

Non Precious Catalysts for Fuel Cells

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The polymer electrolyte membrane fuel cell (PEM-FC) is a promising device for the energy supply in cars. If the hydrogen is produced from renewable energy sources, an indeed zero-emission car could be realized. Today, platinum and platinum alloys are the state of the art material in PEM-FC. However, the high costs of platinum hinder a breakthrough of the FC technology.

As most of the platinum is required for the sluggish oxygen reduction reaction (ORR) the replacement of platinum by a cheap non-precious metal catalyst (NPMC) should enable enormous cost reduction. Especially during the last decade, Fe-N-C catalysts have proven to be a realistic alternative for the ORR. Today, they reach power densities of about 65 % of standard platinum catalysts ($0.3 \text{ mg}_{\text{Pt}} \text{ cm}^{-2}$) [1].

Motivated by these promising results the number of groups working on these materials has drastically increased. They all work on different preparation strategies for the optimization with respect to catalytic activity and stability in wet-chemical and/or fuel cell conditions.

^{57}Fe Mößbauer spectroscopy has proven a powerful technique for the characterization of Fe-N-C catalysts. Important information on the electronic properties of active sites in Fe-N-C catalysts [2-4] but as well insides into the formation processes occurring during the catalyst preparation can be obtained [5-13].

After a first short introduction dealing with different types of NPMC I will focus on the group of Fe-N-C catalysts. In a first part I will give some historical overview of the milestones that enable the preparation of today's highly performing Fe-N-C catalysts. Important factors affecting the catalytic activity will be elucidated.

In a second part different preparation attempts will be compared with respect to their structural composition as well as catalytic performance. It will be shown that the preparations of today's even most promising catalyst materials still have significant space for further improvement with respect to the density of active sites. Possible mechanisms for the degradation of Fe-N-C catalysts will also be addressed.

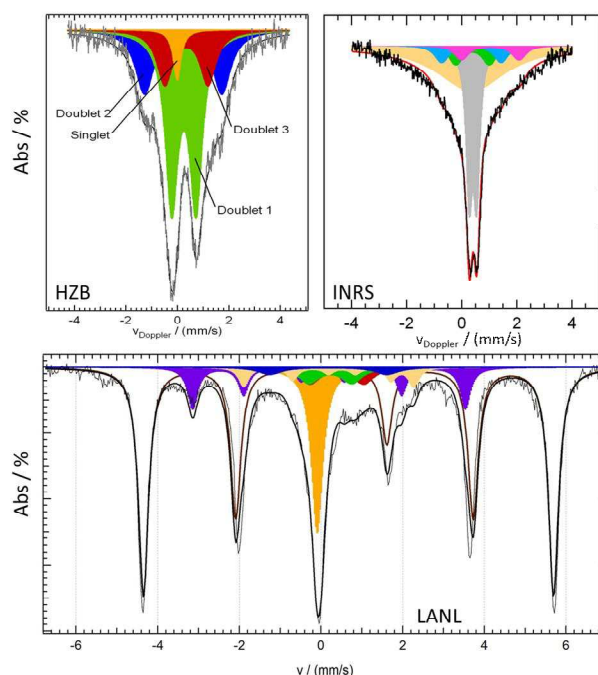


Figure 1: Comparison of the Mößbauer spectra of Fe-N-C catalysts prepared via three different preparation approaches. “HZB” refers to a catalyst prepared by the oxalate-supported pyrolysis of porphyrins [14] as discussed in [2], “INRS” corresponds to the old INRS-standard catalyst (with 0.2 wt% Fe in precursor) as described in [11]. “LANL” stands for the Fe-PANI-C catalyst characterized in [12]. Pictures were taken from refs. [2, 11, 12].

References:

- [1] E. Proietti et al., *Nature* (2011) 2, 416.
- [2] U.I. Kosłowski et al., *J. Phys. Chem. C* (2008) 112, 15356.
- [3] U.I. Kramm et al., *J. Electrochem. Soc.* (2011) 158, B69.
- [4] U.I. Kramm et al., *J. Phys. Chem. C* (2011) 115, 23417.
- [5] Blomquist et al., *J. Chem. Soc., Faraday Trans.* (1992) 88, 2007.
- [6] A.L. Bouwkamp-Wijnoltz et al., *J. Phys. Chem. B* (2002) 106, 12993.
- [7] H. Schulenburg et al., *J. Phys. Chem. B.* (2003) 107, 9034.
- [8] J. Maruyama and Abe, *J. Electrochem. Soc.* (2007) 154, B297.
- [9] P. Matter et al., *J. Phys. Chem. C* (2007) 111, 1444.
- [10] U.I. Kramm et al., *ECS Trans.* (2009) 25, 659.
- [11] U.I. Kramm, *PCCP* (2012) 14, 11673.
- [12] M. Ferrandon, *J. Phys. Chem. C* (2012) 116, 16001.
- [13] J. Tian et al., *Angew. Chem. Int. Ed.*, accepted
- [14] I. Herrmann et al., *Electrochim. Acta* (2009) 54, 4275.