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# Electrophoretic deposition of multi-sized titania nanoparticles to fabricate high performance electrodes for dye-sensitized solar cell application

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Electrophoretic deposition (EPD) is employed successfully in a suspension of multi-sized mixed phase (anatase + rutile) $TiO_2$ nanoparticles to deposit a very robust bi-functional electrode for dye sensitized solar (DSSC) application with an excellent photo electrochemical behavior. First, the small anatase (5–10 nm) nanocrystalites and sub-micrometer-sized “sea urchin”-like rutile (200–400 nm) particles were synthesized via controlled forced hydrolysis and recovered by centrifuging [1]. The aqueous synthesized anatase and rutile gels were washed and dispersed in isopropanol in preparation for EPD. Interestingly, extremely high quality films were obtained on FTO glass without using any organic/toxic binder or charging agent. The EPD formed films were annealed/sintered at ca. 450C and sensitized with the N719 dye. The films were optimized further via changing the concentration of anatase and rutile particles as well as incorporation of P25 nanoparticles in order to improve mesoporosity, dye loading, scattering effects, and charge transport with minimal interfacial charge recombination. DSSC devices built with the newly configured hybrid electrodes rendered an excellent power conversion efficiency (PCE) of 8.25%, which outperforms the cell prepared by double layer electrode from commercial benchmark paste via screen printing (7.85%). The development of this novel binder-free electrode fabrication process via EPD provides a great potential for deposition of high performance films on flexible conducting plastic substrates, where high temperature post treatment cannot be applied.

[1] Charbonneau, C.; Gauvin, R.; Demopoulos, G. P. *Journal of The Electrochemical Society* **2011**, *158*, H224.