Synthesis and characterization of palladium based carbon nanostructure-composites and their clean-energy application

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Akademisk avhandling

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Abstract
Carbon nanostructures are a wide field with many applications. The use of carbon nanostructures as support in heterogeneous catalysis is a key development that led together with the use of nanoparticles to a significant cost reduction of catalysts. Catalysts designed in this way are widely applied in fuel cell technologies. For portable devices especially low temperature fuel cells are desirable with low hazards for the user. One technology which fulfills these requirements is the direct formic acid fuel cell (DFAFC). DFAFC have many promising characteristics, such as high electromotive force and easy fuel handling. However, they still suffer from too low power output and lifetime for commercialization.

This thesis focusses on two main aspects: the synthesis of carbon nanostructures by chemical vapor deposition (CVD) and their application as catalyst support. The materials are investigated by many different techniques ranging from transmission electron microscopy (TEM) to fuel cell tests.

Different carbon nanostructures could be synthesized by catalytic CVD on palladium (Pd) nanoparticles. Multi-walled carbon nanotubes (MWCNTs), carbon nanofibers (CNFs) and helical carbon nanofibers (HCNFs) were grown, selectively, dependent on temperature, using acetylene as carbon precursor. Especially HCNF raised further interest due to their unique structure. A growth model for HCNFs was developed based on an anisotropic extrusion model. The synthesis conditions for HCNFs were optimized until an almost 100 % purity with very high efficiency was obtained.

The unique helical but fiber-like structure made the material very interesting as support for heterogeneous catalysis. Several catalysts based on Pd nanoparticle decorated HCNFs were developed. The synthesis methods ranged from standard methods like the polyol method to phase-transfer methods. The catalysts showed very promising results for the electro-oxidation of methanol, ethanol and formic acid. This makes them highly attractive for fuel cell applications. The catalysts were tested in DFAFC. The superiority of HCNF-based catalysts is attributed to the good attachment of nanoparticles to the defect-rich and easy to functionalize surface of HCNFs in combination with adequate film forming properties during electrode preparation.

Keywords
Carbon nanostructures, chemical vapour deposition, electro catalysts, transmission electron microscopy, direct formic acid fuel cells

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