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Microstructure Design and Interface Engineering in Advanced Filters for High-Efficient Nanoscale Particle Separation

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High-efficient separation technology is highly important for industrial and environmental related purification and separation processes. Filter media have attracted great attention as they provide low-energy consumption, easy-operating, environmental-friendly and highly-efficient separation , and therefore, have been considered as promising strategies in achieving carbon neutrality. In heterogeneous separation systems, the selectivity and permeability trade-offs as well as filter functions and properties are the main limitations to their applications. Thus, through microstructure control and interface engineering, we designed and fabricated a series of functional filters to tailor for specific separation requirements. For examples, the pore mouth decoration, in-situ separation layer formation, co-sintering and other new membrane formation strategies were adopted to optimize the structures and properties of ceramic filters, e.g., SiC, Al_2O_3, etc.. The enhanced filter separation performance including air purification, oil-water separation and membrane jet emulsification have been demonstrated via systematic characterization and mechanism analyses. In organic filters, homo-porous membranes, hollow fiber membranes and thin film composite membranes with enhanced filtration and antifouling performance were developed for liquid phase separation. The pore diameter, distribution, shape, and configuration can be precisely controlled over micrometer scale to enhance the mass transfer efficiency. To improve the separation performance while also maintaining the other properties such as catalytic, adsorption, antibiosis and antifouling properties, nanofiber constructed filters with microscale pore diameter, such as PAN, PTFE, PVDF, and SiO_2 have been constructed. Filters with asymmetric or hierarchical lipophilic properties have been innovated for specific filtration system based on surface engineering and chemical modification. Polluted air containing PM, formaldehyde, microorganisms, and organic gases can be simultaneously treated via the above technologies. Further, recent development from our group in novel membranes in terms of configuration and material design as well as their potential

applications in medical and medicine, e.g., hemodialysis, ECMO, etc., ion separation, and clean energy resources, e.g., battery, hydrogen energy, etc. will be discussed. Finally, a prospective view of the development of new filter materials and their related separation technologies for nanoscale particle removal will be provided. The development trends in China and more widely in Asia will also be discussed.