3.3. Insulation

Test #5 contained NUKON^{TM} fiberglass samples. The fiberglass samples were thoroughly investigated, with samples being removed from the tank on Days 4, 15, and 30.

3.3.1. Deposits in Fiberglass Samples

The fiberglass samples were contained in SS mesh bags to minimize migration of the fiberglass throughout the tank and piping. Small mesh envelopes, approximately 4 in. square, containing approximately 5 g of fiber, were pulled out of the tank periodically for SEM examination. These sample envelopes were placed in a range of water flow conditions, but none experienced direct water flow through the fiberglass. All were thoroughly immersed in the test solution until they were recovered from the tank.

There were four fiberglass locations in the tank that were examined in this test, including the low-flow areas, the high-flow areas, the drain collar, and the birdcage. (See Subsection 2.4.1.1 for descriptions of the fiberglass samples.) Both the exterior and the interior of the fiberglass samples from each location were examined. Subsections 3.3.1.1 through 3.3.1.10 give the ESEM/SEM/EDS results according to the location of the fiberglass samples in the tank and when the sample was removed from the tank. The different samples include Day-4 low-flow, Day-15 low-flow, Day-15 high-flow, Day-30 low-flow, Day-30 low-flow in a big envelope, Day-30 high-flow, Day-30 high-flow in front of a header, Day 30 in nylon mesh, Day-30 drain collar, and Day-30 birdcage. The corresponding figures are Figures 3-16 through 3-70. Additional micrographs of fiberglass samples are presented in Appendices A, B, and C.

In general, particulate deposits were found on only the exterior of the fiberglass. This result suggests that almost all of the particulate deposits were physically retained at the fiberglass exterior. Because there was no significant water flow directly through the fiber, the migration of particulate deposits into the fiberglass interior was insignificant. Comparing the amount of particulate deposits, the greatest amount was found on the drain collar exterior, especially the exterior farthest from the drain screen. Small amounts of particulate deposits were found on the fiberglass exterior within the birdcage and within the big envelope in a low-flow zone. All other fiberglass exteriors were relatively clean, and no significant particulate deposits were found. EDS shows that the particulate deposits on the drain collar exterior were mainly composed of O, Al, Na, Ca, Mg, C, and possibly Si. Unlike the exterior, the interior of the fiberglass samples at each location was relatively clean. Only flocculent and web-like deposits were observed. The web-like deposits were not present on Day-30 samples, which may be due to a change of the solution chemistry. There was no significant trend of the flocculent deposits with respect to either the location or time. The flocculent and web-like deposits were primarily composed of O, Na, Ca, Mg, Al, B, C, and possibly Si. These deposits were likely formed by chemical precipitation during dehydration of the samples after the samples were removed from the tank.

Results also show that the mesh material, i.e., stainless steel or nylon, did not significantly affect the deposits on the fiberglass. In addition, because of suspended particles settling out of the test solution, the Day-30 high-flow fiberglass (placed in front of a header on Day 6) sample exterior had much less particulate deposits attached/retained than did the high-flow samples put in the tank on Day 0.

3.3.1.1. Day-4 Low-Flow Fiberglass Samples

Since there was no significant water flowing through the fiberglass samples during the test, the migration of particulate deposits from the solution into the fiberglass interior was insignificant. ESEM results revealed some deposits on both the exterior and the interior of the low-flow fiberglass samples after 4 days of the test. These deposits were either formed like a webbing among glass fibers (see Figures 3-17 and 3-21) or flocculent (see Figure 3-19). The deposits are likely of chemical origin instead of being physically attached/retained. They may be formed during the drying process (semi-dehydrated) of the samples during ESEM analysis. EDS results indicated that both types of deposits were commonly composed of O, Na, Ca, Mg, Al, B, C, and possibly Si. Comparing the amount of the deposits on fiberglass revealed no significant difference between the interior and exterior samples. Again, this fact may be explained by the likely chemical origin of the deposits, since chemical precipitation would occur to a similar degree on both the exterior and the interior fiberglass samples if the concentrations were similar. Figures 3-16 through 3-22 show the Day-4 low-flow fiberglass results.

Figure 3-16. ESEM image magnified 100 times for a Test #5, Day-4 low-flow exterior fiberglass sample.

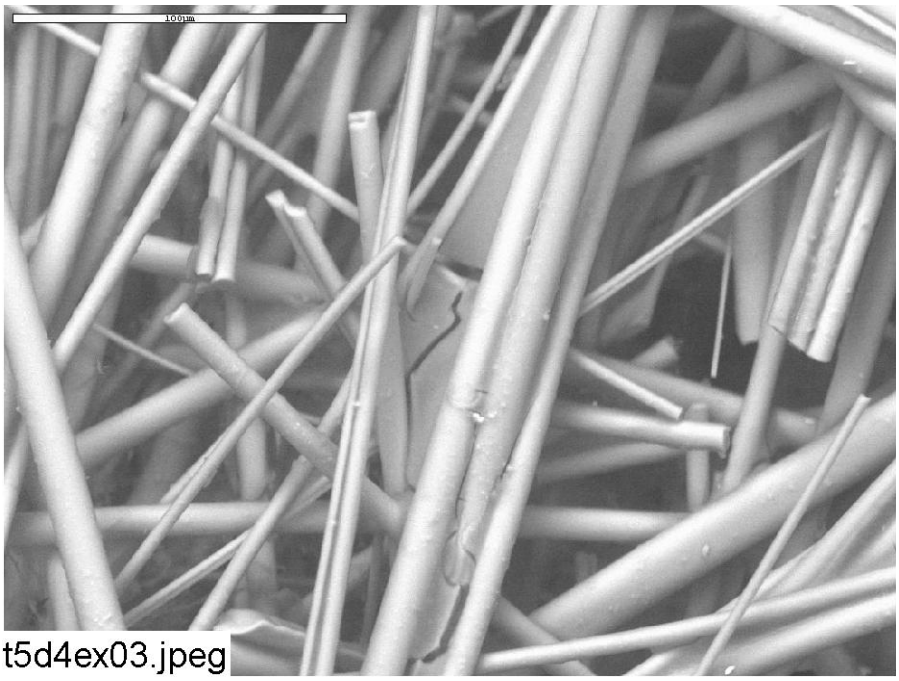

Figure 3-17. ESEM image magnified 500 times for a Test #5, Day-4 low-flow exterior fiberglass sample.

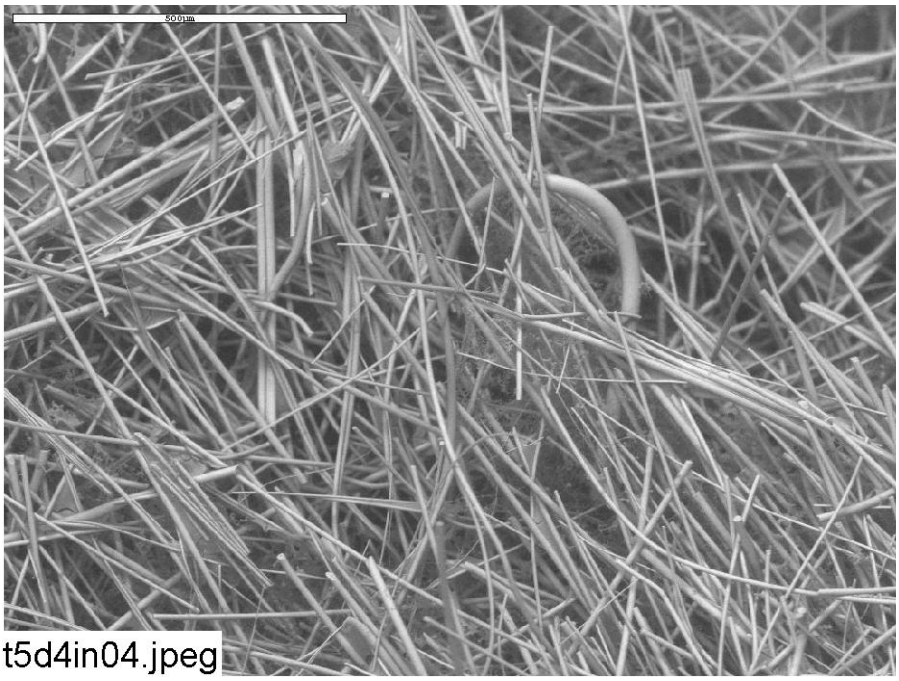

Figure 3-18. ESEM image magnified 100 times for a Test #5, Day-4 low-flow interior fiberglass sample.

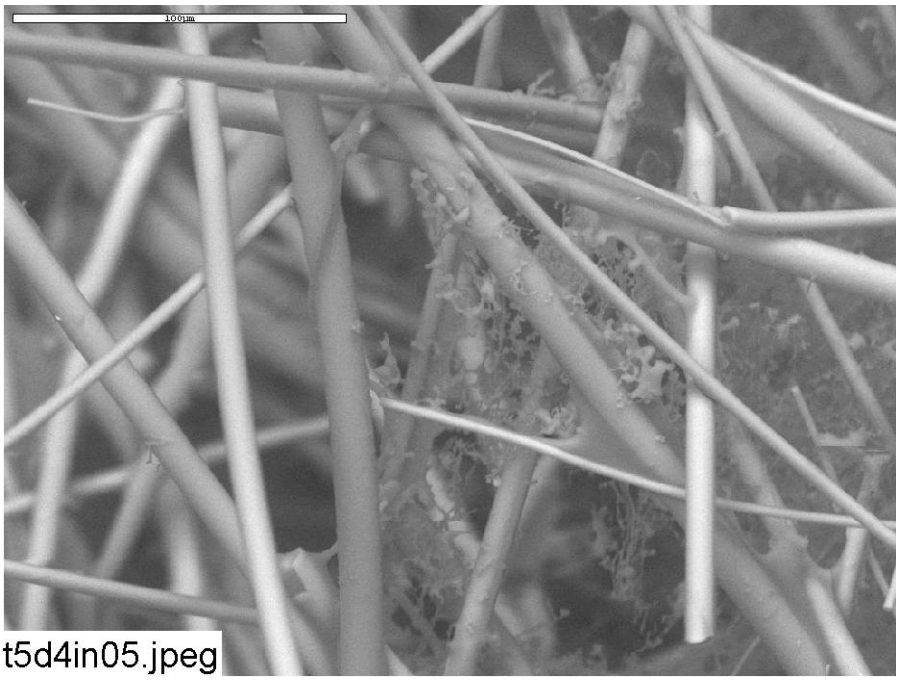

Figure 3-19. ESEM image magnified 500 times for a Test #5, Day-4 low-flow interior fiberglass sample.

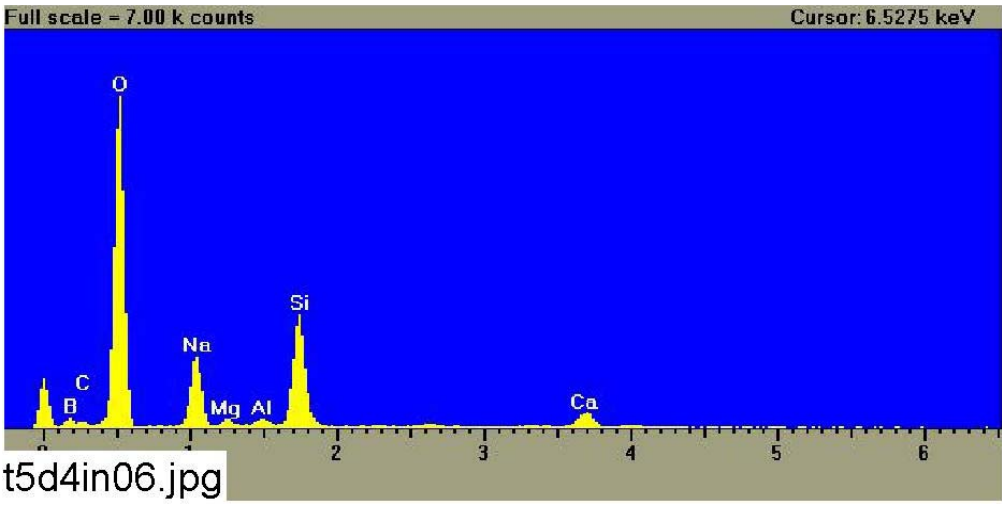

Figure 3-20. EDS counting spectrum for the flocculence between the fibers shown in Figure 3-19.

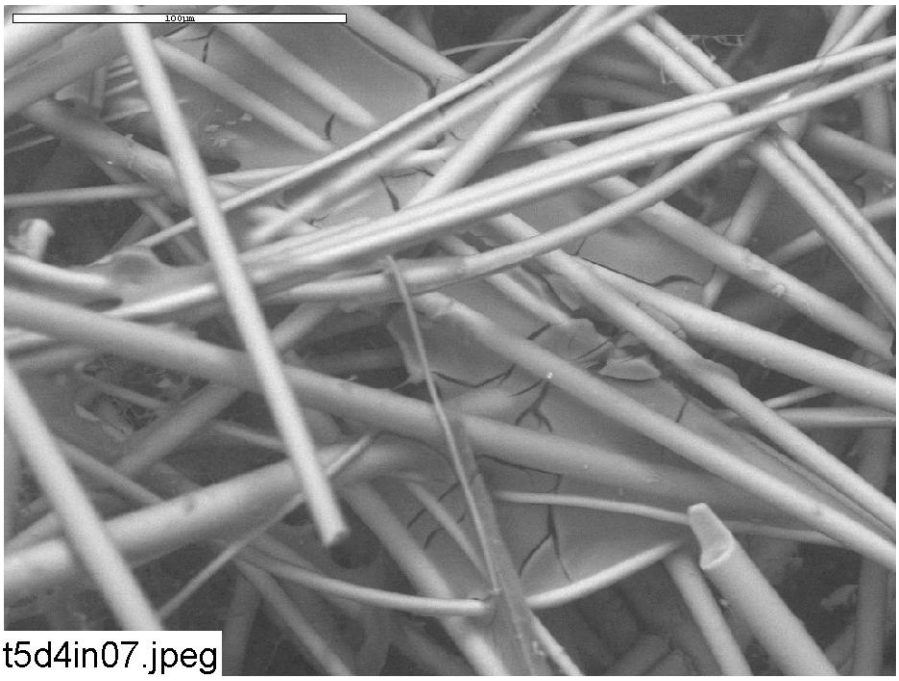

Figure 3-21. ESEM image magnified 500 times for a Test #5, Day-4 low-flow interior fiberglass sample.

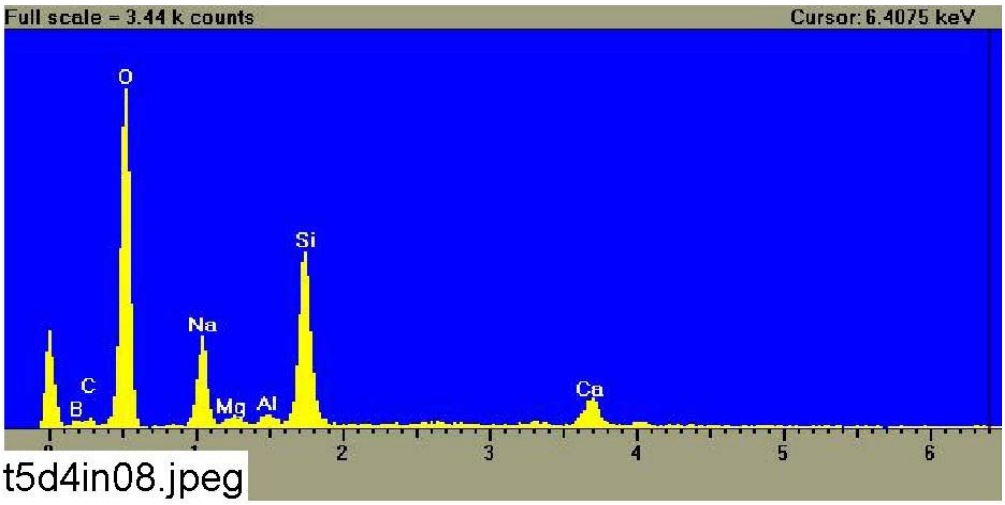

Figure 3-22. EDS counting spectrum for the web-like deposits between the fibers in Figure 3-21.

3.3.1.2. Day-15 Low-Flow Fiberglass Samples

Similar to the Day-4 samples, some flocculent and web-like deposits were found on the fiberglass exterior and interior of the Day-15 samples. EDS analyses showed that the deposits were mainly composed of O, Na, Ca, Mg, Al, B, C, and possibly Si. There was no significant increase in the amount of deposits on Day-15 samples compared with Day-4 samples. In addition, the difference in the amount of deposits on the exterior and the

interior Day-15 low-flow fiberglass samples was insignificant. Figures 3-23 through 3-28 show the Day-15 low-flow fiberglass results.

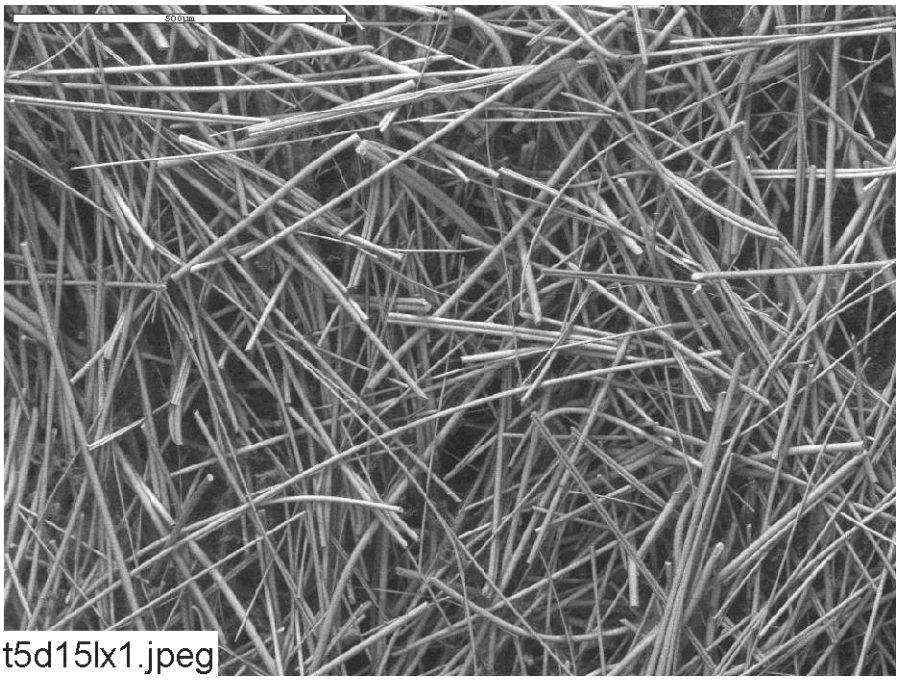

Figure 3-23. ESEM image magnified 100 times for a Test #5, Day-15 low-flow exterior fiberglass sample.

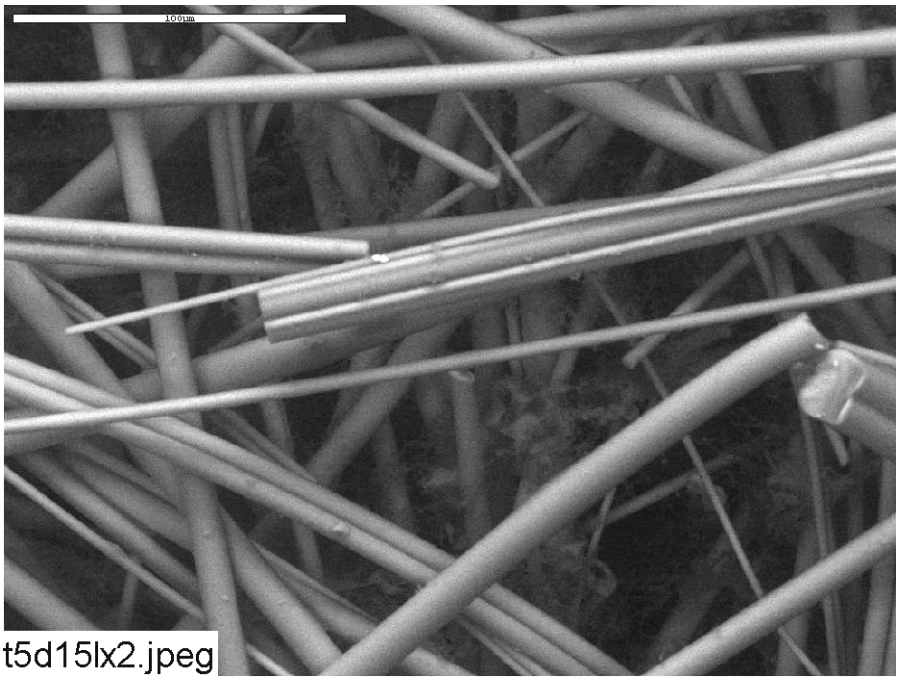

Figure 3-24. ESEM image magnified 500 times for a Test #5, Day-15 low-flow exterior fiberglass sample.

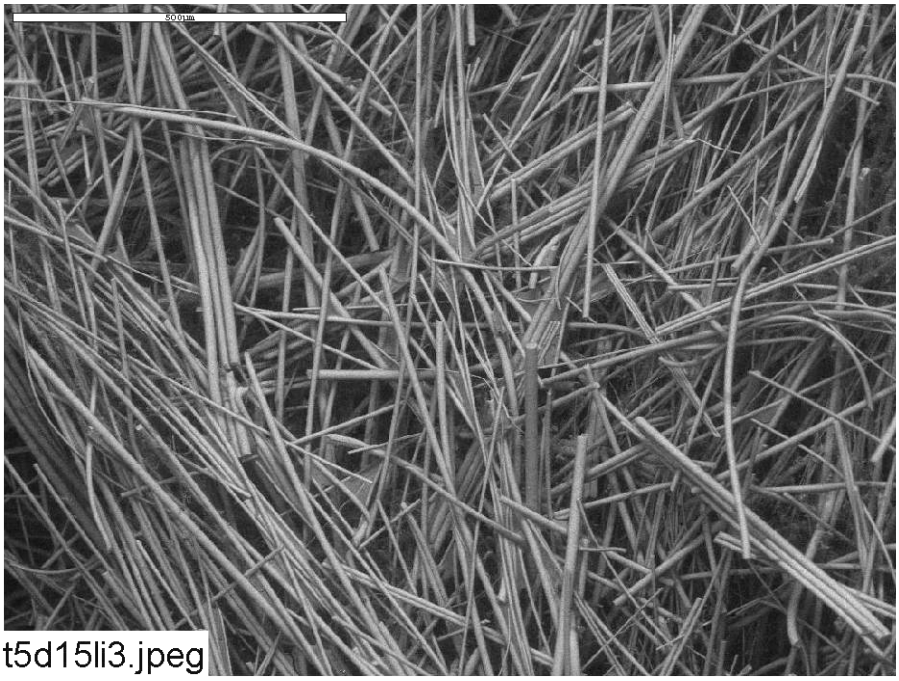

Figure 3-25. ESEM image magnified 100 times for a Test #5, Day-15 low-flow interior fiberglass sample.

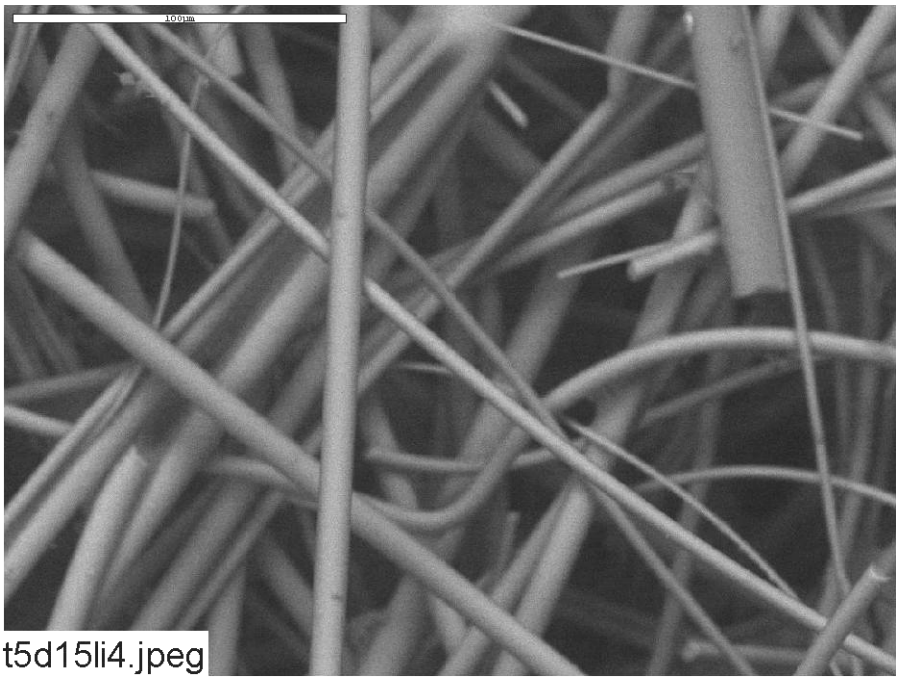

Figure 3-26. ESEM image magnified 500 times for a Test #5, Day-15 low-flow interior fiberglass sample.

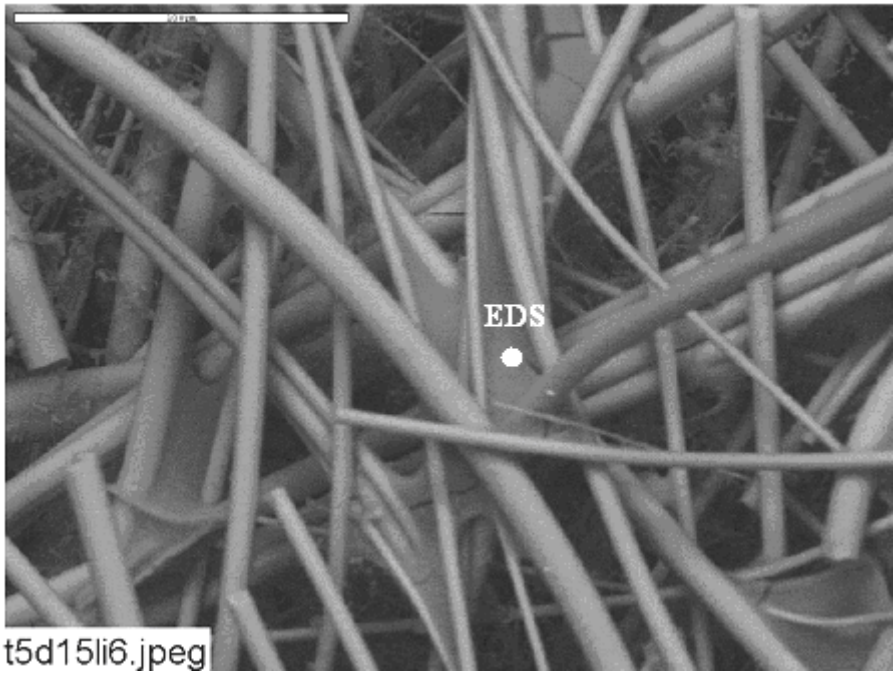

Figure 3-27. Annotated ESEM image magnified 500 times for a Test #5, Day-15 low-flow interior fiberglass sample.

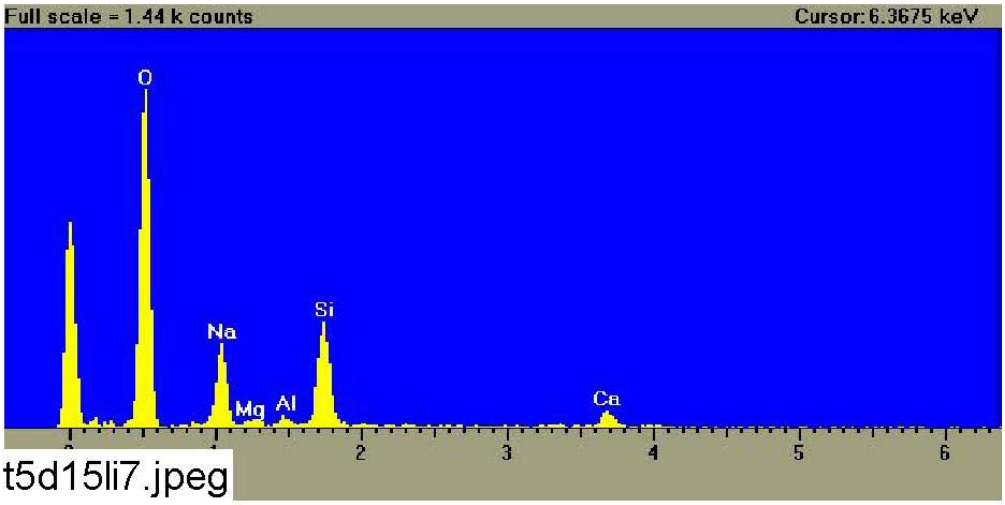

Figure 3-28. EDS counting spectrum for the web-like deposits between the fibers in Figure 3-27.

3.3.1.3. Day-15 High-Flow Fiberglass Samples

In contrast to the Day-15 low-flow samples, no web-like deposits were found in the Day-15 high-flow fiberglass samples. However, flocculent deposits were found on both the exterior and interior Day-15 high-flow fiberglass samples. There was no significant difference regarding the amount of the flocculent deposits between the exterior and the interior fiberglass samples, suggesting the deposits' likely chemical origin. The visual

appearance of the flocculent deposits was similar to other fiberglass samples, so no additional EDS was performed. In addition, no particulate deposits were observed on either the exterior or interior fiberglass samples. Figures 3-29 through 3-32 show the Day-15 high-flow fiberglass results.

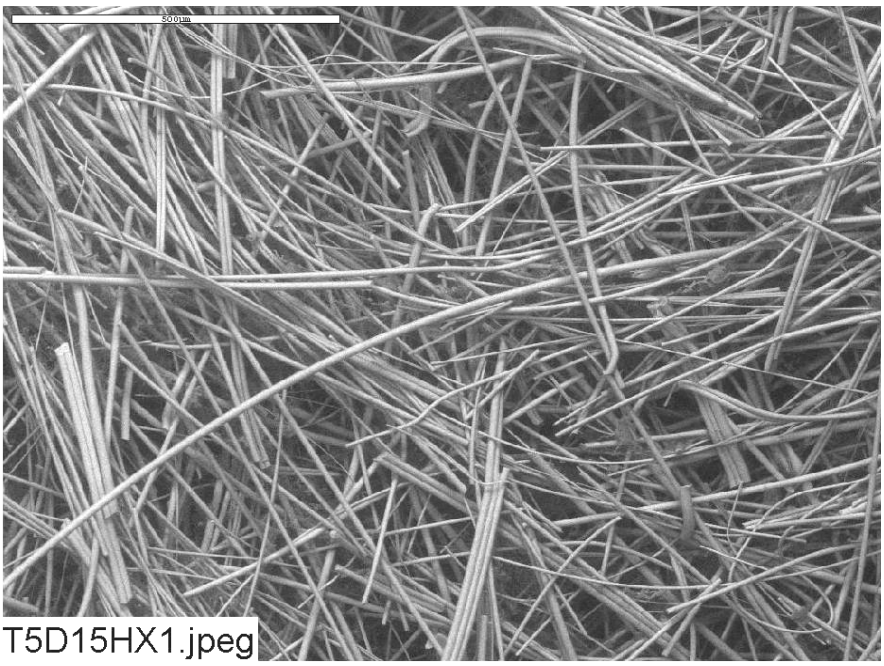

Figure 3-29. ESEM image magnified 100 times for a Test #5, Day-15 high-flow exterior fiberglass sample.

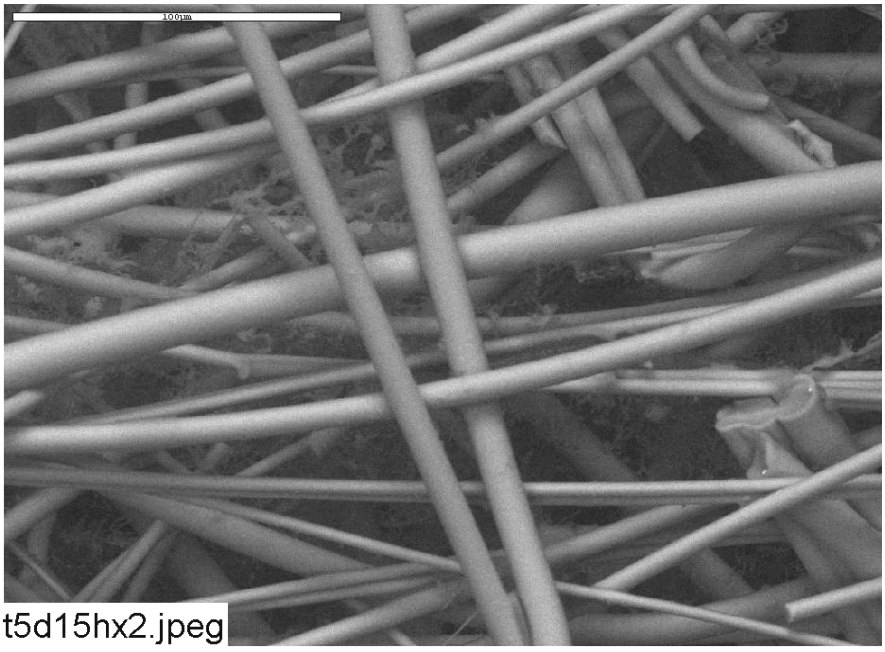

Figure 3-30. ESEM image magnified 500 times for a Test #5, Day-15 high-flow exterior fiberglass sample.

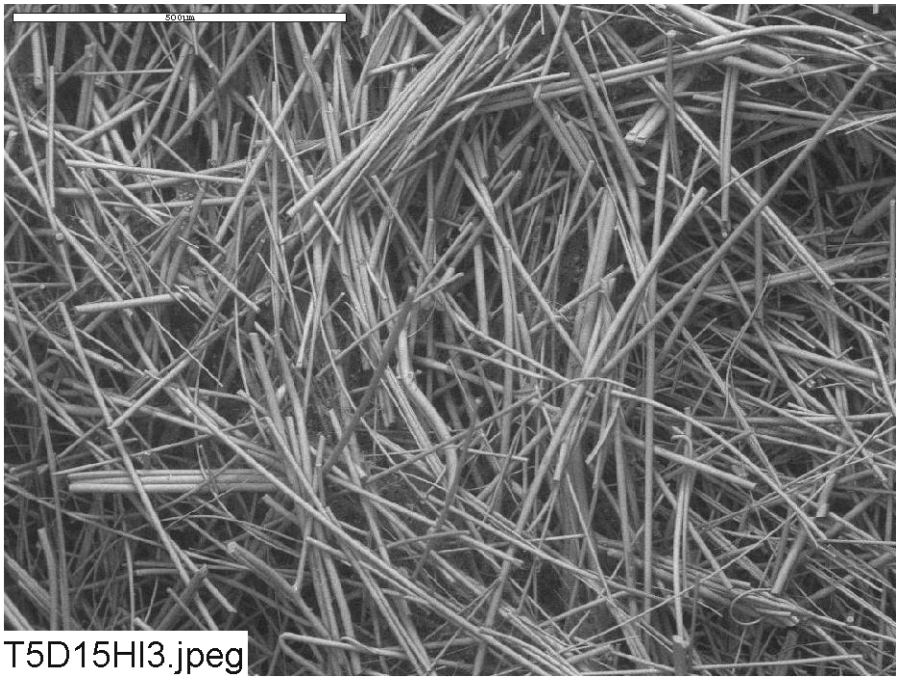

Figure 3-31. ESEM image magnified 100 times for a Test #5, Day-15 high-flow interior fiberglass sample.

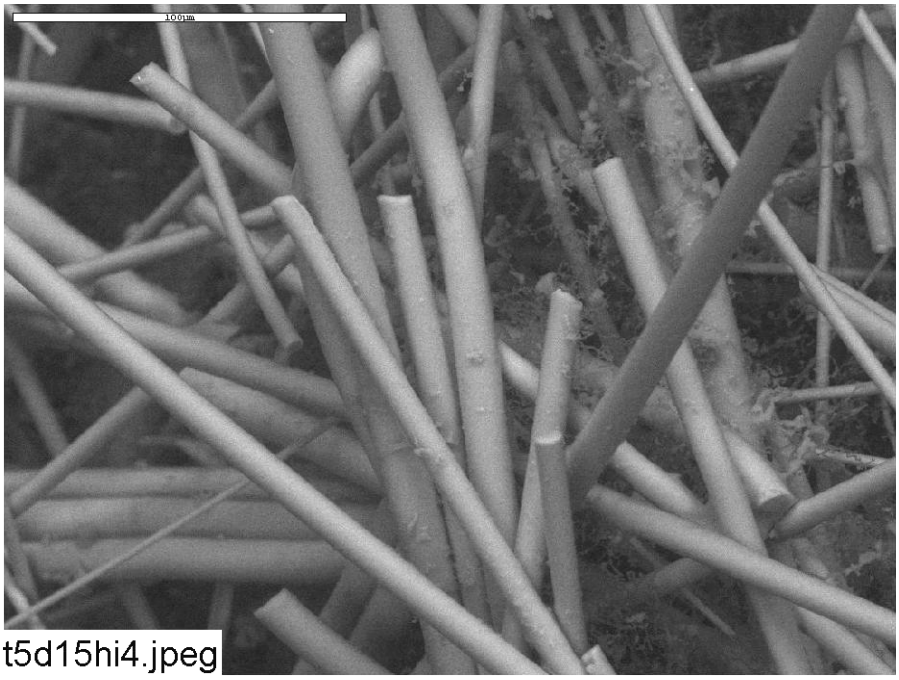

Figure 3-32. ESEM image magnified 500 times for a Test #5, Day-15 high-flow interior fiberglass sample.

3.3.1.4. Day-30 Low-Flow Fiberglass Samples

No observable increase in the flocculent deposits was found with the Day-30 low-flow fiberglass samples compared with Day-4 and Day-15 low-flow fiberglass samples. No significant difference was found regarding the amount of the flocculent deposits between the exterior and the interior of the Day-30 low-flow fiberglass samples. No web-like deposits were found on either the exterior or interior of the Day-30 low-flow fiberglass samples. Furthermore, no particulate deposits were observed on either the exterior or interior fiberglass samples. Figures 3-33 through 3-36 show the Day-30 low-flow fiberglass results.

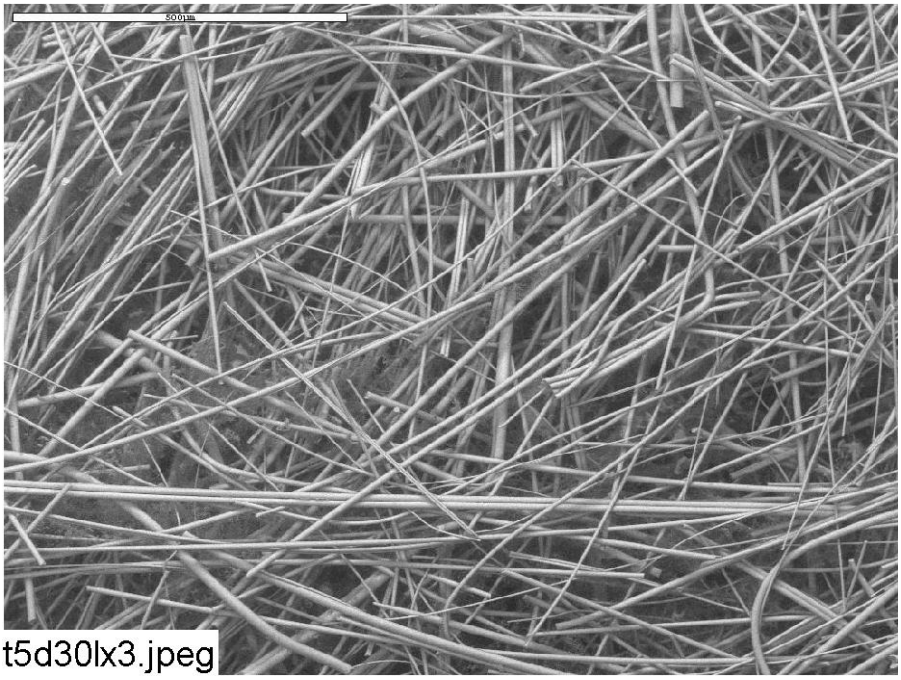

Figure 3-33. ESEM image magnified 100 times for a Test #5, Day-30 low-flow exterior fiberglass sample.

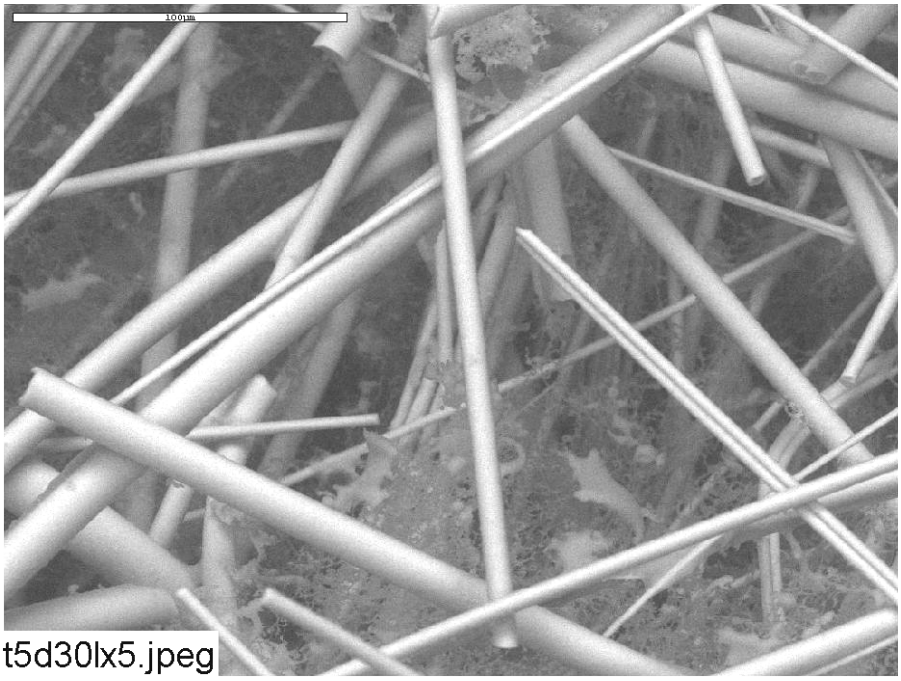

Figure 3-34. ESEM image magnified 500 times for a Test #5, Day-30 low-flow exterior fiberglass sample.

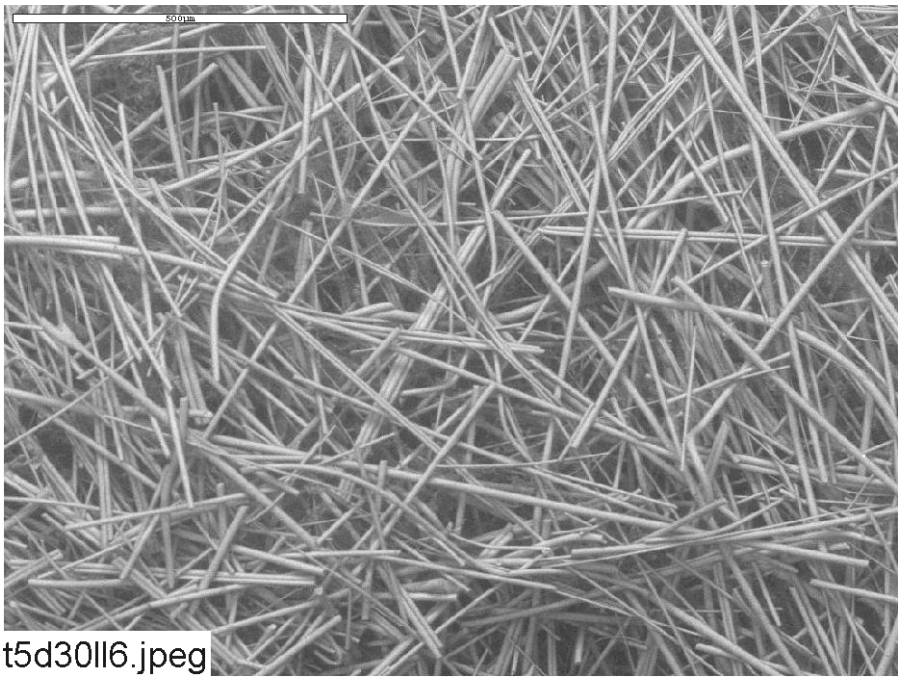

Figure 3-35. ESEM image magnified 100 times for a Test #5, Day-30 low-flow interior fiberglass sample.

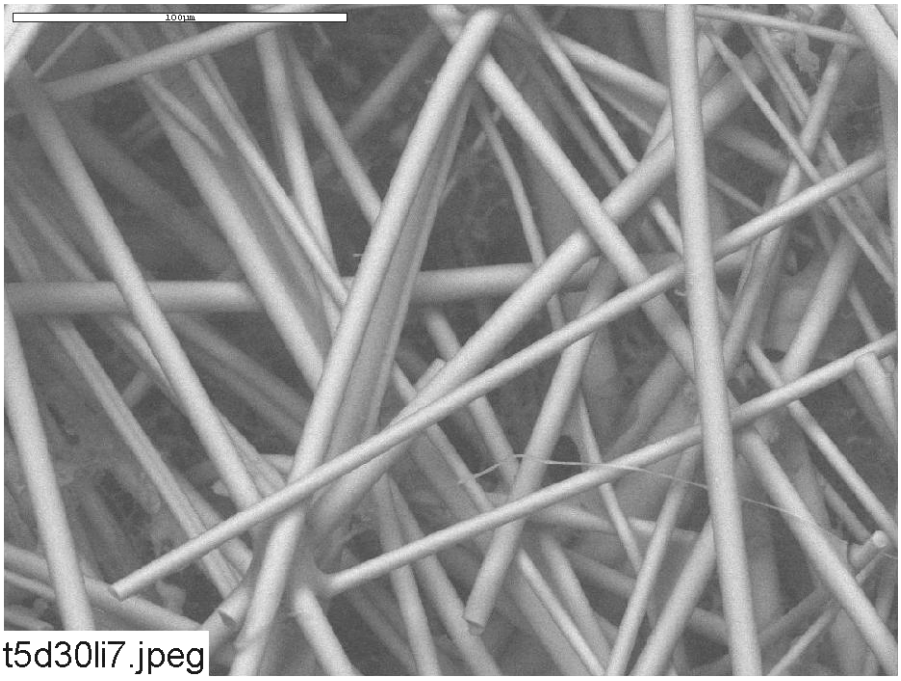

Figure 3-36. ESEM image magnified 500 times for a Test #5, Day-30 low-flow interior fiberglass sample.

3.3.1.5. Day-30 Low-Flow Fiberglass Samples in the Big Envelope

The big envelope was located on the tank bottom, contacting the test sediment on the bottom of the tank. In contrast to Day-4, Day-15, and other Day-30 low-flow fiberglass samples, a small amount of particulate deposits were observed on the fiberglass exterior of the Day-30 low-flow samples in the big envelope. EDS results show that the particulate deposits (see Figure 3-39) were composed of O, Na, Ca, Mg, Al, and possibly Si. However, no particulate deposits were observed on the fiberglass interior. Instead, flocculent deposits were found on the fiberglass interior, as they were with other interior fiberglass samples. Figures 3-37 through 3-41 illustrate these deposits for the Day-30 low-flow fiberglass in the big envelope.

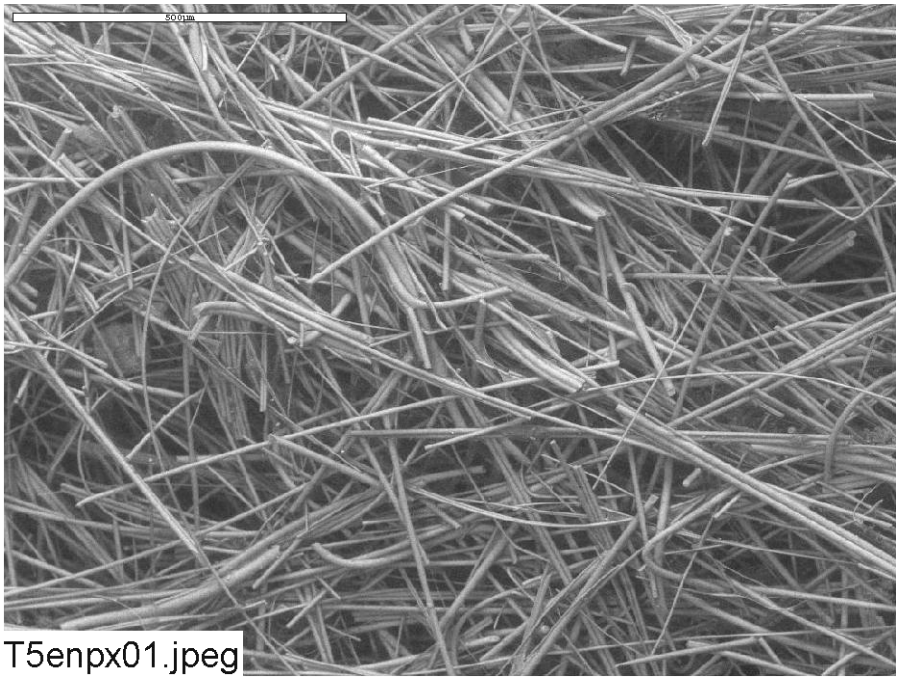

Figure 3-37. ESEM image magnified 100 times for a Test #5, Day-30 low-flow exterior fiberglass sample in a big envelope.

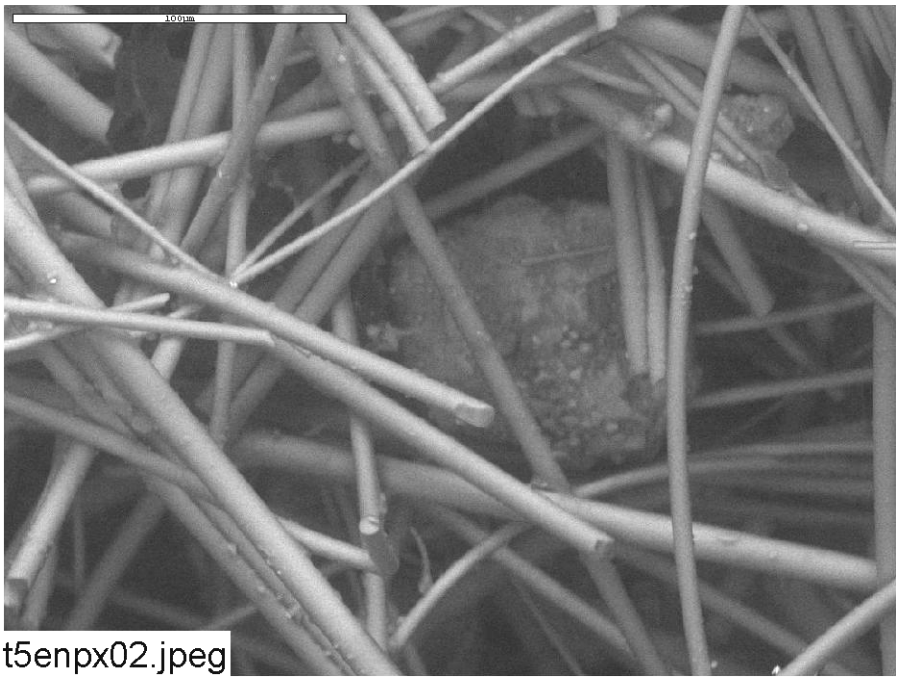

Figure 3-38. ESEM image magnified 500 times for a Test #5, Day-30 low-flow exterior fiberglass sample in a big envelope.

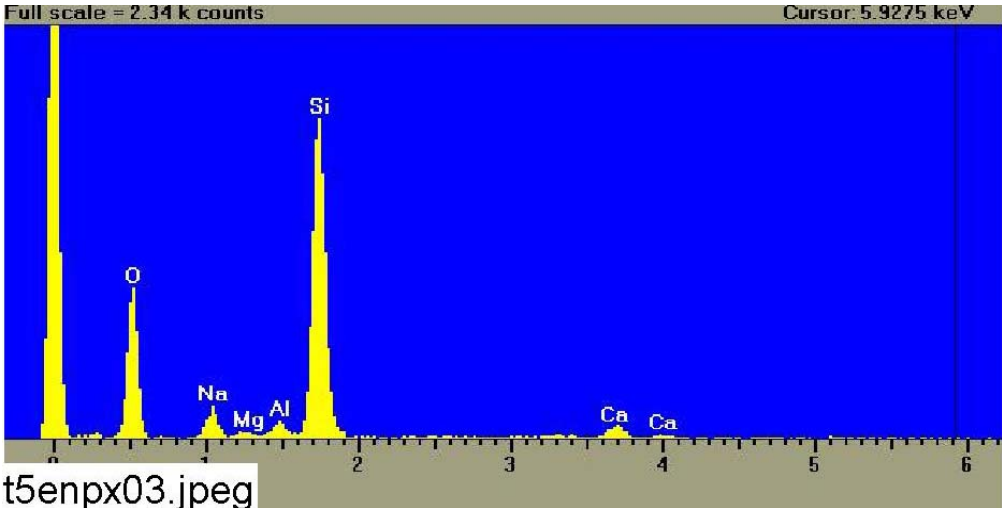

Figure 3-39. EDS counting spectrum for the particulate deposit between the fibers in Figure 3-38.

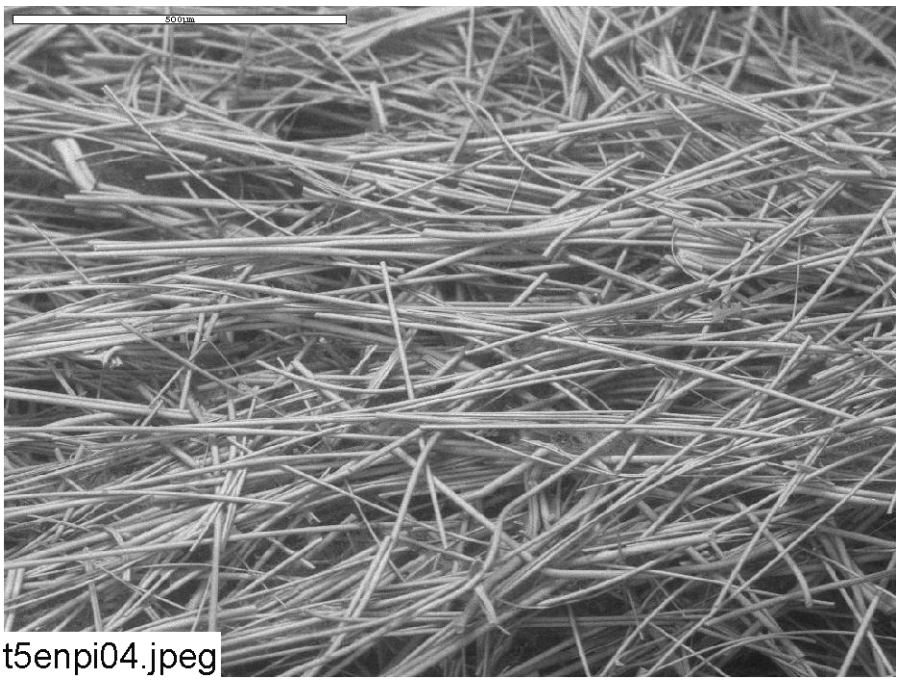

Figure 3-40. ESEM image magnified 100 times for a Test #5, Day-30 low-flow interior fiberglass sample in a big envelope.

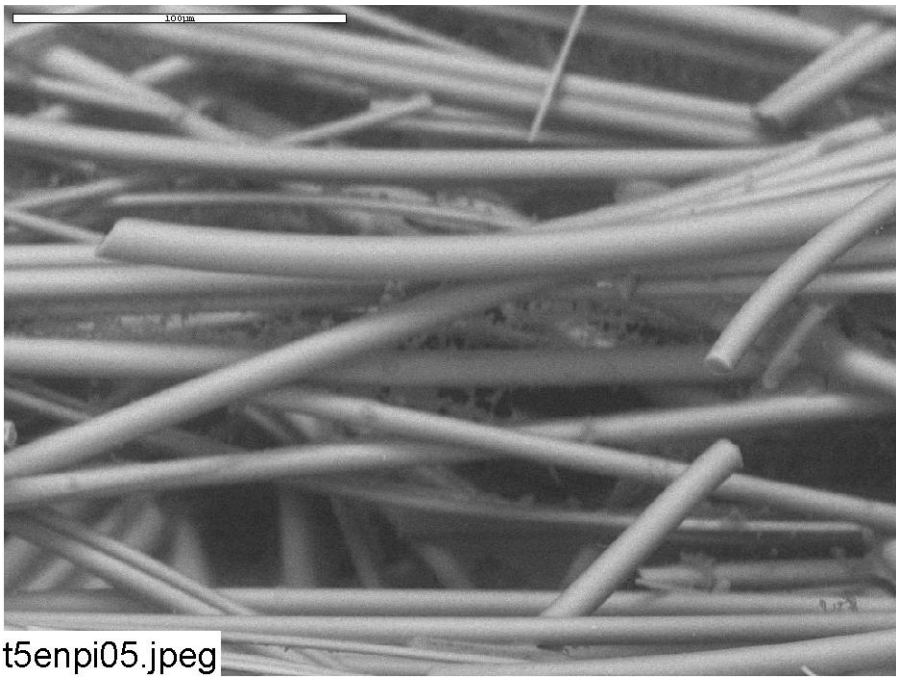

Figure 3-41. ESEM image magnified 500 times for a Test #5, Day-30 low-flow interior fiberglass sample in a big envelope.

3.3.1.6. Day-30 High-Flow Fiberglass Samples

Compared with the Day-30 low-flow fiberglass samples, no significant amount of particulate deposits was found on high-flow exterior samples. In addition, consistent with the findings for other fiberglass interior samples, no particulate deposits were found on the interior. However, similar flocculent deposits were found on both the fiberglass exterior and interior. Figures 3-42 through 3-45 show the Day-30 high-flow fiberglass results.

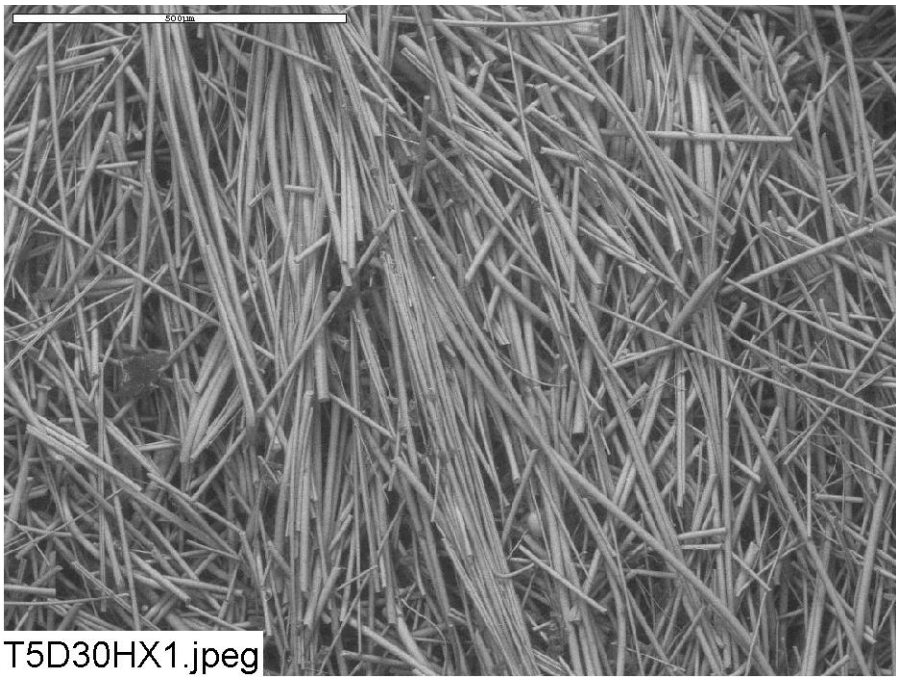

Figure 3-42. ESEM image magnified 100 times for a Test #5, Day-30 high-flow exterior fiberglass sample.

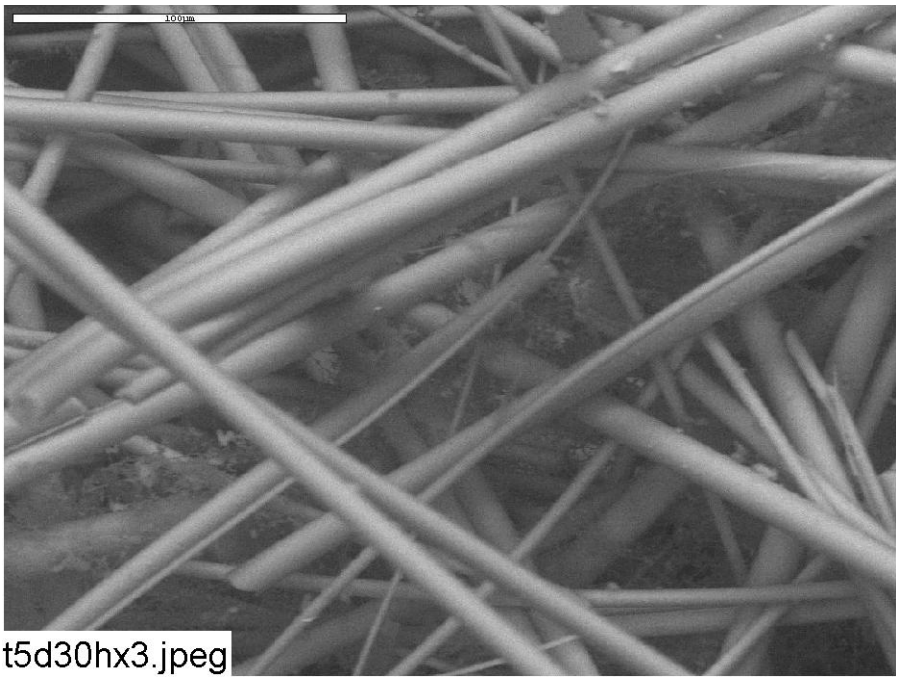

Figure 3-43. ESEM image magnified 500 times for a Test #5, Day-30 high-flow exterior fiberglass sample.

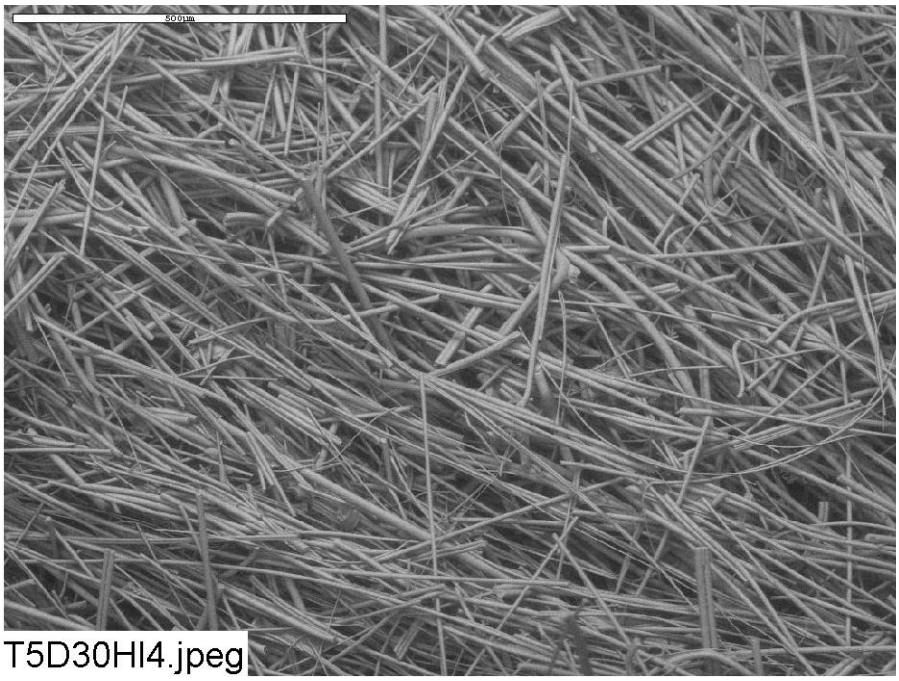

Figure 3-44. ESEM image magnified 100 times for a Test #5, Day-30 high-flow interior fiberglass sample.

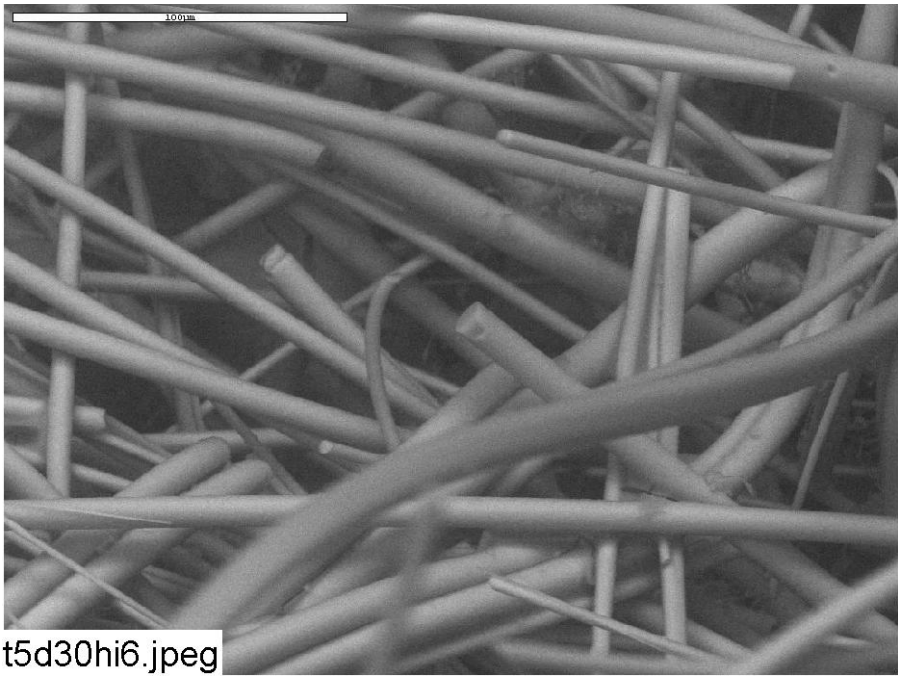

Figure 3-45. ESEM image magnified 500 times for a Test #5, Day-30 high-flow interior fiberglass sample.

3.3.1.7. Day-30 High-Flow Fiberglass Samples in Front of a Header

The fiberglass sample in front of a header was different from the conventional high-flow fiberglass samples discussed in Subsections 3.3.1.3 and 3.3.1.6; the header sample was put in the tank on Day 6. By placing the sample in the tank on Day 6, turbidity and TSS would be much less than on Day 0, and deposits on the sample would be from the tank solution over the last 3 weeks of the test. Due to the settling of suspended particles and the decrease in turbidity during the first several days of the test, no significant particulate deposits were found on the header fiberglass exterior, as shown by ESEM images. However, flocculent deposits were found on both the exterior and the interior of the header samples. This result suggests again that the flocculent deposits were likely caused by chemical precipitation and may have formed when the samples were partially dehydrated. Figures 3-46 through 3-49 show the results from the Day-30 high-flow fiberglass in front of a header.

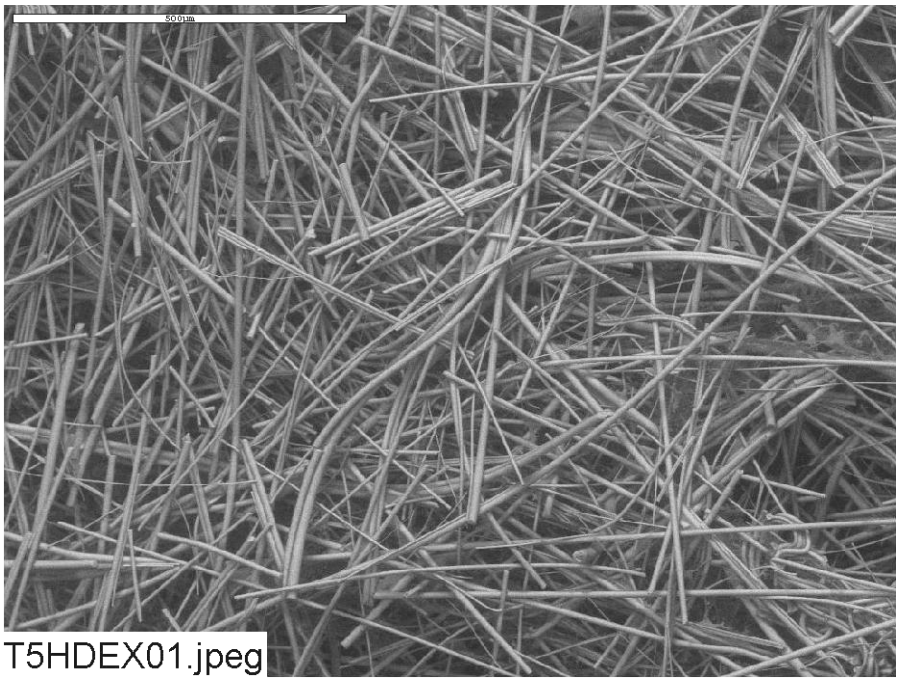

Figure 3-46. ESEM image magnified 100 times for a Test #5, Day-30 high-flow exterior fiberglass sample in front of the header.

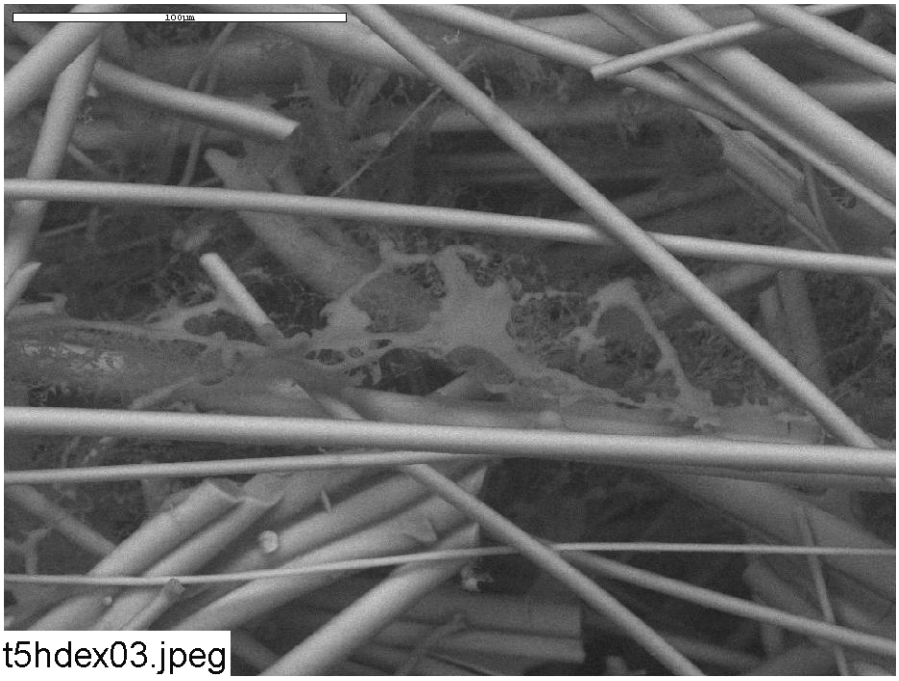

Figure 3-47. ESEM image magnified 500 times for a Test #5, Day-30 high-flow exterior fiberglass sample in front of the header.

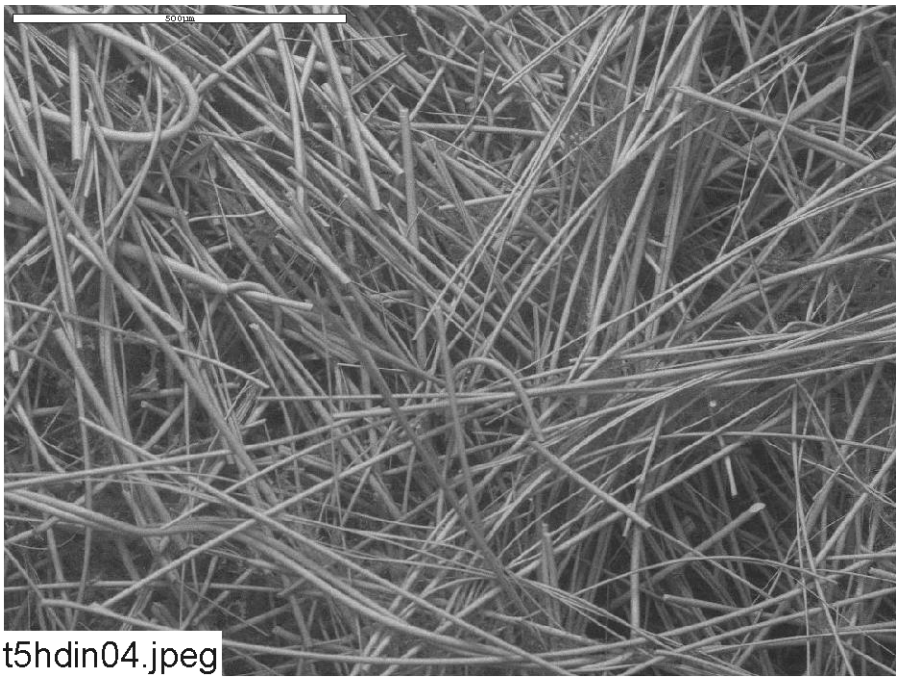

Figure 3-48. ESEM image magnified 100 times for a Test #5, Day-30 high-flow interior fiberglass sample in front of the header.

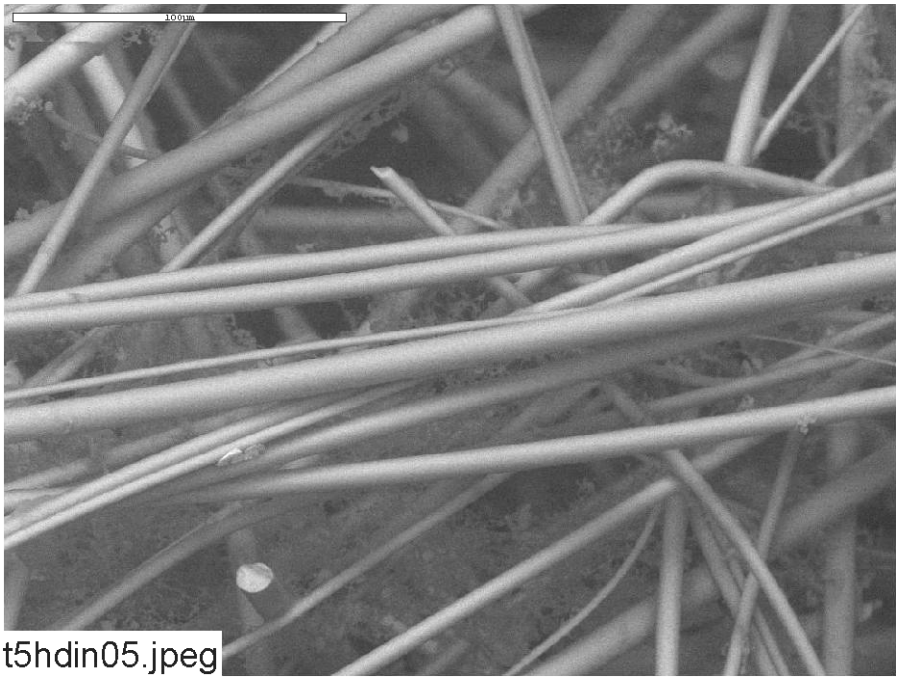

Figure 3-49. ESEM image magnified 500 times for a Test #5, Day-30 high-flow interior fiberglass sample in front of the header.

3.3.1.8. Day-30 Low-Flow Fiberglass Samples in Nylon Mesh

A 5-g fiberglass sample was enclosed in nylon mesh and submerged in a low-flow zone of the tank on Day 6. This sample provided a comparison with all other fiberglass samples, which were enclosed in stainless steel mesh. The purpose of using a nylon mesh was to see if the mesh material (i.e., stainless steel or nylon) affects the deposits on the fiberglass samples. Comparing the sample in nylon mesh with Day-30 low-flow fiberglass samples contained in stainless steel mesh revealed no significant difference. Flocculent deposits were still the dominant deposit on both the exterior and interior samples. No particulate deposits were found on fiberglass. This result suggests that the mesh material did not significantly affect the deposits on fiberglass. Even though the nylon mesh sample was put in the tank on Day 6, no significant difference was observed between these samples and the low-flow fiberglass samples in the stainless steel mesh put into the tank on Day 0. This result is likely due to the low turbidity and low debris concentration in the test solution. Figures 3-50 through 3-54 show the Day-30 low-flow fiberglass in nylon mesh results.

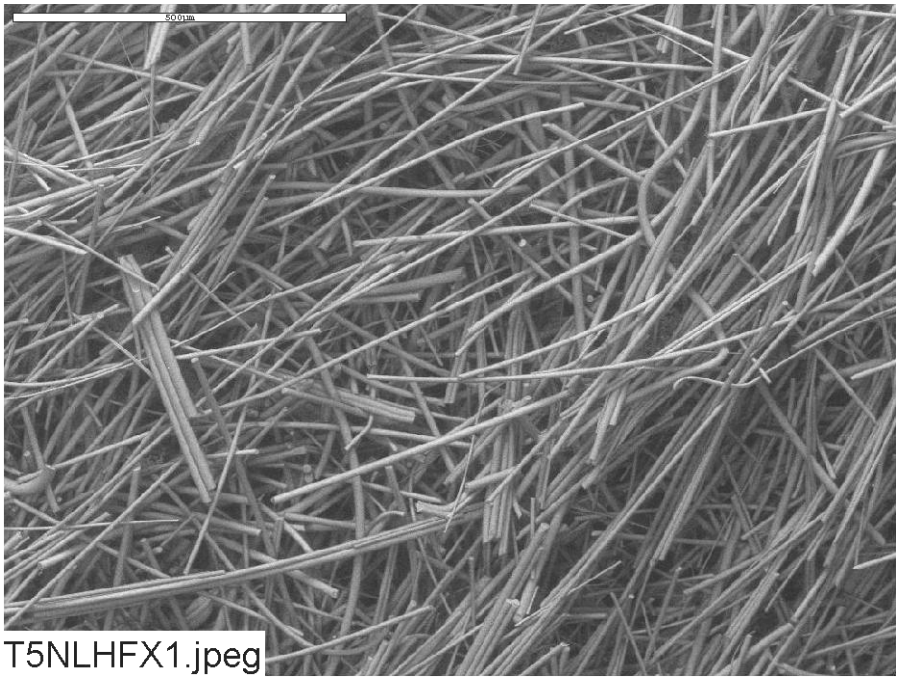

Figure 3-50. ESEM image magnified 100 times for a Test #5, Day-30 low-flow exterior fiberglass sample in a nylon mesh.

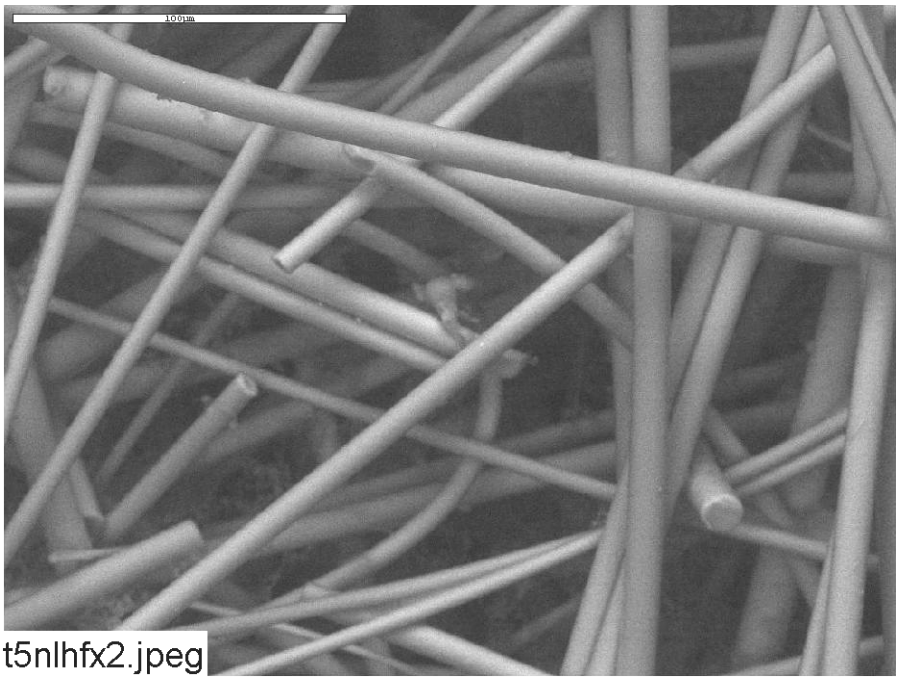

Figure 3-51. ESEM image magnified 500 times for a Test #5, Day-30 low-flow exterior fiberglass sample in a nylon mesh.

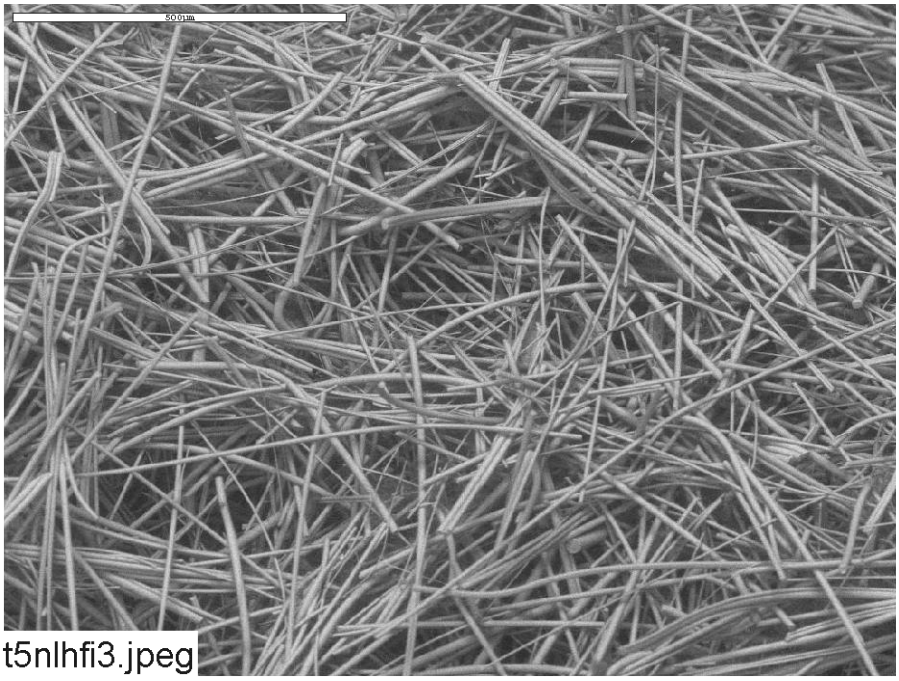

Figure 3-52. ESEM image magnified 100 times for a Test #5, Day-30 low-flow interior fiberglass sample in a nylon mesh.

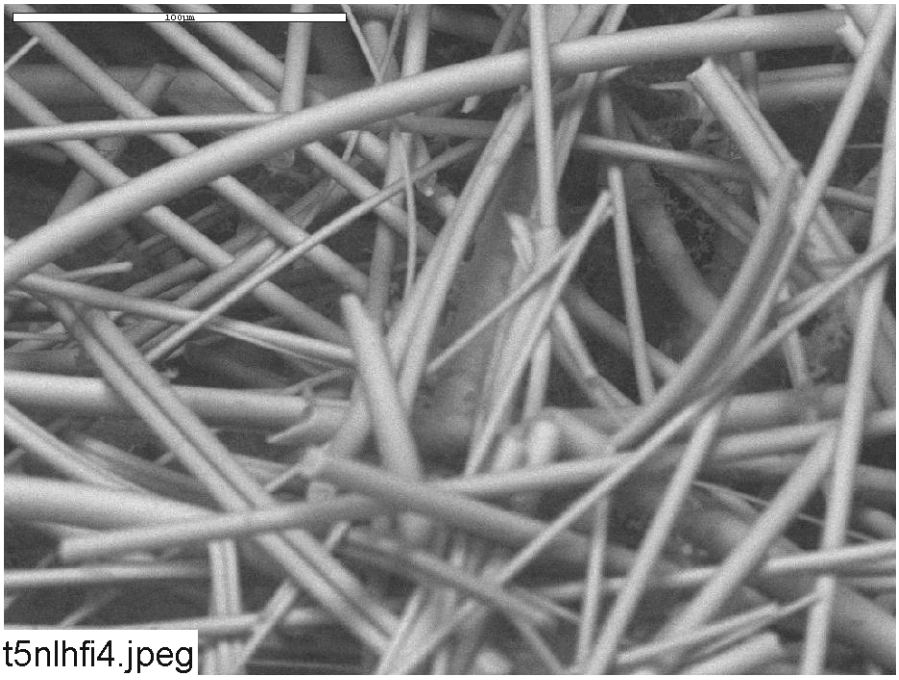

Figure 3-53. ESEM image magnified 500 times for a Test #5, Day-30 low-flow interior fiberglass sample in a nylon mesh.

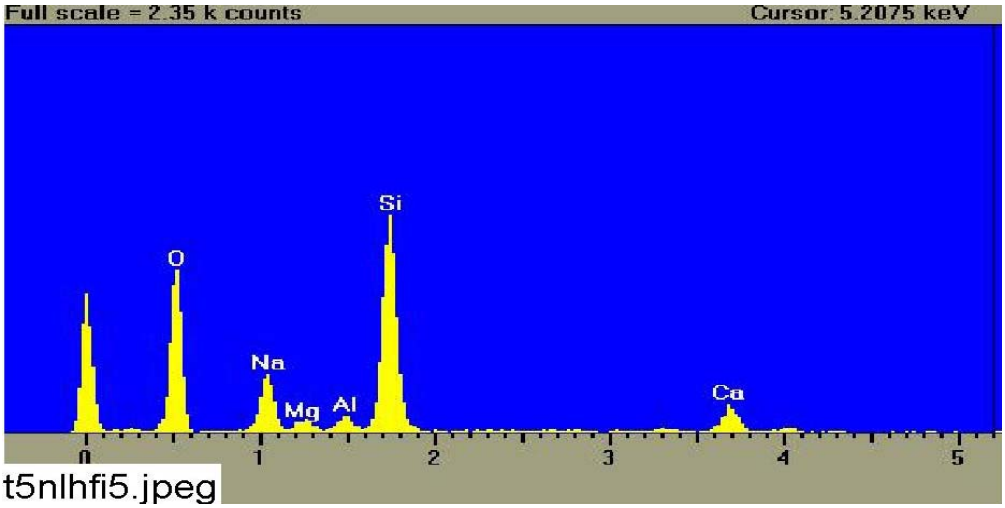

Figure 3-54. EDS counting spectrum for the deposits between the fibers shown in Figure 3-53.

3.3.1.9. Day-30 Drain Collar Fiberglass Samples

Figure 3-94 shows the drain collar after it was removed from the tank. Both the exterior fiberglass sample that was farthest from the drain screen and the exterior sample that was next to the drain screen have significant amounts of particulate deposits. The amount of deposits on the drain collar exterior was much greater than on the high- and low-flow fiberglass samples. However, the exterior farthest from the drain screen had the most particulate deposits. ESEM results show that the development of a continuous coating on the drain collar exterior farthest from the drain screen, which includes particulate deposits that were likely physically retained or attached. EDS results indicate that the particulate deposits were composed mainly of O, Al, Na, Ca, Mg, C, and possibly Si, for both the drain collar exterior farthest from the drain screen and the exterior next to the drain screen. In addition to the particulate deposits, deposits rich in carbon were also found on the exterior farthest from the drain screen (see Figure 3-57). In contrast to the exterior, no significant particulate deposits were found in the drain collar interior sample, and only flocculent deposits were found (see image Figure 3-64). The drain collar interior is as clean as other high- or low-flow fiberglass interior samples. This result suggests that almost all of the particulate deposits were physically retained at the fiberglass exterior. Figures 3-55 through 3-64 show the drain collar fiberglass results.

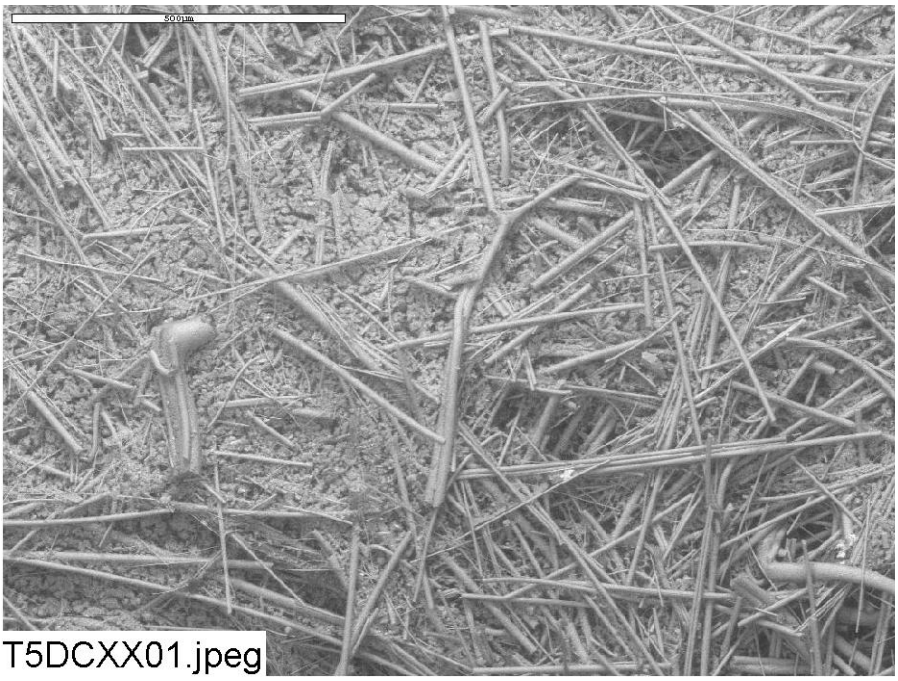

Figure 3-55. ESEM image magnified 100 times for a Test #5, Day-30 exterior drain collar fiberglass sample farthest from the drain screen.

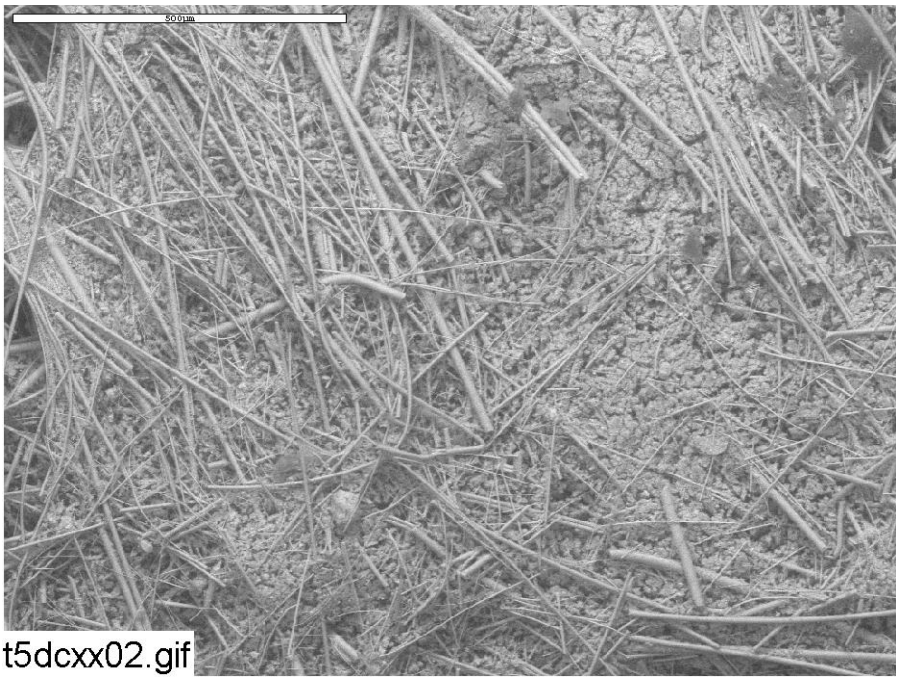

Figure 3-56. ESEM image magnified 100 times for a Test #5, Day-30 exterior drain collar fiberglass sample farthest from the drain screen.

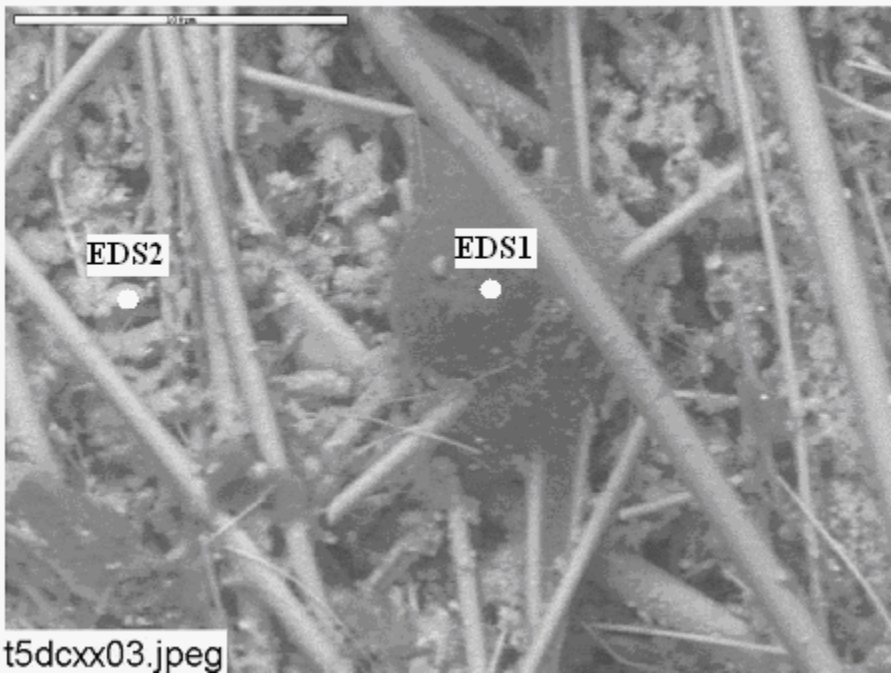

Figure 3-57. Annotated ESEM image magnified 500 times for a Test #5, Day-30 exterior drain collar fiberglass sample farthest from the drain screen.

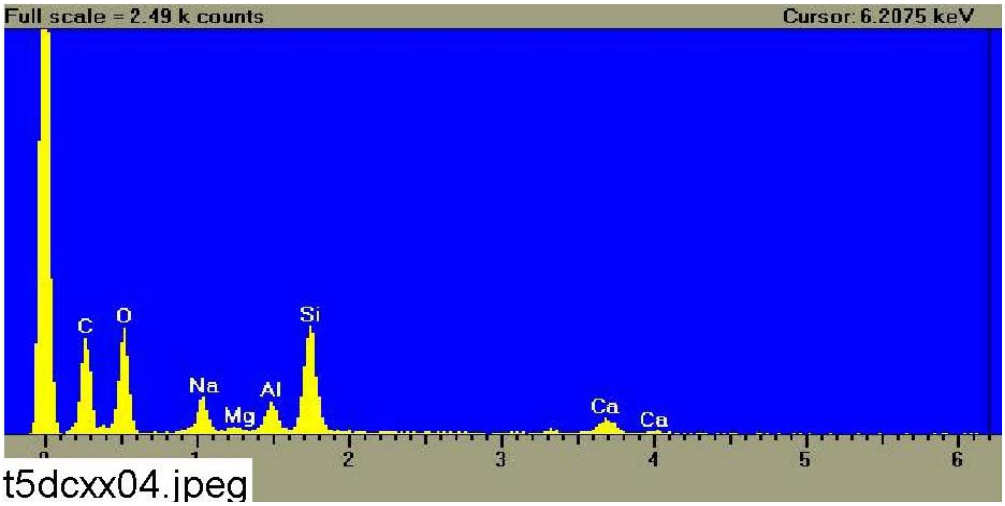

Figure 3-58. EDS counting spectrum for the large mass of particulate deposits (EDS1) on fiberglass shown in Figure 3-57.

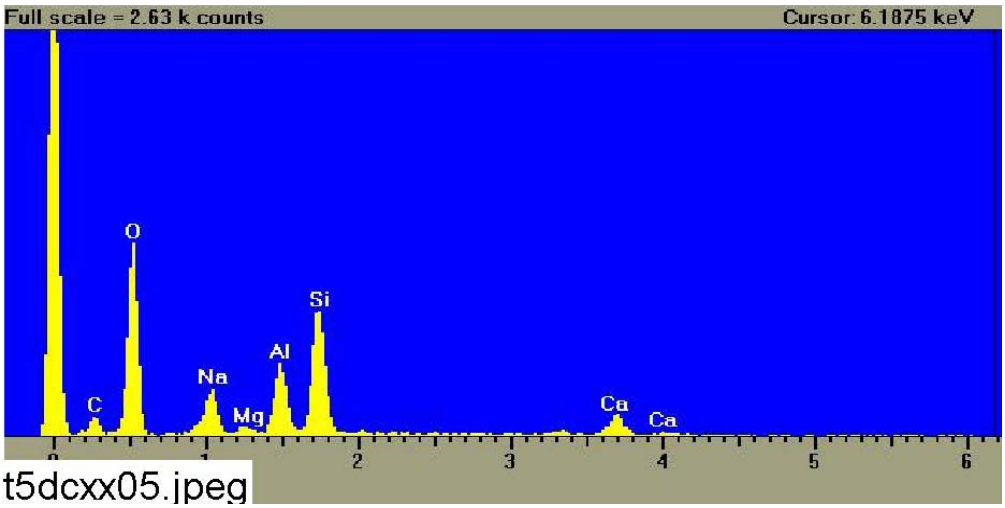

Figure 3-59. EDS counting spectrum for the small particulate deposits (EDS2) between fibers shown in Figure 3-57.

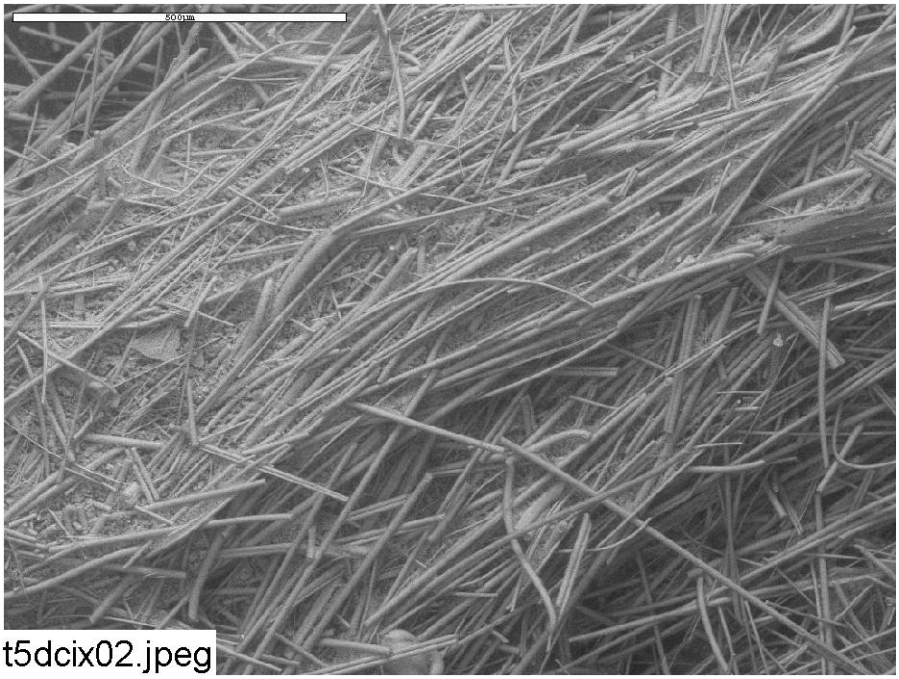

Figure 3-60. ESEM image magnified 100 times for a Test #5, Day-30 exterior drain collar fiberglass sample next to the drain screen.

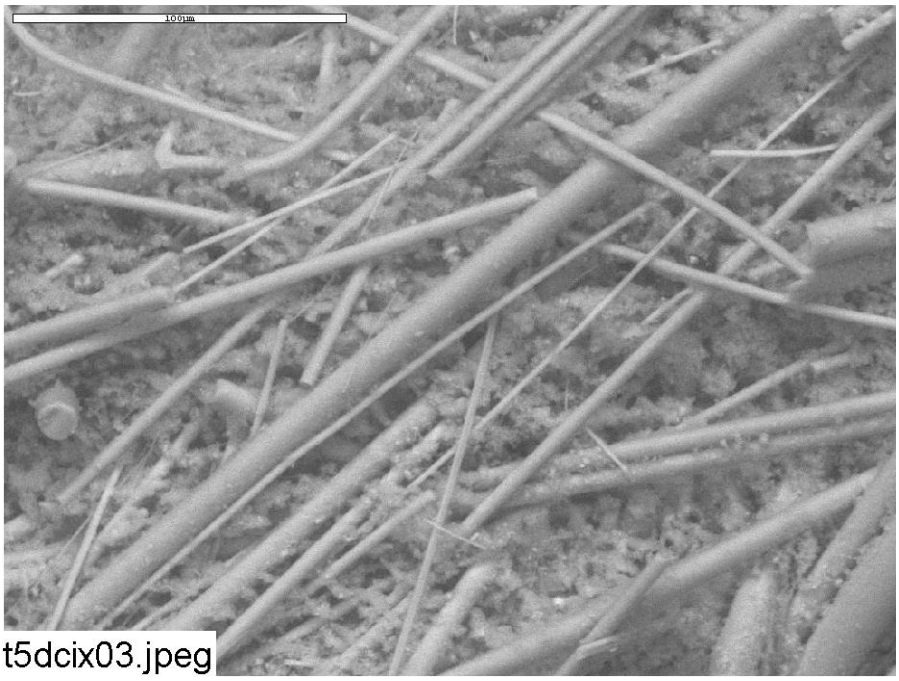

Figure 3-61. ESEM image magnified 500 times for a Test #5, Day-30 exterior drain collar fiberglass sample next to the drain screen.

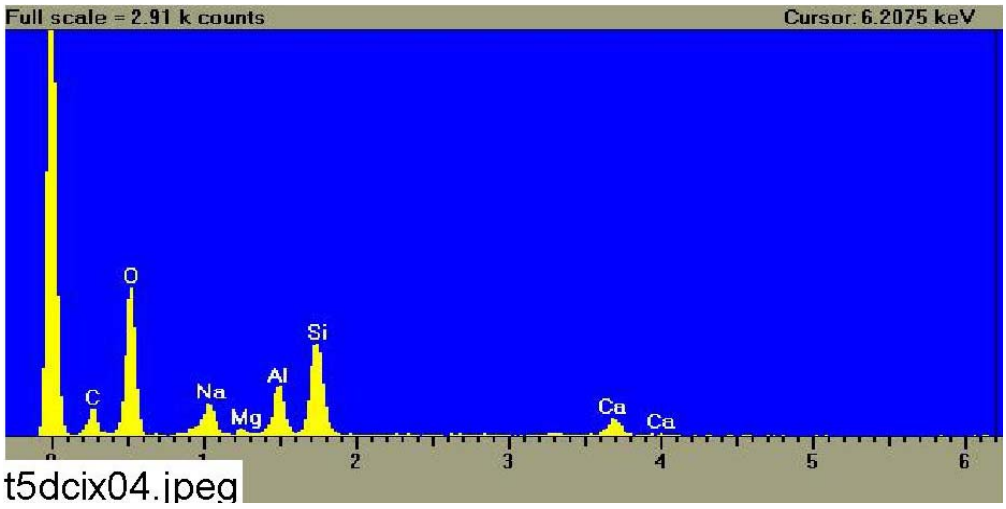

Figure 3-62. EDS counting spectrum for the particulate deposits between fibers in Figure 3-61.

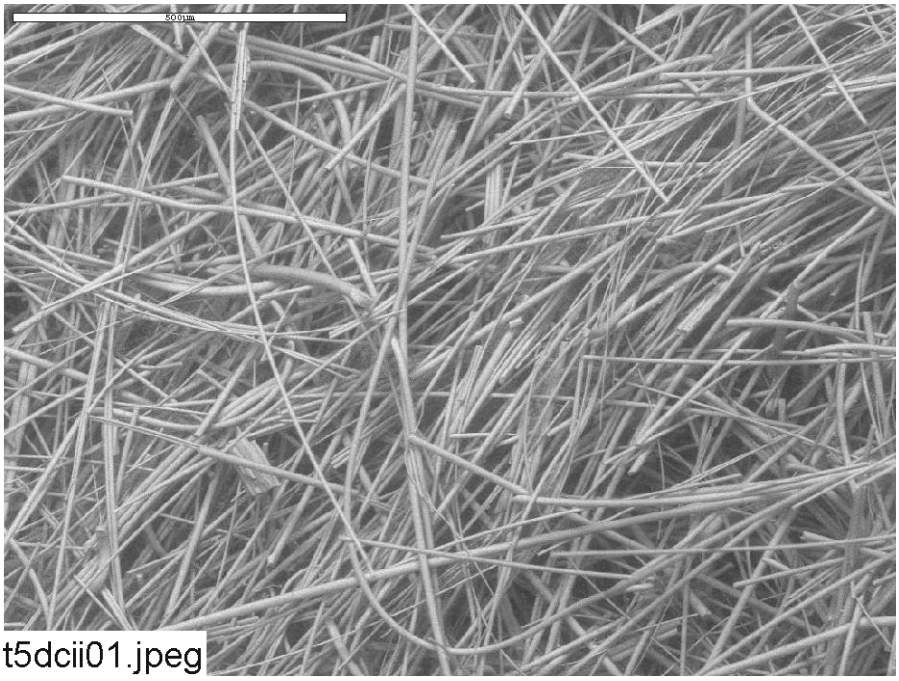

Figure 3-63. ESEM image magnified 100 times for a Test #5, Day-30 interior drain collar fiberglass sample.

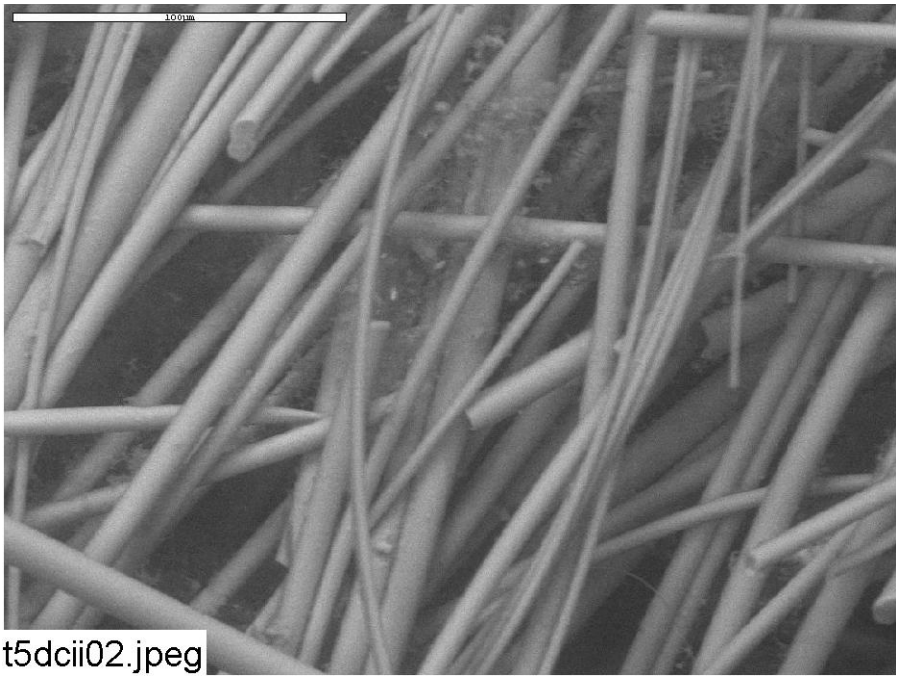

Figure 3-64. ESEM image magnified 500 times for a Test #5, Day-30 interior drain collar fiberglass sample.

3.3.1.10. Day-30 Fiberglass Sample within the Birdcage

For the Day-30 fiberglass sample within the birdcage, the SEM images indicate that a small amount of particulate deposit (see Figure 3-65) was on the exterior of the fiberglass. The amount of particulate deposits was slightly greater than on high- and low-flow fiberglass samples but much less than on the drain collar exterior. The EDS result shows that the particulate deposits were composed of O, Na, Ca, Zn, Al, Mg, and possibly Si. The presence of Zn is inconsistent with the drain collar exterior. Compared with other fiberglass interior samples, the interior birdcage sample was relatively clean. Only flocculent deposits were found. These flocculent deposits were similar to those observed on the high- and low-flow fiberglass samples, which was likely caused by chemical precipitation during the drying process. Again, this result suggests that almost all of the particulate deposits were physically retained at the fiberglass exterior, consistent with findings for the Day-30 high-flow and drain collar fiberglass samples. Figures 3-65 through 3-70 show the birdcage fiberglass results.

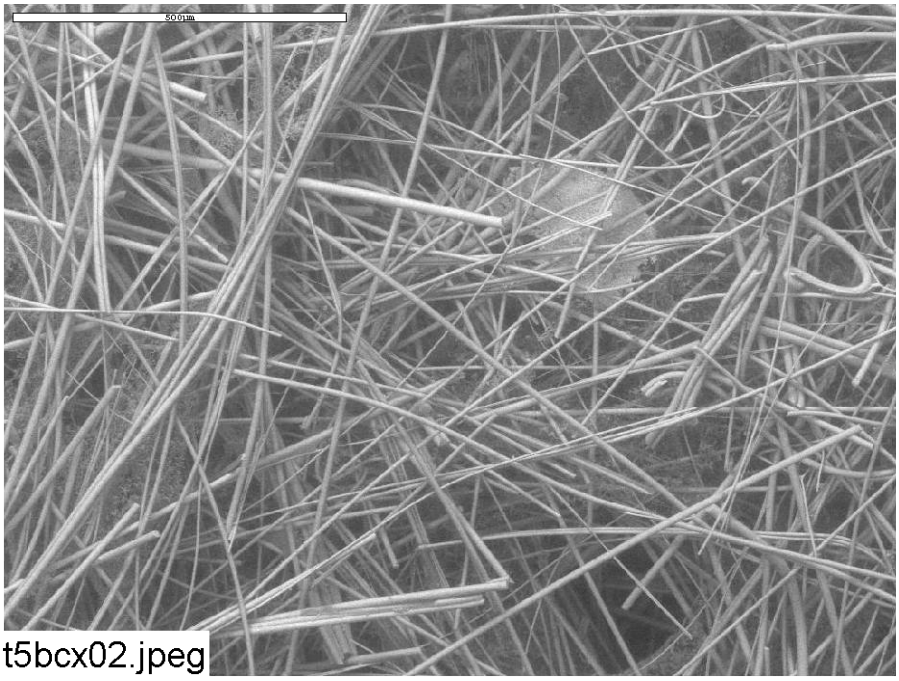

Figure 3-65. ESEM image magnified 100 times for a Test #5, Day-30 exterior fiberglass sample in the bird cage.

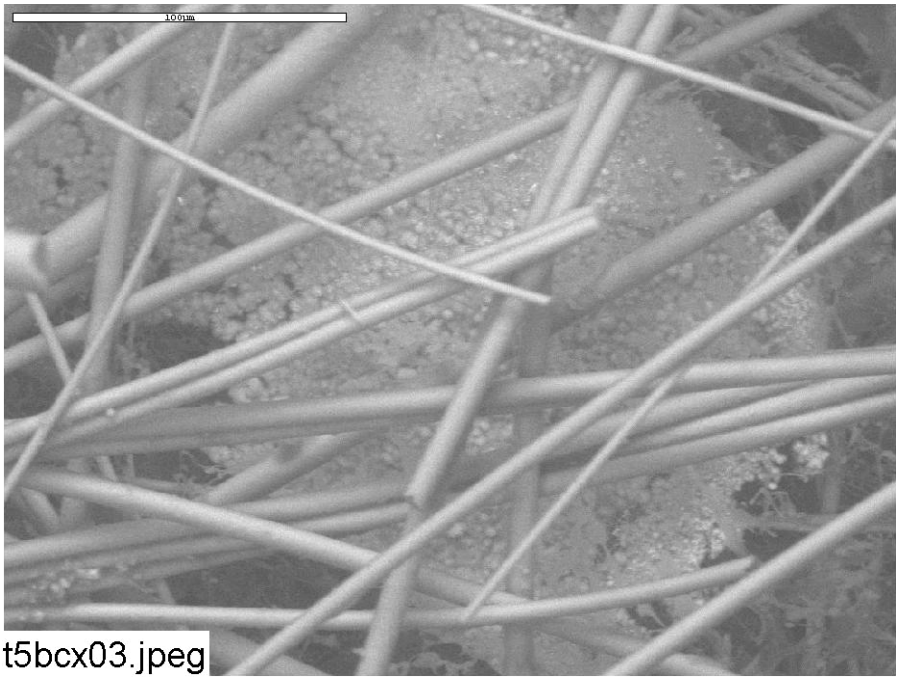

Figure 3-66. ESEM image magnified 500 times for a Test #5, Day-30 exterior fiberglass sample in the birdcage.

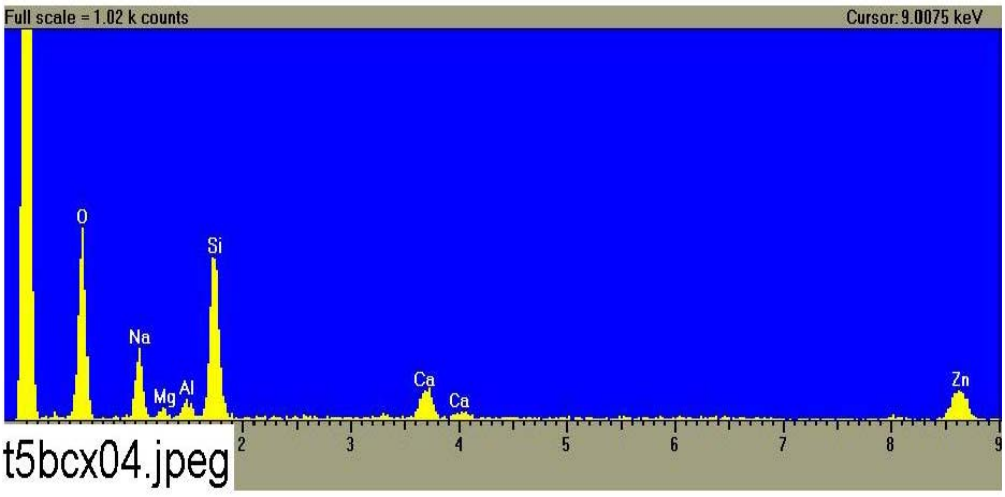

Figure 3-67. EDS counting spectrum for the deposits between fibers shown in Figure 3-66.

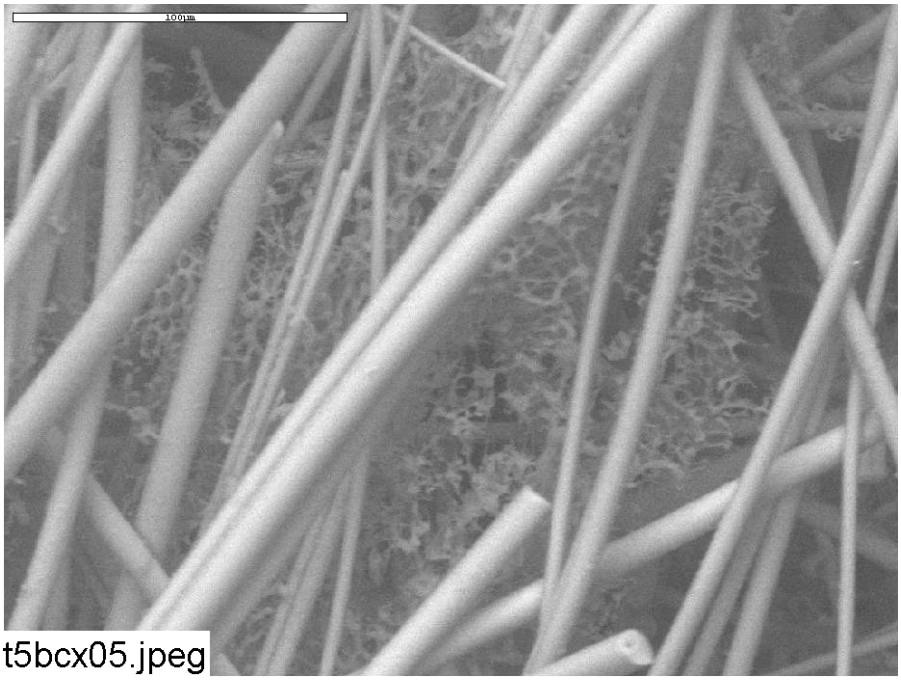

Figure 3-68. ESEM image magnified 500 times for a Test #5, Day-30 exterior fiberglass sample in the birdcage.

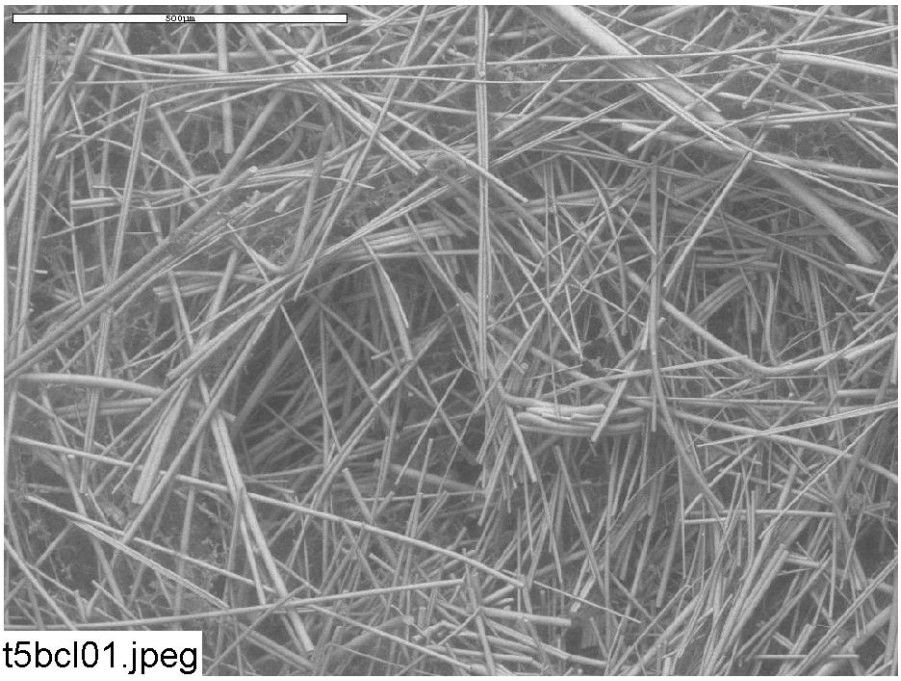

Figure 3-69. ESEM image magnified 100 times for a Test #5, Day-30 interior fiberglass sample in the birdcage.