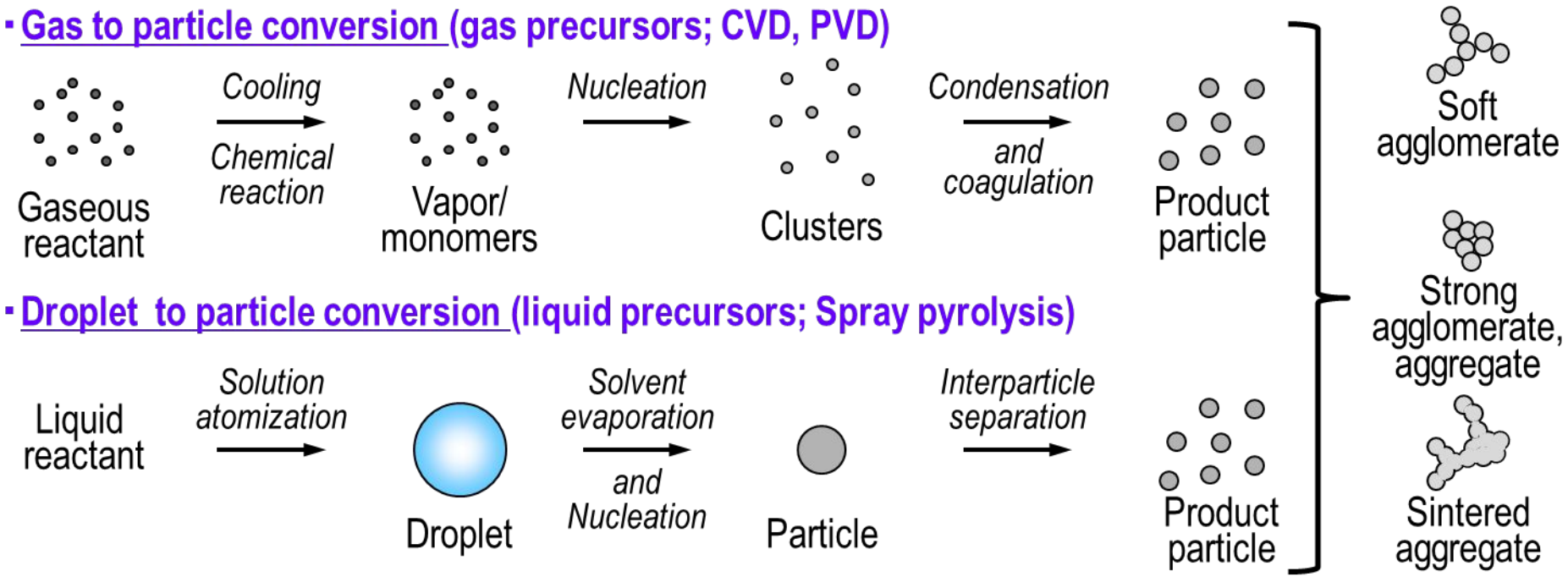
Research Thrust #1:

Design, Manufacturing and Processing of Particles and Fibers

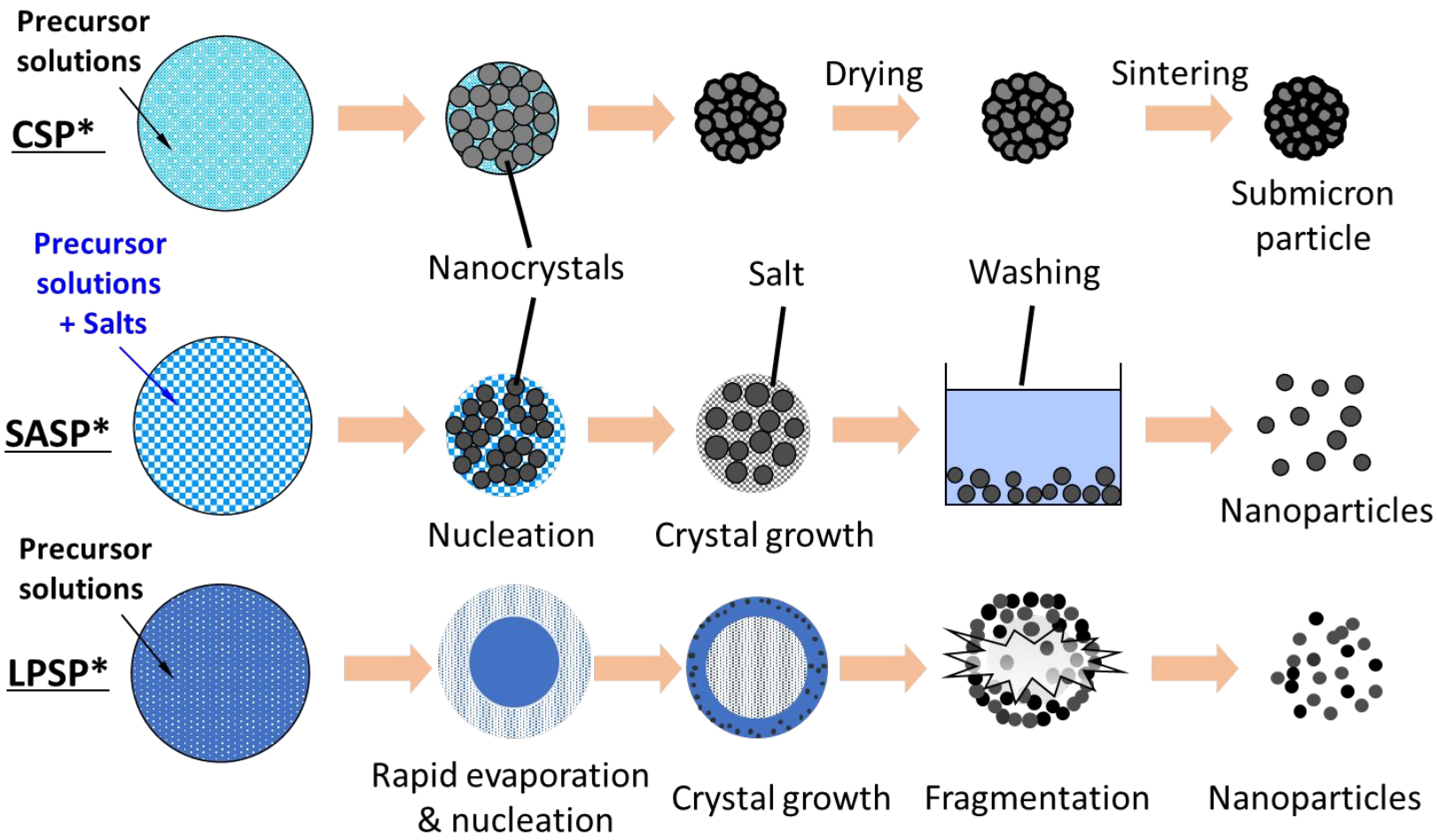
This thrust has major research focuses, including (but not limited to) **particle/fiber design and synthesis**, **particle/fiber processing**, and **particle transport and fate**. To design and produce particles targeted for various applications, scientific understanding of momentum, heat and mass transfer within particle systems/processes should be developed through both experimental and theoretical approaches. The control of the size, morphology, structure, as well as the surface functionality of particles and fibers is the major driving force. For practical applications, it is also necessary to have processing techniques for efficient coating, charging, classification, and fluidization of particles, powders and fibers. The transport kinetics and the fate of particles should be investigated through both online measurements and modeling, which are important for engineering design and applications of the particles.

Example Processes for Particle Design and Synthesis (1) _ General



There are two major particle formation pathways in aerosol routes: gas to particle conversion and droplet to particle conversion. Both processes include major steps of nucleation and growth to form the final particles. Examples processes include but not limited to chemical vapor deposition (CVD), physical vapor deposition (PVD), atomic layer deposition (ALD), spray pyrolysis (SP), and spray drying (SD). More details can be found in W.-N. Wang, W. Lenggoro, and K. Okuyama, Preparation of Nanoparticles by Spray Routes, in Encyclopedia of Nanoscience and Nanotechnology, Edited by H. S. Nalwa, Volume 21, Pages 435-458, 2011.

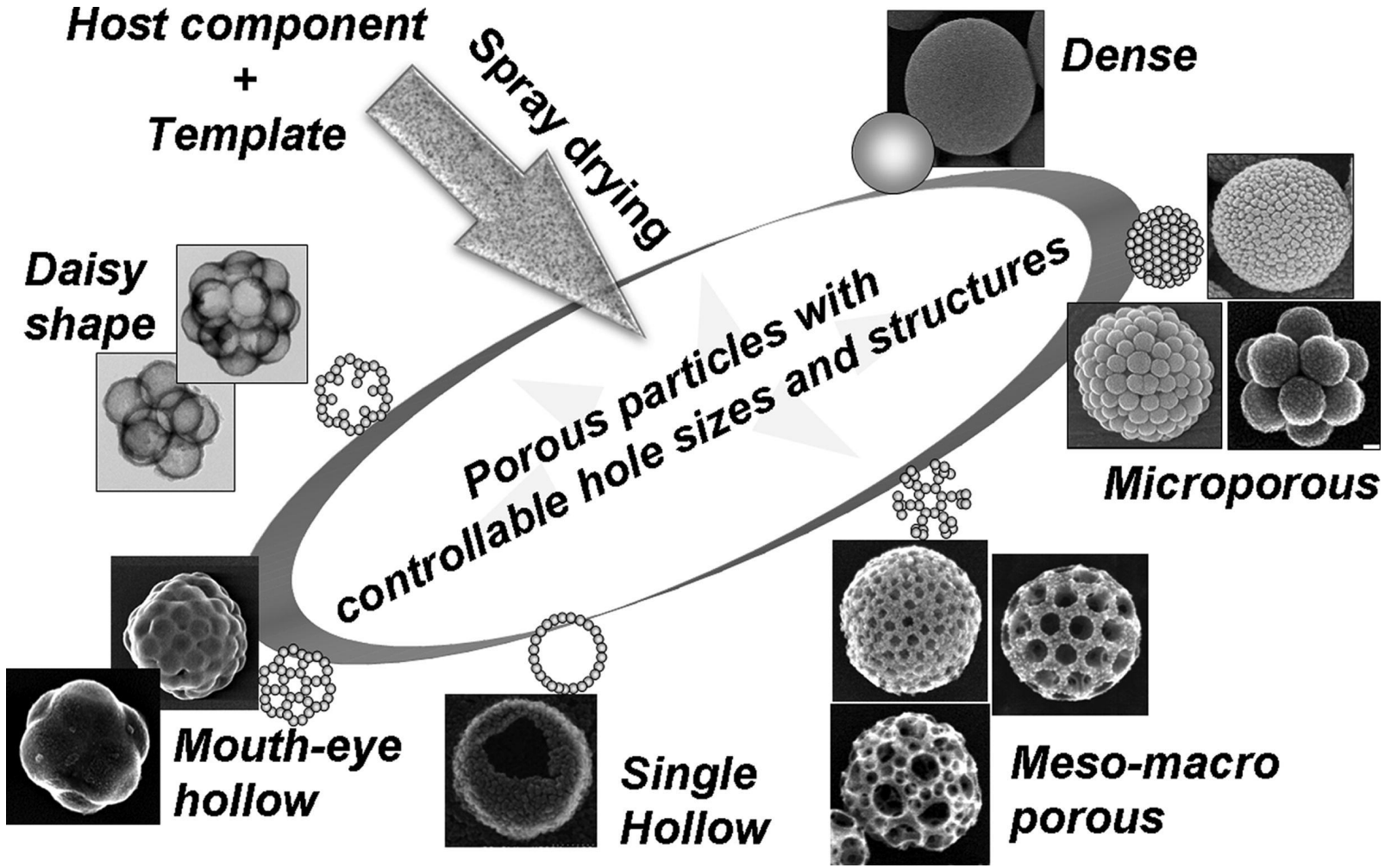
Example Processes for Particle Design and Synthesis (2) _ General



* CSP: conventional spray pyrolysis; SASP: salt-assisted spray pyrolysis; LPSP: low-pressure spray pyrolysis

Particles can be designed and synthesized from microdroplets. Several example microdroplet-based aerosol routes are conventional spray pyrolysis, salt-assisted spray pyrolysis, and low-pressure spray pyrolysis. More details can be found in W.-N. Wang, W. Lenggoro, and K. Okuyama, Preparation of Nanoparticles by Spray Routes, in Encyclopedia of Nanoscience and Nanotechnology, Edited by H. S. Nalwa, Volume 21, Pages 435-458, 2011.

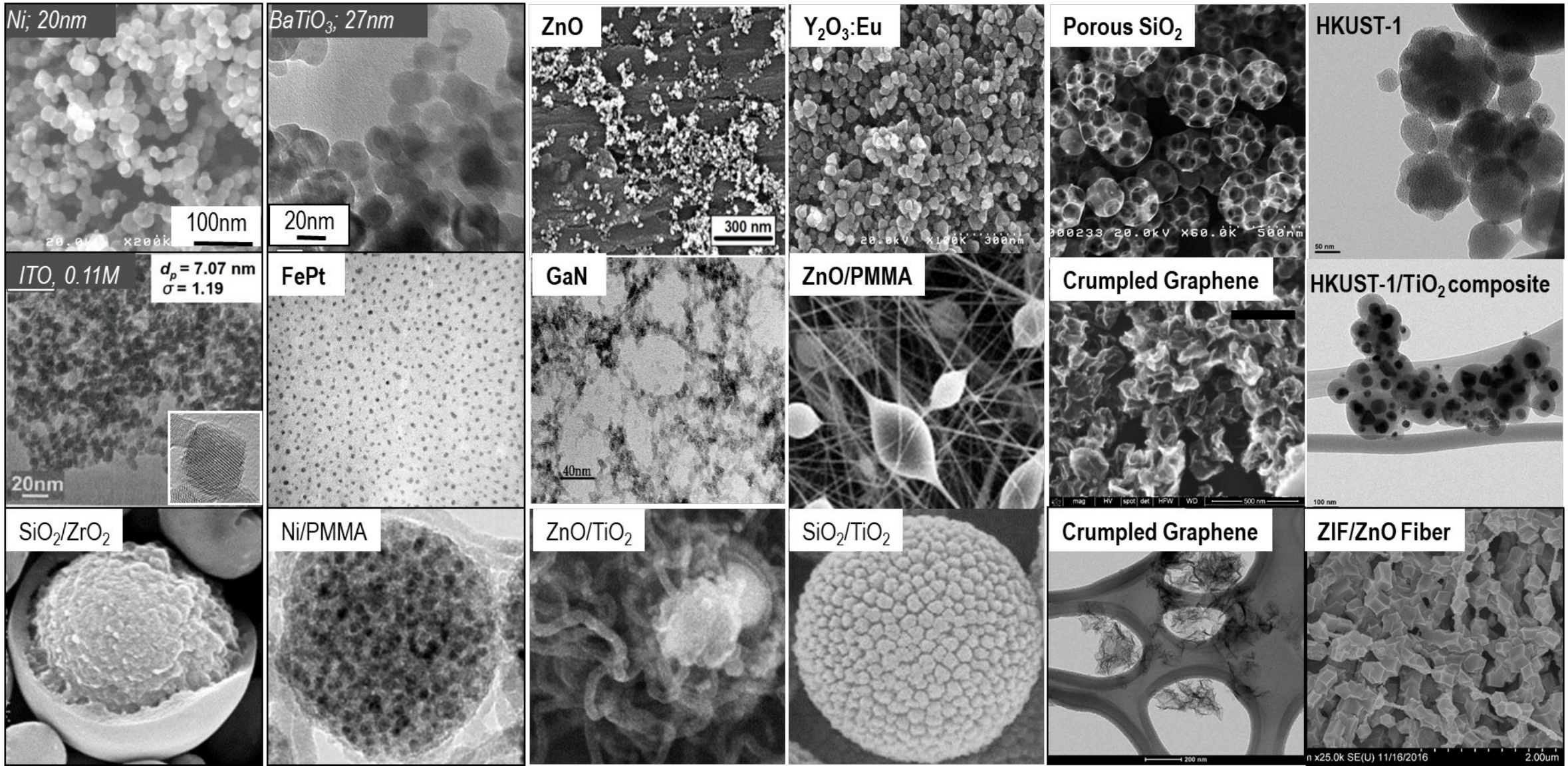
Example Processes for Particle Design and Synthesis (3) _Porous and Hollow Particles



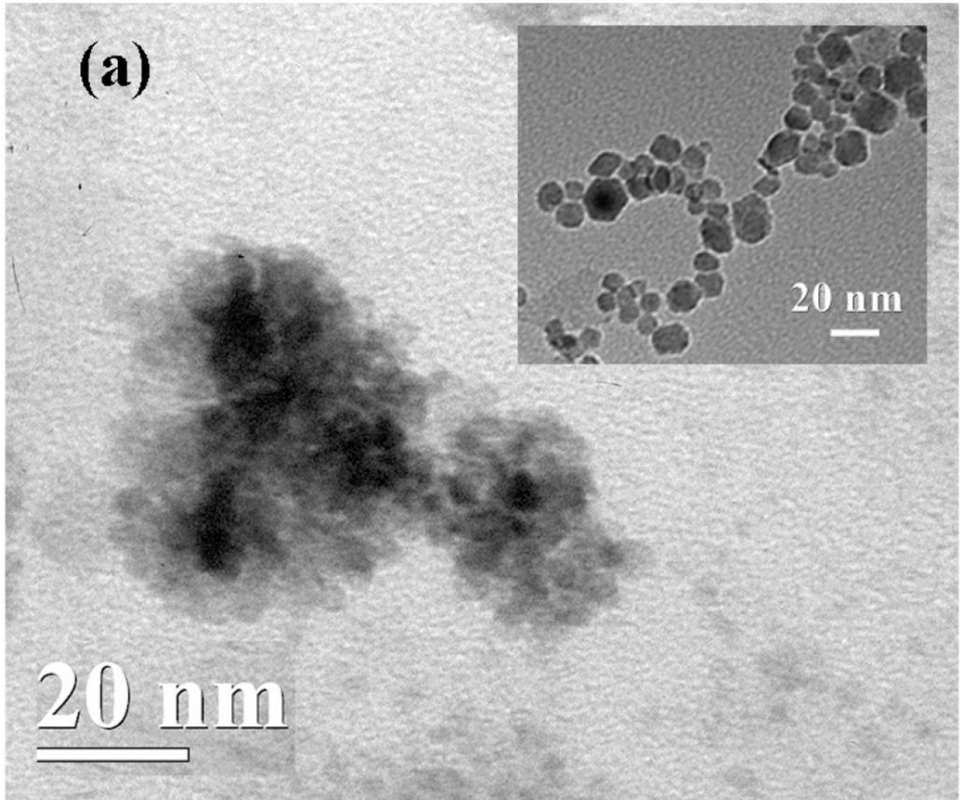
The design of porous and hollow particles with controllable hole sizes and porous structures can be realized by using spray drying techniques. Several examples of porous structures can be found in the figure. More details can be found in the following article.

A.B.D. Nandiyanto, T. Ogi, **W.-N. Wang**, L. Gradon, and K. Okuyama, Template-assisted Spray-drying Method for the Fabrication of Porous Particles with Tunable Structures, ***Advanced Powder Technology***, **30**(12): 2908-2924 (2019)

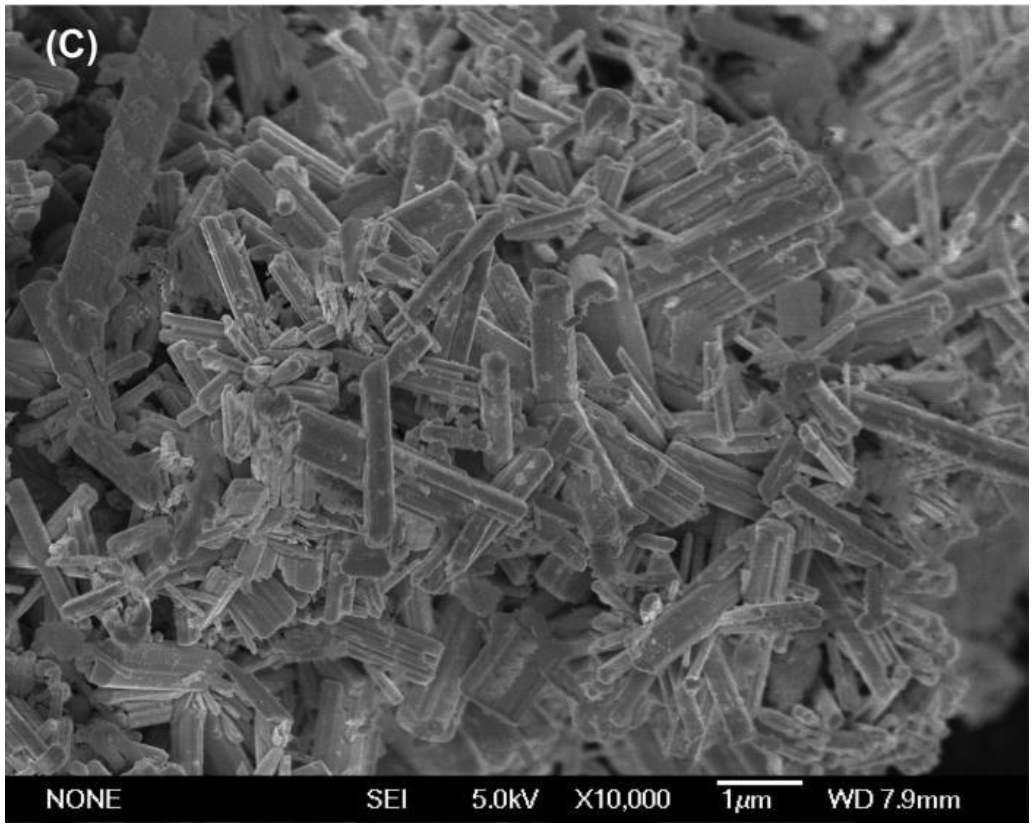
Examples of Particles/Fibers



Particles with various sizes and morphologies can be formed in aerosol routes. Several examples are shown in the figure, ranging from nanoparticles, core-shell particles, porous particles, nanofibers, as well as crumpled 3D balls. By carefully considering the requirements and adjusting process as well as precursor parameters, particles with more interesting structures can be designed.



TEM image of MBTBA-Fe_3O_4@SiO_2 nanocomposites. The inset shows the TEM image of Fe_3O_4 nanoparticles before coating with SiO_2 (Applied Surface Science, 487, 876-888, 2019).



SEM image of superhard nanowires of tungsten monoboride prepared using flux growth (Appl. Phys. Lett. 109, 203107, 2016).