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Morphology control of PS-b-P4VP templated monolayer mesoporous Fe₂O₃ thin films

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Mesoporous Fe₂O₃ thin films with large area homogeneity demonstrate tremendous application potential in photovoltaic industry, lithium ion batteries, gas or magnetic sensors. In the present work, the synthesis of morphology-controlled Fe₂O₃ thin films is realized with the polystyrene-block-poly(4-vinylpyridine) (PS-b-P4VP) diblock copolymer assisted sol-gel chemistry. The effect of the solvent category and polymer-to-FeCl₃ ratio is systematically investigated during the sol-gel synthesis process. Spin coating is used for the thin film deposition and a calcination process in the air condition is used for removing the PS-b-P4VP polymer template. For both DMF and 1,4-dioxane solvent system, nanocluster structures are obtained with low PS-b-P4VP concentration, which is supposed to be the result of the weak phase separation property and thereby the weak template effect of the block polymer. When the concentration of the PS-b-P4VP reaches the critical point of micellization, spherical and wormlike porous structures can be specifically formed in the DMF and 1,4-dioxane solvent system, respectively. The further increase of the polymer-to-FeCl₃ ratio leads to the enlargement of the spherical pore size in the DMF system and the shrink of center-to-center distance of the worm like structure in the 1,4-dioxane system. Moreover, DMF/1,4-dioxane solvent mixture with different volume ratios are applied for the sol-gel solution preparation to trace the effect of the solvent selectivity on the thin film morphology. By adjusting the preferential affinity of the solvent mixture to the polymer blocks, a spherical to wormlike pore shape transition is observed near a critical ϕ value of 0.77.

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