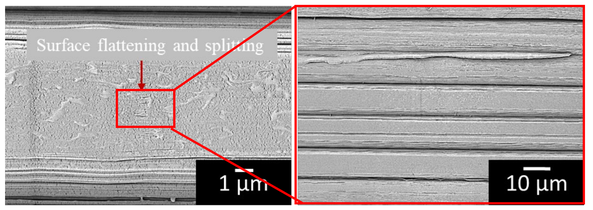
Extracted fibers from consolidated panel



Microdamage Modes Observed by Fibers

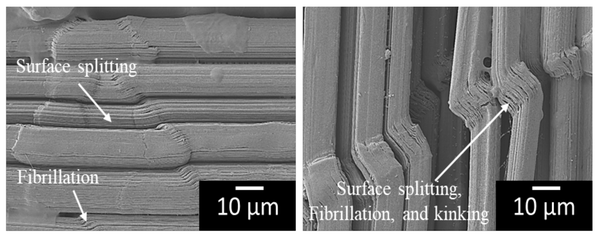
- Fibers exhibit different microdamage modes induced by processing of consolidated HB210 composites, such as kinking/buckling associated with surface splitting, crush deformation/surface flattening.
- Kinking/buckling can be due to CTE mismatch between fiber and matrix, where particularly during cooling cycle, fibers can undergo compression. These damage modes have a contribution to strength reduction of fibers from consolidated/processed panel.

Effect of Transverse Compression



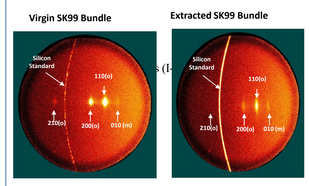
- SEM micrographs of fibers from unprocessed HB210 after compression test at 3ksi/RT.
- Fibers exhibit fiber surface flattening and surface splitting.

Effect of Heating to 125°C for 30 min., followed by cooling to RT

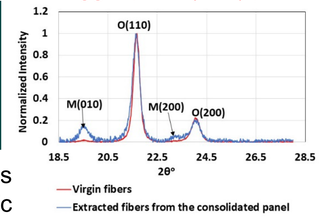


- SEM micrographs of fibers from unprocessed HB210 after exposure to heating/cooling cycles.
- Fibers show that temperature induce (without pressure) kinking/buckling associated with remarkable surface cracks/splitting.

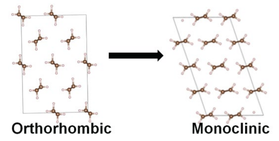
2D-Xray Diffraction Tests on Fibers



Bragg`s plots (I-2θ) plots



- Consolidation process increases the monoclinic phase and reducing the orthodromic phase. So, the crystalline lattice underwent more shear resulting in molecular slippage.



Conclusions

- THF treatment did not affect the strength of extracted fibers from HB210 prepreg.
- On average, consolidation of HB210 composites can induce 15% reduction in fiber strength. Reduction in strength can be due to microdamage modes observed by the fibers (kinks, fibrillation, surface crush deformation, surface splitting along the fiber) and distortion of crystalline structure of fiber Increasing monoclinic phase).
- Damage modes (kinks/buckling) can be caused by temperature (heating at by 125°C for 30min and cooling to RT). But, through processing the pressure (3ksi for 30 min.) induces damage modes (surface crush deformation, surface splitting along the fiber).

Acknowledgements

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