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Deep Generative Modeling of Infrared Images Provides Signatures of Aging and Cracking in Cross-Linked Polyethylene Pipe

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Hyperspectral infrared (IR) images contain a large amount of spatially resolved information about the chemical composition of a sample. However, the analysis of hyperspectral IR imaging data for complex heterogeneous systems can be challenging because of the spectroscopic and spatial complexity of the data. We implement a deep generative modeling approach using a β-variational autoencoder to learn disentangled representations of the generative factors of variance in our large data set of IR spectra collected on crosslinked polyethylene (PEX-a) pipe. We identify three distinct factors of aging and degradation learned by the model and apply the trained model to high-resolution hyperspectral IR images of cross-sectional slices of unused virgin, used in-service, and cracked PEX-a pipe. By mapping the learned representations of aging and degradation to the IR images, we extract detailed information on the physical and chemical changes that occur during aging, degradation, and cracking in PEX-a pipe. This study shows how representation learning by deep generative modeling can significantly enhance the analysis of high-resolution IR images of complex heterogeneous samples.

Keyword-1

deep learning

Keyword-2

hyperspectral infrared imaging

Keyword-3

polyethylene pipe

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