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Atomic Layer Deposition of Pt Nanocatalyst on SiO_2 Supraparticle Scaffolds

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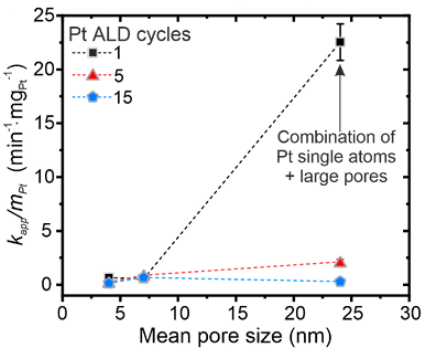
Supraparticles, customizable scaffolds consisting of agglomerates of smaller particles, allow easy manipulation of material properties such as pore size and enable studies of the effect of geometry on catalytic efficiency. Further surface functionalization of supraparticles with ALD platinum enables catalytic experiments with a tunable pore size without altering the material composition.

In a new study[1], researchers from Germany used spray-drying, a droplet-assisted supraparticle assembly method, as a high-throughput, scalable synthesis technique. The assembly process involves evaporating the solvent from nanoparticle-containing droplets. Because the nanoparticles are confined within the vanishing droplet, the particles are forced to assemble into the final 3D framework of the supraparticle.

Following the spray-drying process, the authors deposited Pt ALD conformal coatings in an Arradiance GEMStar™ System. ALD combined with spray-drying delivers excellent surface-to-volume ratios, exceeding those achieved by purely colloid-based approaches due to sub-nanometer control and avoiding using excessive volume of the material. By varying the nanoparticle size (8nm and 60nm SiO_2), the ALD process parameters (precursor dose and soak duration) and the number of ALD cycles, they achieved various morphologies, e.g., continuous films or island structures with varying porosity, resulting in diverse and customizable material properties.

This work includes a combination of high-resolution STEM, TEM and SEM analysis of Pt clusters to observe the shape of the Pt particles during ALD nucleation, with spectroscopy techniques, to maximize catalytic activity of the composite material. It was found that instead of expected crystalline structure, Pt forms tiny 2D "rafts" that were previously found to be highly active in photocatalytic water splitting. In this work, the authors used the hydrogenation of 4-nitrophenol to quantify catalyst performance. A faster hydrogenation kinetics in samples with just one Pt ALD cycle, compared to multicycle Pt ALD, suggests that small Pt particles are more catalytically active.



Arradiance enables thin-film semiconductor, solar and green energy state-of-the-art ALD solutions. For more information on Arradiance® Technology, GEMStar™ ALD system or Foundry Services, please contact Arradiance.

[1] *Philipp Groppe, Valentin Müller, Johannes Will, Xin Zhou, Kailun Zhang, Michael S. Moritz, Christian Papp, Jörg Libuda, Tanja Retzer, Erdmann Spiecker, Julien Bachmann, Karl Mandel and Susanne Wintzheimer,* ***Chem. Mater. 2025****, 37, 8, 2815–2826* https://doi.org/10.1021/acs.chemmater.4c03429