

of the wipes are presented in Figure 3. The wipes were found to lose mass during the 500-h evaluation, which likely indicates that the wipe was being abraded by the coatings. Mass gain was observed during the 1,000- and 1,500-h UV/condensation exposure evaluations. The mass of the coating removed was significantly greater for the samples exposed to UV and condensation compared to the samples that were only exposed to UV. This indicates that the presence of moisture is involved in chalking. The results of the repetition of the 1,500-h UV/condensation exposure were consistent with the initial 1,500-h exposure.

Infrared Analysis of the Residue

The residue collected on the laboratory wipes after 1,500 h UV/condensation exposure was analyzed by infrared (IR) spectroscopy. The residue was extracted with methylene chloride (CH_2Cl_2). The extracted solution was allowed to dry. Potassium bromide (KBr) powder was then added to the solvent residue that included the removed residue and ground to a fine powder. The powder was then pressed into a pellet for analysis.

The IR analysis revealed that there was epoxy residue in the chalk removed from the samples (Figure 4). The intensities of the epoxy bands were in the range of 0.5 to 2% of the transmission scale, which indicates it was present in a low quantity. Crystalline silica was observed as evidenced by the band near $1,100 \text{ cm}^{-1}$ along with the epoxy resin.

Discussion

The field study of pipe stored for several years in the U.S. mid-Atlantic found an average DFT loss of roughly $15 \mu\text{m}/\text{y}$. This is consistent with results of field studies of pipe stored for seven to nine years in Alberta, Canada and Arkansas, United States published in two recent papers by researchers from TC Energy.^{8,9} They reported essentially no DFT loss for the pipe stored in Alberta, while the pipes stored in Arkansas showed DFT losses of $25 \mu\text{m}/\text{y}$.

The mass of chalk removed by the wipes from the laboratory FBE samples exposed to 1,500 h of cyclic UV and condensation was $\sim 0.1 \text{ mg}/\text{cm}^2$, which is equivalent to $4 \mu\text{m}/\text{y}$ assuming a FBE density of $1.4 \text{ g}/\text{cm}^3$. But further examination of the 500- and 1,000-h results suggest that calculation of average loss is misleading because the rate of DFT loss does not appear to be linear. Furthermore, the amount of chalk removed by the wipe is not a direct measurement of DFT loss because some fraction of the coating could have chalked and been washed away during the condensation cycle during exposure.

The chalk mass removed by the wipe was much greater for the exposure that combined the UV and condensation cycles compared to the UV exposure alone. The role of the condensation evidently extends beyond washing the chalk from the surface because the results reflect the chalking that remained on the surface.

The presence of the epoxy resin in the chalk from the lab wipe is not understood. It is not believed to be due to abrasive action of the wipe because the results of the 500-h exposure showed that it was the wipe that was being abraded, not the FBE. It could be that the UV exposure is breaking down the bonds to the extent that the epoxy functional groups are still recognizable.

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