Modeling of reversible and irreversible degradation in Direct Methanol Fuel Cells

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Direct-methanol fuel cells (DMFC) are promising as a power source for both, stationary and mobile applications. However, DMFCs show severe performance degradation during operation. This degradation can be divided into a reversible and irreversible part. Understanding the underlying mechanisms is crucial to reduce the performance losses and increase the lifetime of the cell.
Irreversible degradation can be attributed to a loss of the electrochemically active surface area (ECSA) at the cathode side, which is related to a growth of the platinum particles. On the other hand, reversible degradation can be related to the formation of platinum oxides.
Here we present a model which combines reversible degradation due to platinum oxide formation and irreversible degradation due to platinum particle growth. For the particle growth we consider two different mechanisms, namely Ostwald ripening and coalescence. Furthermore, we discuss the coupling effects between reversible and irreversible degradation.
Finally, we include the degradation model into a DMFC cell model in order to study the transient effect on the cell performance.

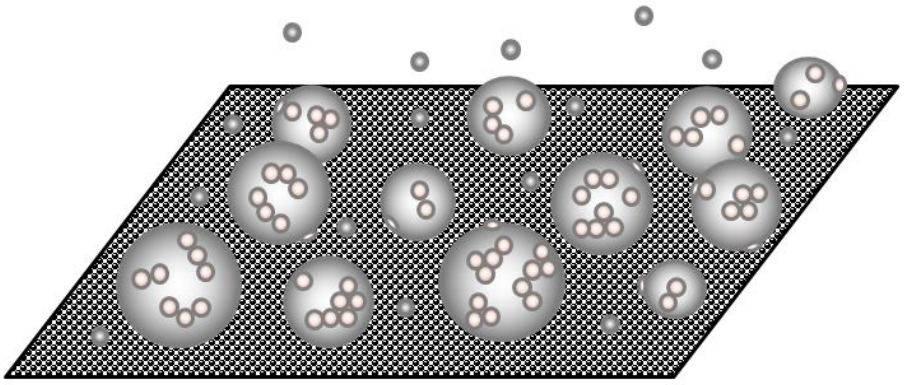

Fig. 1: Schematic diagram of the model: Irreversible degradation is caused by dissolution and precipitation of Pt^{2+} ions (leading to a particle growth) while reversible degradation is caused by the formation of platinum oxides. Both mechanisms reduce the ECSA, i.e., lead to a loss of cell performance.