Control of Inorganic Fouling in Direct Contact Membrane Distillation by Membrane Vibration: Effect of Vibration Types

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Abstract:

Inorganic fouling due to scale formation has been known to be a critical problem in membrane distillation (MD) systems because it reduces the membrane permeability, induces a wetting phenomenon, and shortens the membrane lifespan. To overcome this, there have been many works, including the use of antiscalants, application of chemical cleaning, modification of membranes, and the design of novel modules. In our work, an antifouling approach based on membrane vibration was implemented to retard inorganic fouling in MD. Various types of vibrations, including sine waves, random signals, and music waveforms, were applied to a bench-scale direct contact membrane distillation (DCMD) module. Not only the antifouling performance but also the energy efficiency were quantitatively measured to explore the optimum vibration types. Morever, the effectiveness of the membrane vibrations on fouling control was compared with those of conventional antifouling methods. Results showed that mitigation of inorganic fouling on MD was intensively influenced by vibration intensity, frequency, and patterns. When vibrations of different types were applied, their antifouling effects were substantially different under the same energy consumption. This suggests that there may be the optimum vibration types for the control of inorganic fouling. To further understand the correlation between the vibration types and their antifouling effects, deep learning techniques were also applied, including convolution neural networks (CNN) and random forests (RF).

Keywords: Membrane distillation, Anti-fouling, Patterned vibration, Music, Energy consumption