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Controlled Nanoparticle Synthesis via Opposite-Polarity Electrospray Pyrolysis

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Abstract
We report on a novel approach for the controlled synthesis of nanoparticles of uniform size and composition that is well suited to particle functionalization and scaleup. It relies on Electrospray Pyrolysis (ESP) in which charged, monodisperse liquid precursor droplets are first generated, then electrically neutralized by a second ES of opposite polarity and finally carried through a furnace for the synthesis of the desired nanoparticle, with each droplet serving as a nanoreactor in an environment of independently controlled temperature and residence time. We apply the approach to metal nitrates and synthesize a variety of metal oxides and mixed metal oxides, carbon coated nanoparticles, and hybrid structures of metal oxide-decorated graphene. In a proof-of-concept demonstration of inexpensive scale-up of the technique, we synthesize metal oxides using an array of ESs operating in parallel and a corona discharge to neutralize them, demonstrating the expected increase in nanoparticle production rate. Electrospray scaling laws and knowledge of flow rate(s) as well as physical properties of the liquid precursor(s) enable apriori determination of nanoparticle size, facilitating the selection of the synthesis protocol.

Keywords: Electrospray, pyrolysis, synthesis, nanoparticles