Transport and immobilization of colloids into sub-100 nm porous structures by electrophoretic methods in aqueous media

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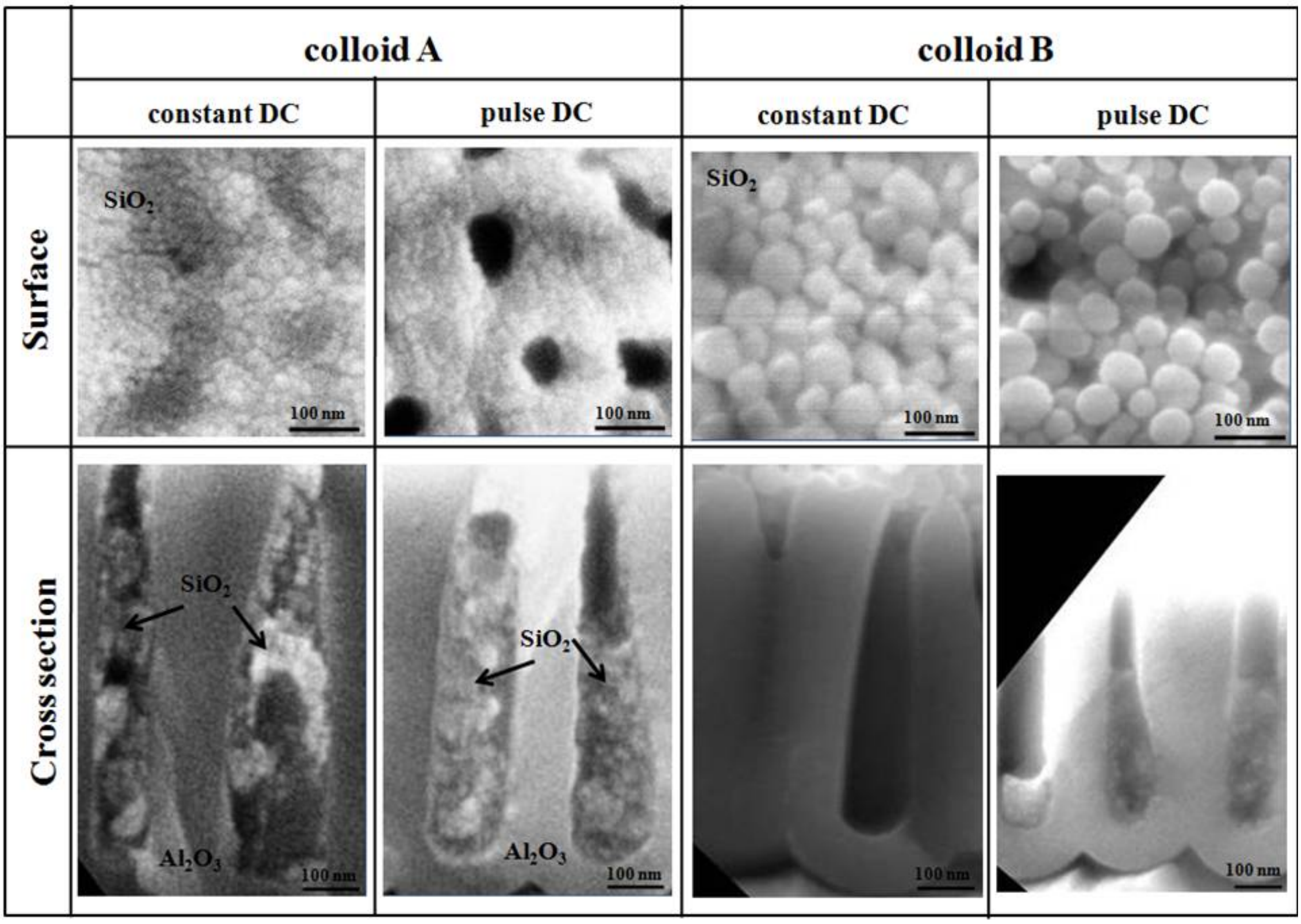
Deposition of suspended particles in aqueous media using electrophoretic deposition (EPD) promotes electrokinetic phenomena such as electrophoresis, water hydrolysis and electro-osmosis. When the electric field implies a bulk liquid that consists of the suspended particles, a significant motion of charged particles in a suspension or electrophoresis is noticed. In the vicinity of two electrodes, deposition of charged particles onto a substrate surface with an opposite charge occurs. Since then, various techniques to deposit particle materials have been invented. However, bubble generation coming from water hydrolysis interrupted the deposition and causes the nm-order particles fail to deposit. Thick film using EPD also contribute to electro-osmosis that could damages deposit layer and the surface when long deposition time was conducted. Therefore, controls of certain EPD parameters are very important in order to ensure the deposit are uninterrupted during the deposition process. For examples to prevent the bubble generation, several EPD techniques has been invented such as alternating current (AC) EPD, pulse DC EPD, low voltage deposition and solvent–aqueous mixtures.
In the current work, we demonstrate the immobilization of presynthesized nanoparticles (with average sizes of 10 and 50 nm) by EPD technique with conventional-DC and pulse-DC modes onto the porous anodic aluminium oxide substrate having pore size of below 100 nm. At the applied voltages lower than the decomposition voltage of water (~1V),the number concentration of particle deposited on the surface by conventional DC was higher than that of pulse DC. The number of deposited particles increased with increasing pH. Deposition efficiency inside the pores can be enhanced by applying pulse DC. In the case of high (~10V) applied voltage, no particles were observed inside pores even though pulse DC has been applied. The adhesion strength (removal behavior) of deposition was evaluated by applying a particle detachment simple system based on ultrasonic energy. The particles deposited inside the pores were not detached compared with those of the surface of the substrate.

Keywords: Nanoparticle, Electrophoresis, Pulse, Water, Silica, Nanoporous


colloid A
colloid B
constant DC
pulse DC
constant DC
pulse DC
Surface
Cross section
SiO2
SiO2
SiO2
SiO2
Al2O3
Al2O3
100 nm