Increasing fog harvesting efficiency through hydrophobizing steel meshes

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Abstract

As the global water shortage crisis increases, the demand for water resources raises, in many regions and countries, such as Iran and Italy. Collecting water from fog, especially in humid coastal areas, presents a promising solution to this issue, complementing other strategies, e.g. water desalination. This research attempts to enhance fog harvesting efficiency by investigating the crucial factors of surface structure and wettability. Our methodology involves the fabrication of superhydrophobic meshes by electrodepositing copper onto steel meshes, followed by a silica-sol modification to enhance hydrophobicity. This fabrication approach results in high surface roughness, coupled with low surface energy, leading to significant advancing and receding contact angles (>145° and >130°, respectively), minimal wetting hysteresis (<20°), and a low sliding angle (<15°) for a 2.5 mm drop. Our previous studies on single drop impact experiments with millimeter-sized drops indicate that while hydrophobicity has a minor effect on initial penetration stages, increased hydrophobicity aids in breaking down drops after penetration through the mesh. Further proof-of-concept tests were conducted in a fog chamber, where microdroplets with an average diameter of $\sim 5 - 10\ \mu m$, mimicking natural fog, were sprayed onto the mesh surface mounted at the front of a wind tunnel with a wind speed of $\sim 0.3\ m\ s^{-1}$. Experiments on fog collection and wetting durability reveal that copper-coated meshes without a silane layer experience clogging, leading to reduced wetting durability and fog collection efficiency, a phenomenon not observed in single droplet impact experiments. Conversely, copper-coated meshes with an additional silane thin layer demonstrate a fog collection efficiency of $\sim 600\ \ mg/cm^2h$, representing a 40% improvement compared to an uncoated stainless steel mesh. This technological advancement holds promise for addressing water scarcity challenges through innovative and efficient fog water harvesting technologies based on surface property design and control.

Keywords: Surfaces; Wetting in liquid-solid interfaces; Water collection from fog; Hydrophobic mesh; Electrodeposition of copper; Silica–sol surface modification.