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Multifunctional nanowires and 3D nanostructures of materials composites in large scales

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Synthesis of a composite is proven to be one of the best method to synergistically combine properties of two or more materials. Composite properties are achieved through many methods such as physical mixing of its components, chemical methods such as core/shell, nanoparticle-decorated nanowires and so on. While the chemical methods offer superior properties, they are hardly scalable and often requires a secondary processing to achieve the composite properties. This paper covers synthesis of composite materials in two typical morphologies, viz. nanowires and 3D nanostructures, of a range of materials and their applications in energy conversion and storage, catalysts, sensors and so on by large scales by multi-needle electrospinning technique. Nanoflowers of TiO_2/SnO_2 composites gave one of the best performance as a charge separation and transport medium in dye-sensitized solar cells and perovskite solar cells. The best-performing energy conversion device so far produced using these materials was a perovskite solar cell fabricated using 3D composite nanoflowers with a photoconversion efficiency of 17.25%, open circuit voltage of ~1V, short circuit current density of ~23.73mA/cm^2 and fill factor 73.07%. The TiO_2/SnO_2 composite flower was shown to be ideal for supercapacitive charge storage, lithium ion battery, catalysis, and sensors. The best performing morphology for the energy storage device was nanobelts composing NiO and Co_2O_3 nanoparticles. Using appropriate electrolyte, the nanobelts offer possibilities of fabrication of battery-supercapacitor hybrid devices with energy density similar to batteries and power density similar to supercapacitors.

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