Metamaterials for passive daytime radiative cooling

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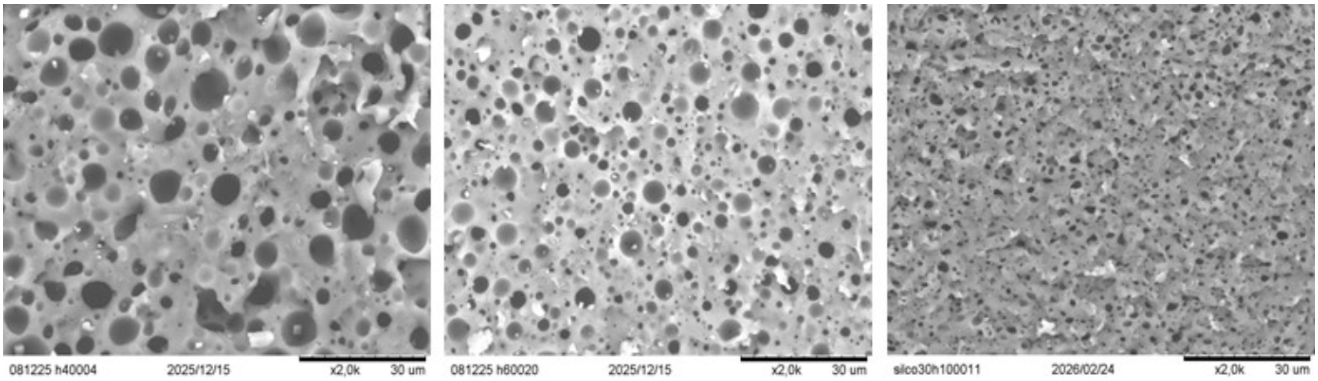
In recent decades, the acceleration of global warming has become increasingly obvious. Research has expanded in the fields of renewable energy and materials with the ability to produce cooling without energy input.

Classical building air-conditioning is highly energy demanding and results in a global increase of temperature outside of the room. Both effects are problematic given the current climatic and economic context. Passive radiative cooling is a natural phenomenon that helps regulate the Earth's temperature. The Earth's atmosphere has a transparency window (wavelengths 8 to 13 µm) that coincides with the peak radiation of terrestrial objects (black body radiation peak at 298 K) [1]. This radiation can therefore be lost into deep space, which acts as a thermal sink at 3 K. Materials capable of emitting electromagnetic radiation at these wavelengths thus exhibit a strong cooling effect when exposed to the sky. Moreover, if these materials also reflect solar light in the solar range (0.2 µm - 2.5 µm), they maintain this cooling effect even when exposed to sunlight. This referred to as "Passive Daytime Radiative Cooling" (PDRC), which is the process by which a surface exposed to the sky emits more energy than it absorbs from incident solar radiation. This unbalance leads to passive cooling of the surface, meaning no external energy input is required.

To achieve this effect, it is necessary to design materials that strongly emit within the 8-13 µm range while being highly scattering in the 0.2-2.5 µm range [2]. Simulations conducted in our team at CRPP (PhD Nigar NAMAZZADE) have helped to determine the optimal material properties in terms of both polymer matrices (for the emitting function in the IR) and inclusion sizes and number density (for the scattering in visible-NIR) [3]. For this reason, we study porous PDMS, varying both pore size and volume fraction to optimize the PDRC efficiency.To create such materials we use the templating emulsion method, crosslink the PDMS with a UV lamp, and dry the sample. The optical properties are measured with an integrating sphere to measure the total reflection (IR and UV-visible) of the material. We managed to achieve solar reflectance comparable with the literature (around 96%) but also probe the evolution of this value as a function of the materials structure and composition. Our study opens new routes for the optimization of passive cooling devices.

Keywords:
Radiative cooling, Polymer, Porous, Optical properties



Scanning electron microscopy image of samples with different pore sizes

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