# Qualitative Characterization of Geotextile Material for Downhole Application

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## Abstract

There are various methods available to control sand production from oil and gas wells, among them is through the application of downhole screen. However, conventional screens have their own operational issues such as erosion due to production of fines through the screen openings leading to development of localized high-velocity hot spots in the screen filter media and subsequent failure of the media. The aim of the present work is to investigate the chemical resistance and temperature stability of geotextile material as screen filter media through exposure to reservoir fluids and temperatures. Limited studies exist on examining geotextile material as screen filter media as its applications generally revolves around civil, coastal and marine engineering. In this study, woven polypropylene and woven polyester geotextile samples were selected and exposed to crude oil for a period of 1 to 5 days through immersion test and temperatures ranging from 150°F to 219°F through thermal stability test. The samples were then analyzed and characterized by the use of analytical equipment such as Energy Dispersive X-Ray Spectroscopy and Scanning Electron Microscope to observe deformation after the exposure. Results revealed that the test samples were remained in their original state and did not degrade after the treatments.

## Keywords
Sand production, sand control, geotextile, polypropylene, polyester

## 1. Introduction

One of the toughest hydrocarbon extraction related problems faced by the oil and gas industry all over the world for decades is sand production from wells. Sand production is defined as the migration of formation sand caused by the flow of reservoir fluids such as water, oil and gas in unconsolidated formation (Naz et al., 2016; Nguyen et al., 2014). The production of sand is initiated when rocks around the perforations fail and the loose grains are thrusted by fluids into the borehole. Generally, it occurs when the stresses in the formation rock exceeds the rock material mechanical strength due to high drawdown, reservoir depletion, change in wellbore fluid composition and wellbore cyclic loading (Zhou and Sun, 2016). Before flowing into the wellbore, the sand particles are disintegrated from their parent rock. This happens when the reservoir rock has low formation strength and fails under the in situ stress conditions and the imposed stress changes due to the hydrocarbon production.

The problems of sand production range from short term to long term effects. Among the issues are downhole sand accumulation downhole, sand accumulation in surface and subsurface equipment, erosion of surface and subsurface facilities and collapse of formation (Naz et al., 2015). One of the common methods to control sand production is by installing downhole standalone screens such as slotted liners, wire wrapped screens, metal mesh screens or expandable screens. However, these screens have their own operational limits such as being susceptible to plugging, limited flow area which restricts oil production and screen collapse due to low mechanical strength. In addition, Tiffin et al. (1998) reported that the existing sand screens can prevent sand production in a reservoir that has normal distribution pattern but not for a reservoir that is dominant by fines sand. Screen erosion occurs mainly due to production of fines sand through the screen openings leading to development of localized high-velocity hot spots in the screen filter media and subsequent failure of the media. Fine sand is defined as formation sand with size ranging from 50-75 microns. Fines sand are able to pass through the screen openings and find its ways to piping components leading to erosion of surface equipment. Figure 1 shows an example of component failure due to the fines production.

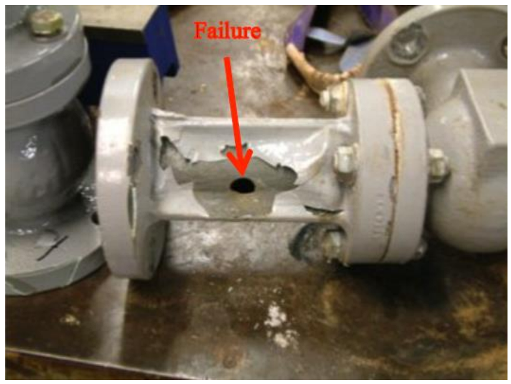


Figure 1. Equipment failure caused by fines production (Subramani et al., 2014)

This study focuses on the qualitative characterization of the geotextile samples after being immersed in crude oil and exposed to reservoir temperatures to investigate its chemical resistance and temperature stability as downhole screen filter media. The study is divided into three main steps which are to test the stability of geotextile samples when exposed to temperatures ranging from 150°F to 219°F, to test the chemical resistance of geotextile samples when immersed in oil solution and to observe the physical changes of the geotextile samples after the treatments using analytical tools such as Scanning Electron Microscopy (SEM) to quantify its molecular surface structure and Energy Disperse X-ray Spectroscopy (EDS) to determine its chemical composition.

## 2. Materials and Methodology

### 2.1 Materials

In this study, polypropylene and polyester woven geotextiles with apparent opening size of 200 μm were adopted as test materials. The geotextile samples were supplied by TenCate Geosynthetics Asia Sdn Bhd. Polypropylene and polyester are thermoplastic polymers. Generally, they are resistant to many bases, acids, and chemical solvents. The samples were cut into square shape with a size of approximately 1cm by 1cm. The cut samples were then heated at their edges using a lighter to ensure the samples remain intact when experiments are conducted. Tapis crude oil with viscosity of 25.658 cp, density of 0.9255 g/cm$^3$ and the surface tension of 26.04 mNm$^{-1}$ was used in this study as the immersion solution.

### 2.2 Thermal Stability Test

Thermal stability test was conducted to investigate the stability of the geotextile samples at various temperatures. The test was performed by placing the samples in a beaker filled with 150 ml of water. After that, it was heated to temperatures ranging from 150°F to 219°F by the use of electric-heater. The test samples were then characterized by using analytical tools such SEM and EDS. The sample condition before and after experiment was compared and analyzed. The experimental setup is shown in Figure 2.

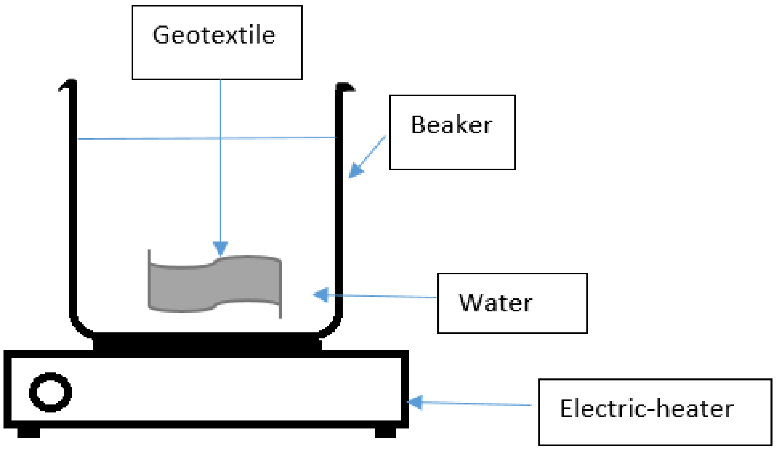


Figure 2. Thermal stability test experimental setup

**2.3 Immersion Test**

Immersion test was adopted by following compatibility test method for wastes and membrane liners known as Method 9090A. The test was conducted to investigate the effect of crude oil on the deformation of geotextile samples after the exposure. The samples were immersed in the crude oil solution for 1 day to 5 days at room temperatures (23± 2°C). The samples were further characterized using analytical tools such as SEM and EDS to observe the deformation before and after contact with the crude oil. The experimental set up is illustrated in Figure 3.

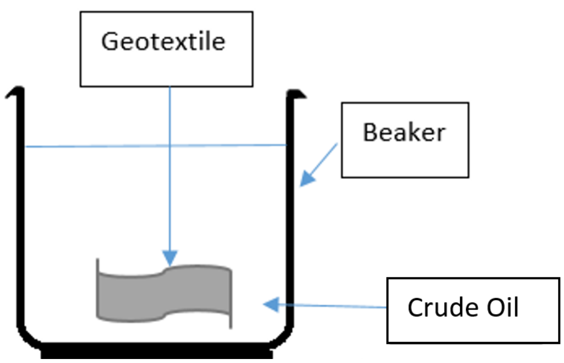


Figure 3. Immersion test experimental setup

## 3. Results and Discussion

The SEM images of geotextile samples from thermal stability test show that both polypropylene and polyester samples did not deform after being heated at 150°F to 219°F. The images were magnified at 500 resolutions which allow observation area to be less than 20 microns. The post-experiment samples appear to be similar with the unexposed samples indicating that no deformation occur on the test samples. This may be true as polypropylene and polyester can withstand temperatures of at least 300°F without melting. However, geotextile is a thermoplastic material where the physical properties of the material will change with temperature. If it is exposed to high temperature and then taken out of that temperature, the properties of the geotextile will restore back according to the new temperature, unless it reached a point where it undergoes permanent deformation. The EDS results of geotextile samples from thermal stability test indicate that the weight percent of the constituent components such as carbon (C) and hydrogen (H) are relatively constant for both polypropylene and polyester geotextile samples before and after the experiment. This could indicate that there is no possible degradation occurs on the test samples as degradation may break the polymer main chain and therefore may change the weight percentage of its constituent components after the test.

The SEM images of geotextile samples from immersion test also show that both polypropylene and polyester samples were remained in their original state after contact with the crude oil for a period of 1 to 5 days at room temperature. The SEM image for the unexposed sample was magnified at 500 resolutions while the post-experiment samples images were magnified at 150 resolutions. The EDS results of polypropylene samples from immersion test show presence of 100 wt % of Carbon from a test period of 1 to 4 days except for polypropylene samples immersed for a test period of 5 days. The EDS results reveal the presence of 0.1 wt % of Aluminium (Al) and 0.1 wt % of Silicon (Si) and the remaining is Carbon (C) component after the 5 days. However, it is believed that the changes in the percentage of constituent components may not be due to polymer degradation but due to presence of contaminants in the crude oil. The images of samples before and after experiments are illustrated in Table 1 to 4.

Table 1. Thermal stability test results for polypropylene samples

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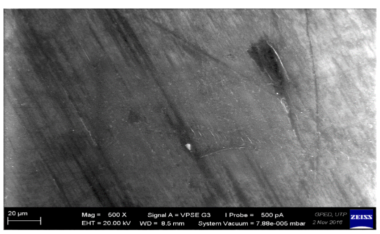
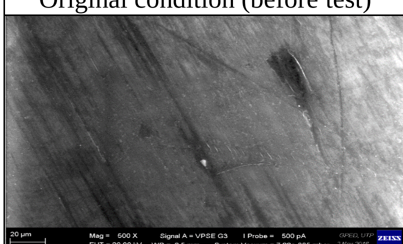
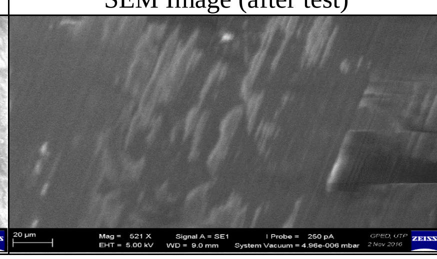
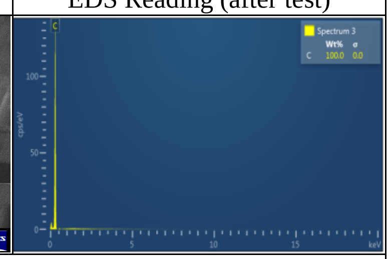
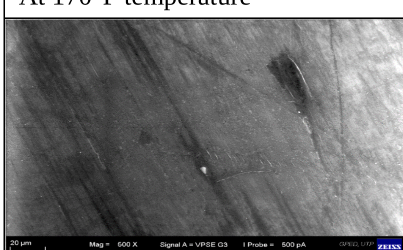
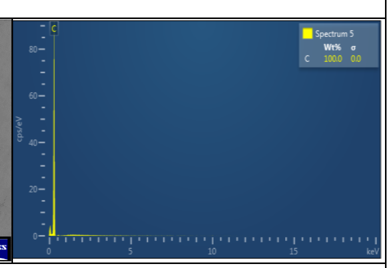
<tr><td>Original condition</td><td colspan="2">Description</td></tr>
<tr><td></td><td colspan="2">SEM Image<br>• Woven polypropylene geotextile samples<br>• All images were magnified at 500 resolutions</td></tr>
<tr><td></td><td colspan="2">EDS Reading<br>• 100% carbon element was detected from the original sample</td></tr>
<tr><td colspan="3">At 150°F temperature</td></tr>
<tr><td>Original condition (before test)</td><td>SEM Image (after test)</td><td>EDS Reading (after test)</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="3">At 170°F temperature</td></tr>
<tr><td></td><td></td><td></td></tr>
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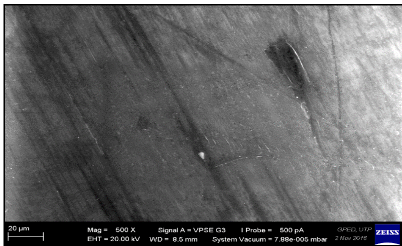
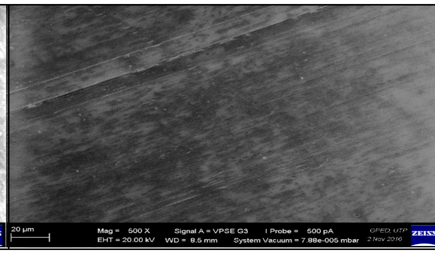
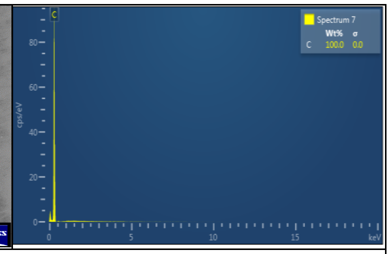
|  |  |  |
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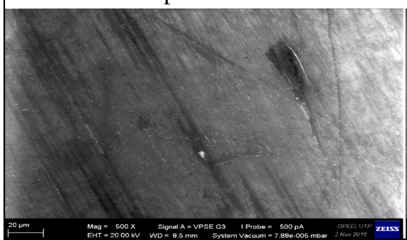
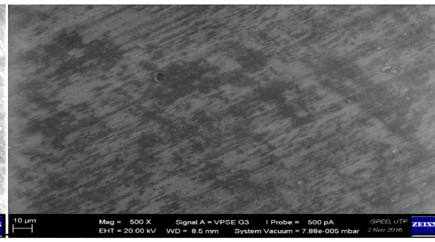
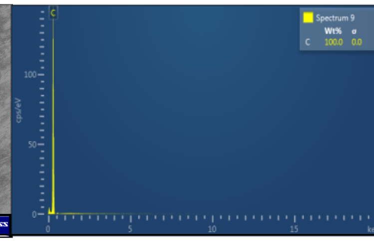
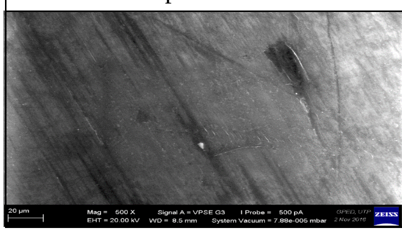
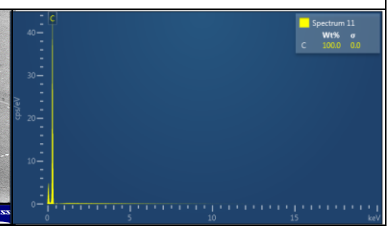
|  |  |  |
| At 219°F temperature | | |
|  |  |  |

Table 2: Thermal stability test results for polyester samples

| | | |
|---|---|---|
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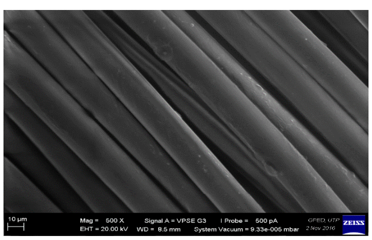
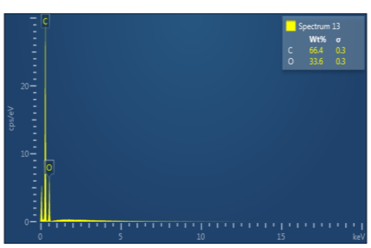
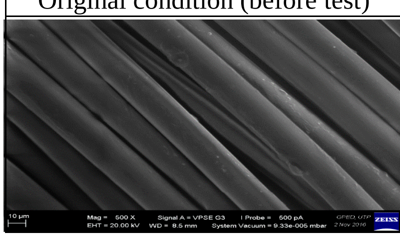
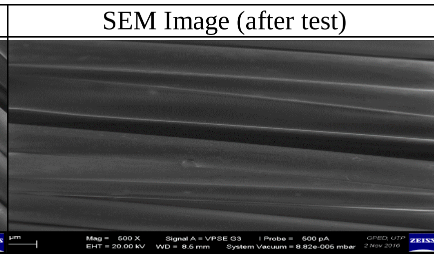
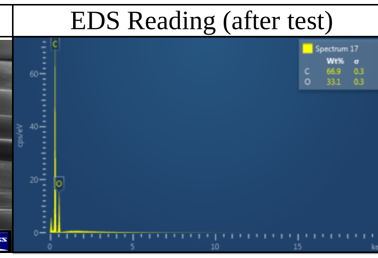
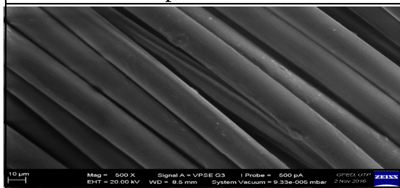
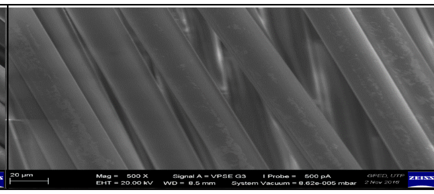
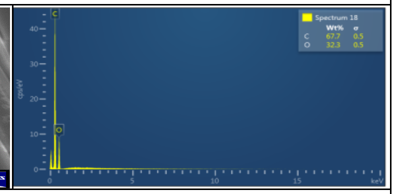
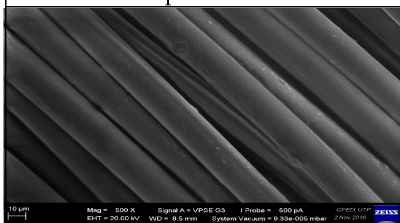
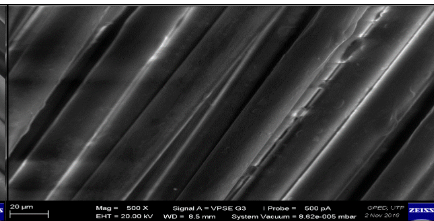
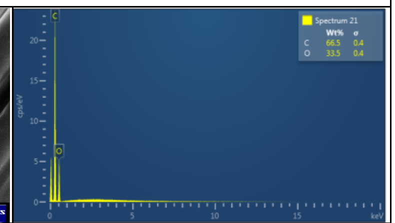
| Original condition | Description | |
|  | SEM Image<br>• Woven polyester geotextile samples<br>• All images were magnified at 500 resolutions | |
|  | EDS Reading<br>• 66.4% carbon and 33.6% oxygen elements were detected from the original sample | |
| At 150°F temperature | | |
| Original condition (before test) | SEM Image (after test) | EDS Reading (after test) |
|  |  |  |

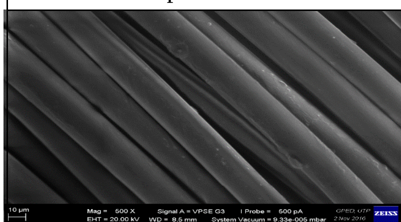
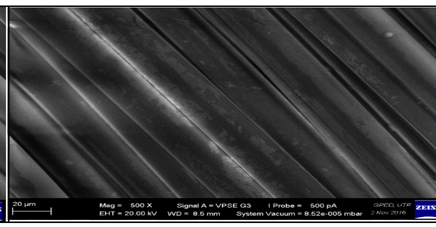
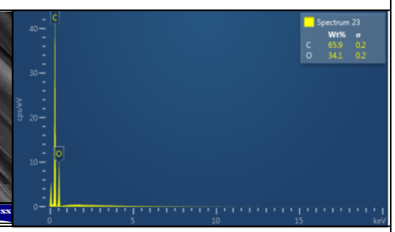
At 170°F temperature


At 190°F temperature


At 210°F temperature


At 219°F temperature

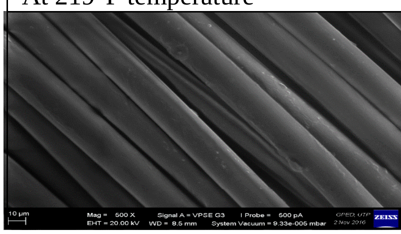
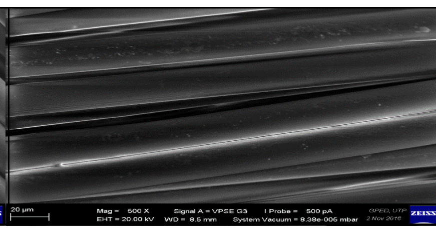
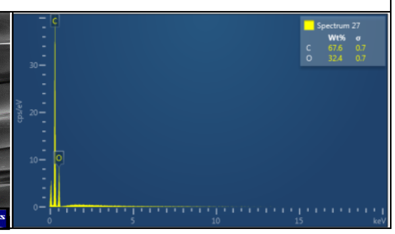





Table 3: Immersion test results for polypropylene samples

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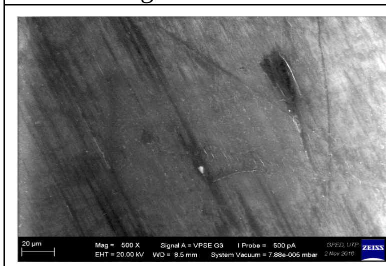
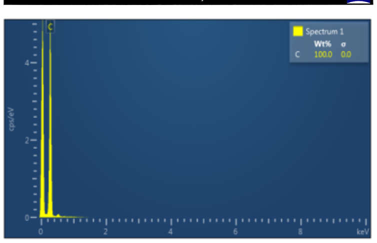
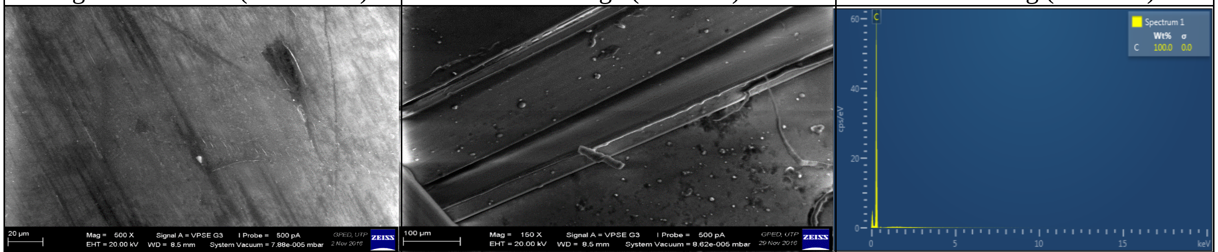
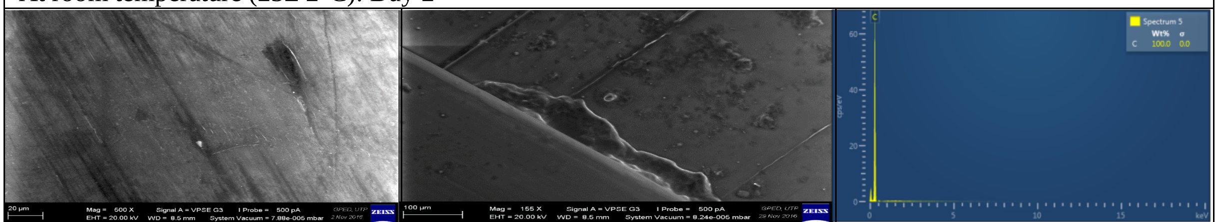
<tr><td>Original condition</td><td>Description</td></tr>
<tr><td><br></td><td>SEM Image<ul><li>Woven polypropylene geotextile samples</li><li>The original image was magnified at 500 resolutions</li><li>The post-treatment images were magnified at 150 resolutions</li></ul>EDS Reading<ul><li>100% carbon element was detected from the original sample</li></ul></td></tr>
<tr><td colspan="2">At room temperature (23± 2°C): Day 1</td></tr>
</table>

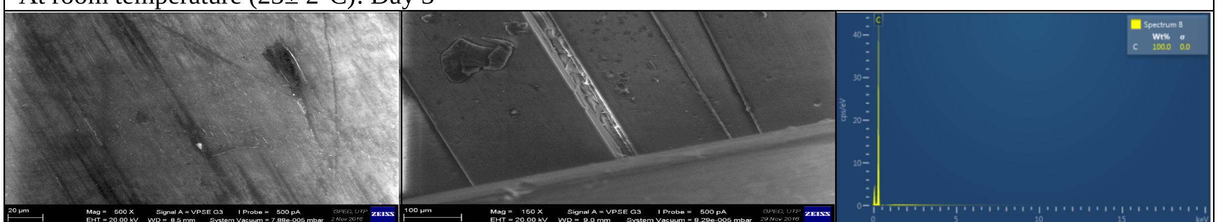
| Original condition (before test) | SEM Image (after test) | EDS Reading (after test) |
|---|---|---|



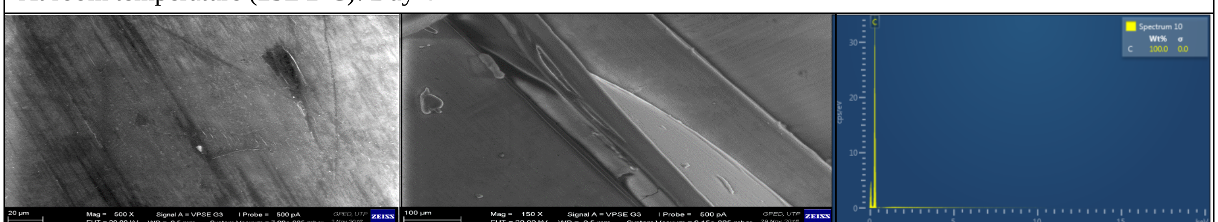
At room temperature (23± 2°C): Day 2



At room temperature (23± 2°C): Day 3



At room temperature (23± 2°C): Day 4



At room temperature (23± 2°C): Day 5

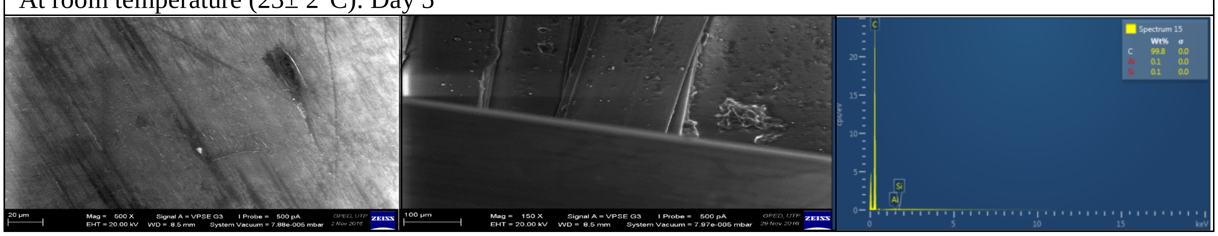


Table 4: Immersion test results for polyester samples

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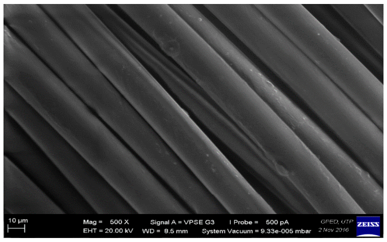
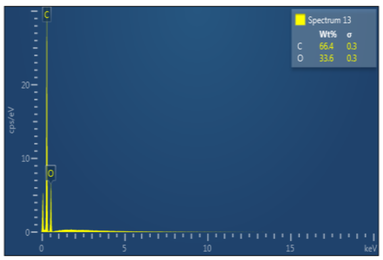
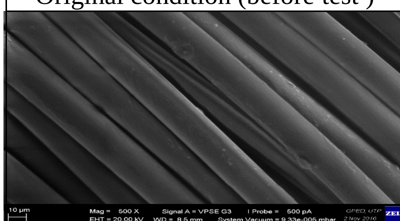
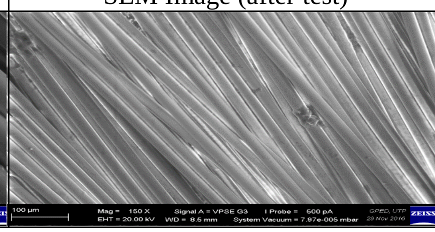
<tr><td></td><td colspan="2">SEM Image<br>• Woven polyester geotextile samples<br>• The original image was magnified at 500 resolutions<br>• The post-treatment images were magnified at 150 resolutions</td></tr>
<tr><td></td><td colspan="2">EDS Reading<br>• 66.4 % carbon and 33.6% oxygen elements were detected from the original sample</td></tr>
<tr><td colspan="3">At room temperature (23± 2°C): Day 1</td></tr>
<tr><td>Original condition (before test )</td><td>SEM Image (after test)</td><td>EDS Reading (after test)</td></tr>
<tr><td></td><td></td><td></td></tr>
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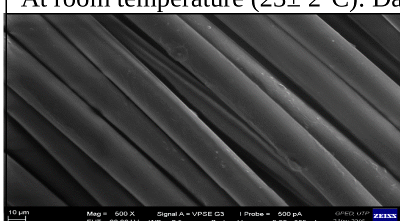
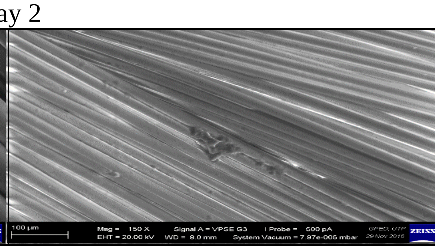
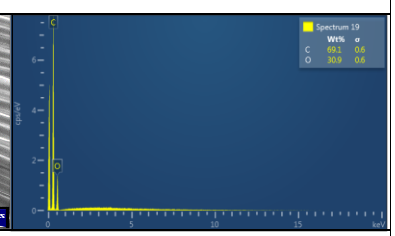
<tr><td></td><td></td><td></td></tr>
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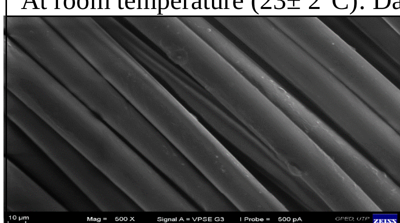
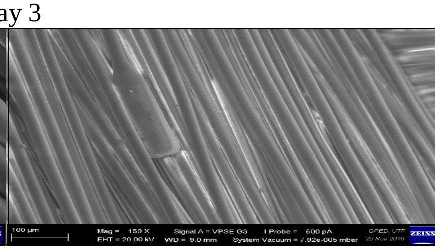
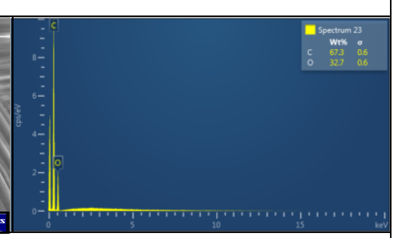
<tr><td></td><td></td><td></td></tr>
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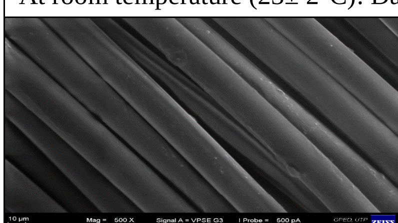
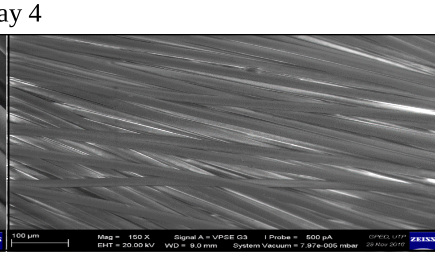
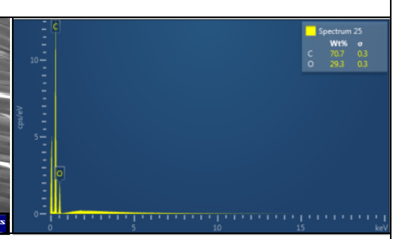
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="3">At room temperature (23± 2°C): Day 5</td></tr>
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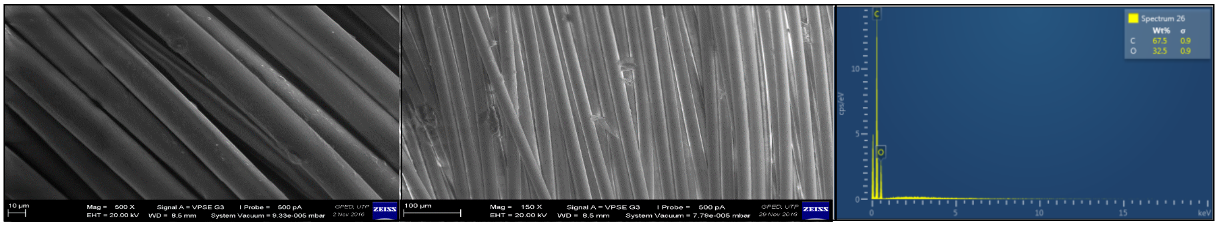


## 5. Conclusion

This paper presents a qualitative characterization study of geotextile samples after being immersed in crude oil and exposed to reservoir temperatures to study its chemical resistant and thermal stability. Woven polypropylene and polyester geotextile samples have been used in this study. The samples were immersed in Tapis crude oil solution for 5 days at room temperature and exposed to different ranges of reservoir temperatures. The test samples were then analyzed using SEM to quantify its molecular surface structure and EDS to identify changes in the material constituent components before and after the experiments. The SEM images of geotextile samples from thermal stability test show that both polypropylene and polyester samples did not deform after being heated at 150°F to 219°F. The post-experiment samples appear to be similar with the unexposed samples indicating that no deformation occur on the test samples. The SEM images of geotextile samples from immersion test also show that both polypropylene and polyester samples remain unchanged after contact with the crude oil for a period of 1 to 5 days at room temperature. The EDS results of polypropylene samples from immersion test show presence of 100 wt % of Carbon (C) element from a test period of 1 to 4 days except for polypropylene samples immersed for a test period of 5 days. The EDS results reveal the presence of 0.1 wt % of Aluminium (Al) and 0.1 wt % of Silicon (Si) and the remaining is C component after the 5 days. However, it is believed that the changes in the percentage of constituent components may not be due to polymer degradation but due to present of contaminants in the crude oil. Further numerical and simulation approaches are required to quantify and validate the findings.

## Acknowledgements

The work is funded by Malaysian-Thailand Joint Authority (MTJA) under Research Cess Fund and supported by TenCate Geosynthetics Asia Sdn Bhd, Petroleum Engineering and Civil Engineering Departments of Universiti Teknologi PETRONAS.

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