Effect of the drying techniques on the morphology of silica nanoparticles synthesized via sol–gel process

Abstract

The effect of drying techniques on the dispersion and agglomeration of silica nanoparticles were studied using alcohol-dehydration (AD), freeze-drying (FD) and oven drying (OD) techniques. Observation under optical microscope showed that aqueous-dispersion with OD technique led to the formation of densely packed particles (islands) while AD resulted in loosely packed particles with non-isotropic aggregation pattern. TEM analysis showed that most of the silica nanoparticles were homogenous and discrete in nature. The comparison between experimental (S_{BET}) and theoretical ($S_{spherical}$) surface area indicated that the agglomeration of nanoparticles increased in the order of AD < FD < OD. The decrease in the silanol number in the order of AD > FD > OD and the increase in the pore size (D_p) and pore volume (V_p) in the order of AD < FD < OD further supports the agglomeration trend predicted by the surface area comparison. The results suggested that agglomeration can be effectively reduced by eliminating water from the system before solidification since the presence of water during the process could intense the interparticle interactions leading to agglomeration. Overall a new, simple and cost effective drying technique (AD) has been developed to produce silica nanoparticles with improved dispersion and reduced agglomeration.