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Editorial to the Special Issue on Advanced Micro/Nanoscale Porous Materials for Novel Applications: Answering to Future Needs

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The application of novel lightweight porous materials includes but is not limited to acoustics, heat transfer, fluid flow, and aerospace. Depending on the application, porous materials can be of open-cell (permeable) or closed-cell (non-permeable) types. While the open-cell foams are intended and designed for transferring or manipulating different types of media or waves through them, closed-cell porous materials are usually considered for insulation (thermally, acoustically, electromagnetically) of a system from surrounding, or to provide structural mechanical integrity with low weight.

In particular recent applications, both the physical characteristics namely strength and permeability are required. For instance, in biomechanical engineering, while the novel implants are made out of open-cell porous biomaterials to allow for osseointegration, they should also have high static and dynamic durability to be capable of sustaining human weight in long term (Hedayati et al. 2018; Pałka and Pokrowiecki 2018). Also, high-throughput computers generate ample local heat which needs to be dissipated at the chip level. Recent immense increase in interest in sending human to other celestial bodies such as the Moon and Mars has unique challenging limitations in terms of weight they can carry to outer space (Hedayati et al. 2021). An approach to decrease the amount of weight needed to be transported to space is to 3D print lightweight yet strong structures which has led to design of several types of topologies for porous materials. Nanoporous materials

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with predefined regular topology have recently been used to create surface functionality (e.g., increasing wettability, adsorption, or cell growth catalyzer) at nanolevel.

This special issue which includes 18 papers is devoted on recent advances in development, manufacturing, and characterization of advanced porous materials in different research and industrial fields. In the first paper, Mazloomi and Ranjbar (2021) propose a novel graded core with anti-tetrachiral unit cell type for sandwich structures and evaluate their numerical vibroacoustic response in using a modal analysis of homogenized model. Their optimized 2D gradient configurations show up to 78% reduction in radiated sound power level and a 15% increase in the fundamental frequency, as compared to the baseline sandwich panel. Bagherian et al. (2021) present a novel statistical descriptor, called quality of connection function (QCF), for physical characterization and 3D reconstruction of heterogeneous materials. Effective mechanical properties of the proposed descriptor are evaluated on trabecular bone models obtained from X-ray micro–computed tomography (μCT), as an example of heterogeneous materials with complex microstructures. Ansari et al. analyze hygrothermally (Ansari et al. 2021a) and thermal shock (Ansari et al. 2021b) induced vibration of functionally graded (FG) porous beams using generalized differential quadrature (GDQ) method. The formulations were based on Timoshenko beam theory (TBT) and von Karman geometrical nonlinearities. They derive the governing equations of motion and use them as the basis for investigating the effects of porosity volume fractions, porosity cases, thermal boundary conditions, moisture concentration, FG indexes, slenderness ratio, and temperature rise. Beni and Alihemmati (2021) analyze transient coupled heat and moisture transfer in the cylinders and porous cylindrical panels using finite element method (FEM). They derive FEM-based weak forms of the equations using Galerkin method and solve the obtained time-dependent differential equations using Ronge–Kutta method. Barati et al. (2021) analyze nonlinear free/forced vibrational behavior of sandwich plates with honeycomb cores and graphene platelet (GPL) reinforced face sheets. They use harmonic balance technique to solve the nonlinear governing equations of the sandwich panel. Hosseinkhani et al. (2021) optimize vibroacoustic performance of hybrid (non-) auxetic sandwich panels with re-entrant honeycomb core using geometry optimization method. The results show that the auxetic core is preferable for reduction of structural vibrations and noise. The optimization algorithm concentrates auxetic parts around the load application regions. Khorasani et al. (2021) study the vibrational behavior of a novel type of equipped sandwich beams (ESBs) analytically. The ESB is composed of three layers: functionally graded porous core (FGPC) and two identical agglomerated carbon nanofiller reinforced composite (ACNFRC) skins. In addition, the effect of agglomeration is considered in nanocomposites. Bendaida et al. (2021) study the effects of thermal environments on dynamic behavior of FG nanobeams under various types of thermal environments by considering the Navier type procedure and a new two-unknown cubic shear deformation beam theory. Akbaş et al. (2021) analyze the dynamic behavior of a simply supported FG porous microbeam subjected to a moving load. A comprehensive parametric study is carried out to evaluate the influences of porosity coefficient, porosity and material distribution, and length scale on the dynamic responses. Shakibanezhad et al. (2022) study the mechanical behavior of aluminum foams under quasi-static loading using experimental tests and FE models based on Weaire–Phelan and Kelvin tessellations. The results indicate that among the two tessellation types, the Weaire–Phelan models better mimic the deformation of manufactured specimens, while the Kelvin models are capable of providing mechanical properties which are closer to the experimental results. Ahmed et al. (2021) study the stability behavior of porous double-curvature shells under transverse mechanical loading using third-order shear deformation shell theory. They implement Airy stress function for their analytical derivation. The results show that porous shells are more prone to instability as compared to their solid counterparts. The results also show that utilizing stiffener and considering non-uniformity in the distribution of pores improves stability significantly.

Iranmanesh et al. (2021) review the application of 3D bioprinters for pulp regeneration and Tissue Engineering. Several 3D printing techniques for the production of soft and hard tissues are investigated and their pros, cons, and limitations are presented. Niroumandi et al. (2021) investigate the functionality of micro-valves composed of pH-sensitive cylindrical hydrogel jackets coated on rigid pillars considering fully coupled fluid–solid interaction (FSI) analysis. The novelty of their paper is considering 3D geometry, new micro-valve designs, and transient swelling analysis of hydrogels by coupling ions diffusion and their large deformation. Dolatabadi et al. (2021) present computational modeling of a miniaturized version of an on-chip electromembrane extraction (EME) configuration, where the donor solution is delivered by a syringe pump to the sample reservoir. They use Poisson, Nernst–Planck, and Navier–Stokes equations in their modeling. The proposed approach can be extended for extraction of different analytes such as ionic drugs in wastewater.

Anusha et al. (2021) study 2D laminar magnetohydrodynamics (MHD) couple stress fluid flow with hybrid nanofluid in the presence of inclined magnetic field over the stretching-shrinking sheet embedded in porous media. The hydrodynamic characteristics are evaluated in response to different physical parameters such as porosity, couple stress, suction/injection, magnetic field, mass transpiration, and stretching/shrinking parameters. Vishalakshi et al. (2022) study the influence of MHD and mass transpiration on Rivlin–Ericksen steady-state 2D flow over a stretching sheet in a porous media with thermal communication. The analytical results of the temperature and mass transfer equations are stated in the form of Kummer's function for prescribed surface temperature as well as for prescribed wall heat flux. Sneha et al. (2022) study the slip flow of an electrically conductive viscoelastic fluid over a porous stretching/shrinking sheet with mass and heat transfer analytically.

We hope that the published papers in this special issue are useful and rich resources for scientists and researchers who are interested in the fields of advanced micro and nanoporous materials and that it will open new venues for their future research. We would like to thank the many dedicated authors, reviewers, and the Editorial office of Transport in Porous Media who have contributed greatly to this special issue.

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