A Novel Design to Tailor Microstructures of Nanowire Foams as Efficient, Reusable Filters

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Frequent forest fires, persistent air pollution, and the COVID-19 pandemic have sparked a surge in the widespread use of disposable face masks. At the height of the pandemic, 1.6 million tons of non-biodegradable masks were discarded daily into landfills and oceans, posing long-term environmental threats. This urgent issue calls for the development of efficient, reusable masks that protect both people and the planet. My research aims to develop a new type of filtration media using metallic nanowires that are highly effective against ultrasmall particulates while being robust, reusable, and recyclable. I hypothesized that by controlling the foam microstructures, the filtration performance can be substantially enhanced. To test this, I synthesized copper nanowires through electrodeposition into nanoporous alumina templates. I then harvested, freeze-casted, and sintered them into free-standing foams. I further strengthened these foams using a second electrodeposition (2ED) process to improve their applicability as filters. To optimize filtration performance against hardest-to-capture 200-300nm airborne particulates, I tailored the foam microstructures by incorporating 200nm-sized copper nanoparticles during the 2ED process. This innovation boosted capture efficiency by over 30%, creating additional sites within the foam to trap deep-submicron particles. This approach not only produces highly effective filtration media but also introduces a new design strategy for superior filtration performance. By capturing the most challenging ultrasmall particulates, the nanowire foams provide a robust, reusable, and recyclable alternative to disposable masks. This sustainable solution addresses pressing public health needs while mitigating the environmental impact of single-use masks.

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