Aligned Porous Networks by Directional Freezing of Nanoparticle Dispersions

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Directional freezing is a simple and novel route to produce aligned porous materials in the form of 2D patterns. A solvent-typically water but also organic solvents-is frozen uni-directionally, and the structures of pores after drying reflect the spaces occupied by the uni-directionally frozen and aligned crystals of solvents. When SiO_2, TiO_2, or PTFE (polytetrafluoroethylene) nano-dispersions sprayed onto a glass were quickly frozen by immersing them into a liquid N_2, ice spheres grew inside their matrixes. The growth of ice crystals expelled the nanoparticles to ice grain boundary region (cryo-concentrates). Under these conditions, the nanoparticles were aggregated between the growing ice crystals. The size of ice crystals could be adjusted by varying freezing rate and dispersion concentration. It was investigated that the effects of annealing on the structural and mechanical properties of networks. The morphology was characterized in detail by OM, SEM, and AFM. The mechanical properties were investigated by AFM Force-Distance curve.