# Catalytic nanoparticles generated by a UV-mediated spark discharge generator

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Emissions from diesel engines are a major contributor to reduced air quality and resultant human health impacts. Exhaust after-treatment devices are routinely used to reduce emissions of harmful pollutants. Diesel oxidation catalysts, mainly consisting of nanoparticles of platinum and palladium, oxidise harmful pollutants such as carbon monoxide and unburnt hydrocarbons and convert them to carbon dioxide and water. Commercial catalysts are typically produced using wet-chemistry methods, which are batch processes suffering from poor control over the ratio of platinum and palladium in the catalyst nanoparticles, and from impurities introduced by solvents and precursors.

This study presents a gas phase approach, which utilises an electrical spark discharge to generate catalyst nanoparticles from appropriate electrode metals. A high voltage current source was used to generate a potential difference across a gap between platinum and palladium electrodes in excess of the breakdown voltage, which is a function of the inter-electrode distance and carrier gas. The resultant discharge occurs on the microsecond-scale and a >200 A current pulse is accompanied by an expanding shock wave. The pulses of electrical discharge create a ~20,000 K hot spot on the tip of electrodes (Reinmann & Akram, 1997), which causes material to sublimate from the electrodes to the surrounding inert gas. The large temperature gradient results in nucleation of nanoparticles. Contaminants are minimised, depending only on the purity of the electrodes and carrier gas.

To control agglomeration processes, photoelectric charging of the newly-formed nanoparticles was achieved by illuminating the generated catalyst nanoparticles with ultraviolet (UV) radiation. The energetic photons liberated surface electrons from the nanoparticles, resulting in a unipolar positive charge state. Excess free electrons were removed by a positively biased precipitator to avoid charge recombination.

A schematic of the experimental setup is shown in Figure 1. A Scanning Mobility Particle Sizer (SMPS) or a Centrifugal Particle Mass Analyser (CPMA) was employed to measure particle size/mass distribution at the exit of the spark generator. Particles were then collected by a thermophoresis-enhanced diffusion collector on an alumina-coated monolith substrate. The catalysed substrates were heated up gradually in a furnace and a Fourier Transform Infrared Spectroscopy (FTIR) was employed at downstream to measure hydrocarbon gas conversion efficiency. Furthermore, particles were analysed by transmission electron microscopy (TEM) and x-ray diffraction (XRD) to study their morphology.

Figure 2 shows that the geometric mean diameter (GMD) and geometric standard deviation (GSD) of the spark-generated nanoparticles are dependent on the gap distance between the electrodes. A larger gap distance, with constant current and hence the discharge frequency, leads to a smaller GMD and GSD. We will show the effect of other experimental parameters on the particle size and charge distribution, catalytic activity and morphology.

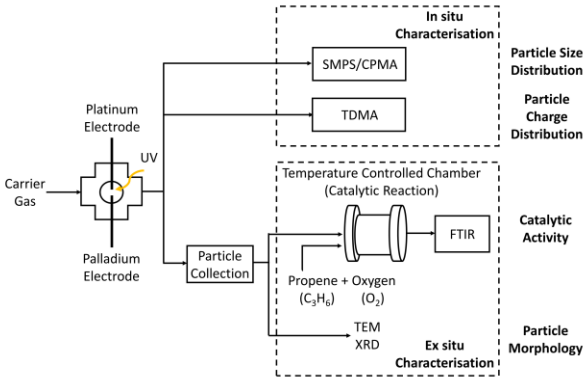


Figure 1. Schematic of the in situ and ex situ characterisations of the spark-generated catalysts.

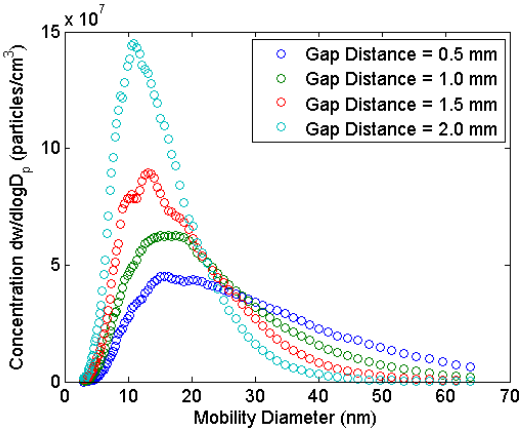


Figure 2. Particle size distribution measured by SMPS using a constant current output.

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Reinmann, R., & Akram, M. (1997). *J. Phys. D Appl. Phys.*, 30, 1125-1134.