Scaling of Nanostructured Superhydrophobic Surface Fabrication for Improving Efficiency of HVAC Systems

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Project Goals

Accelerating dropwise condensation and shedding

Testing surfaces in simulated AC conditions

Scaling superhydrophobic surface fabrication

Scaling superhydrophobic surface fabrication for reducing air handler energy consumption

Motivation

Biomimicry of superhydrophobic surfaces (ex. Lotus leaf, Namib beetle)

Fabrication on **common AC evaporator coil materials** (ex. Aluminum)

Testing surface hydrophobicity and **scaling** fabrication

We have previously demonstrated an ultrahydrophobic, nanoporous coating technique based on hydrothermal growth (Patent application PCT/US2016/047680; *Mater. Res Express,* 2017) . Here we investigate temperature, concentration, and solution synthesis time sweeps to optimize nanoporous structure growth by increasing surface roughness and hydrophobicity. The growth conditions that show the best condensation and water shedding performance will be used to scale surface modification for a full-scale cooling coil. In addition to hydrothermal synthesis, the chemical vapor deposition and annealing are also scaled to render a superhydrophobic evaporator coil.

Scaled Synthesis Setup

1) ZnO Nanoporous Structure Synthesis:

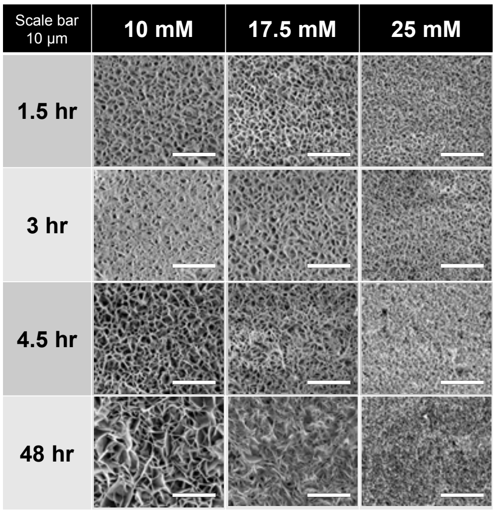
Using a walk-in fume hood, the bath synthesis conditions from the nanostructure growth sweep will be scaled for a full-sized cooling coil to grow the nanoporous ZnO structures.

2) Silane Deposition:

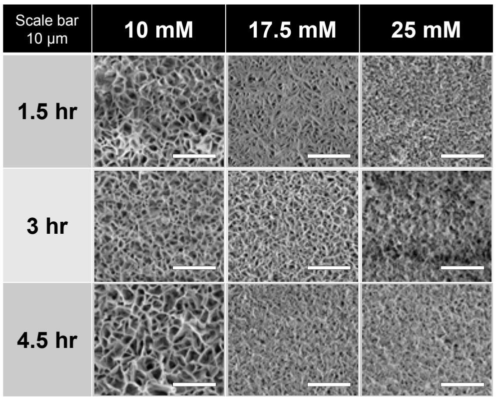
To perform a chemical vapor deposition process for superhydrophobic surface functionalization, a 55-gallon drum will be used as a vacuum chamber to fit a full-sized cooling coil. Rinsing and room temperature annealing will follow this step.

Nanostructure Growth Parameter Sweep

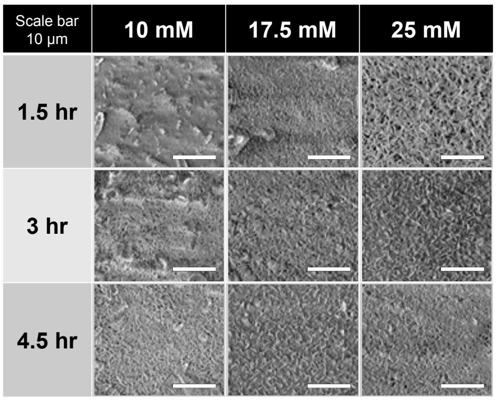
Synthesis Temperature 50 °C



Synthesis Temperature 60 °C



Synthesis Temperature 70 °C



- The important parameters for our ZnO nanoporous structure are synthesis temperature, solution molar concentration, and synthesis time.
- There is a distinct trend in nanopore size with respect to solution concentration and synthesis time. As the synthesis time increases and the bath temperature increases, the nanowire growth becomes more dense resulting in a smaller pore size.
- This trend is most obvious for the 50 °C and 60 °C temperatures which both exhibit a large porous structure for the longest synthesis time and lowest solution concentration.
- The 70 °C formed a dense structure for all times and concentrations with less of an obvious trend. This can be attributed to the solution having a faster reaction rate at higher temperatures, thus, generating a thicker layer of nanostructures.

Conclusions

In this study, we characterized the growth parameters for an ultrahydrophobic nanoporous ZnO structures. Temperature, solution molarity, and synthesis times were all varied to determine how each factor affected the nanostructure growth and size. Following this study, the surfaces will be silane-treated and tested for static contact angle and condensation performance. The surface with the best dropwise condensation performance in dynamic test conditions will be used for the full-scale coil synthesis process described previously.

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