Carbon Aerogels as Promising Carbon Supports in Fe-N-C Catalysts for Oxygen Reduction Reaction in High Temperature Proton Exchange Membrane Fuel Cells

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Motivation & Approach

- Pt poisoning in high temperature proton exchange membrane fuel cell (HT-PEMFC) by phosphate ions from electrolyte → high loadings (1 mg_{Pt} cm^{-2}) and material costs
- Promising alternative **Fe-N-C** as cathode catalyst for oxygen reduction reaction (ORR): cost effective, adequate activity
  - Challenges: Mass transport limitation, low volumetric activity[1]
- **Carbon aerogel (CA)** as $Fe-N_x$ support: tuned structure for optimal mass transport and improved oxygen and proton access[2]
- Investigation of **CA composition** (functional groups, ball milling, pore size distribution, iron content) on **activity and stability**

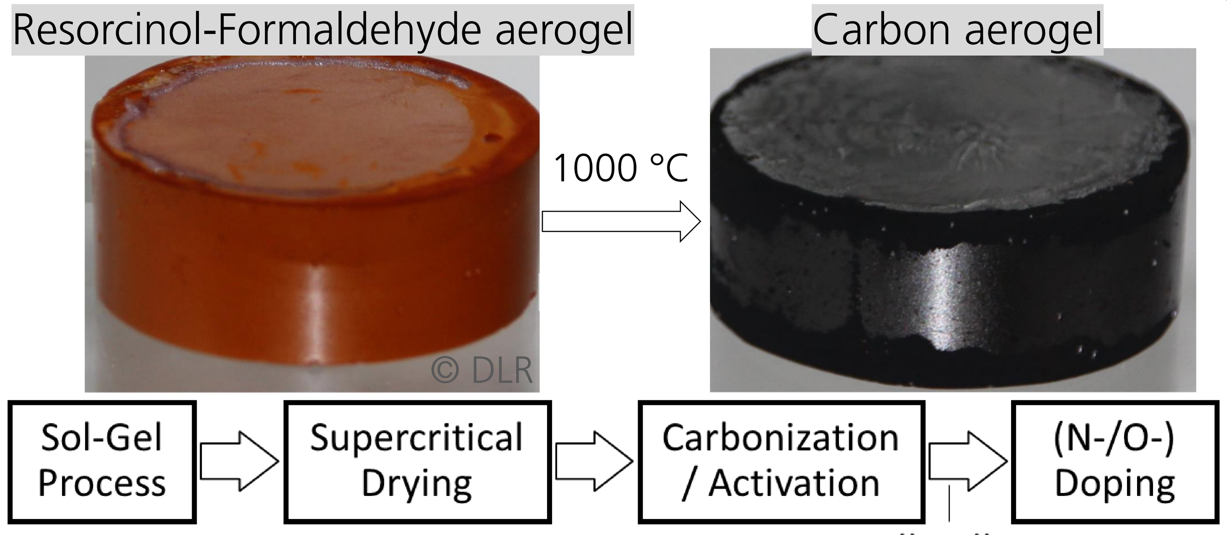


Fig. 1. Synthesis of carbon aerogel.

Synthesis and Physical Analysis of CA and Fe-N-CA

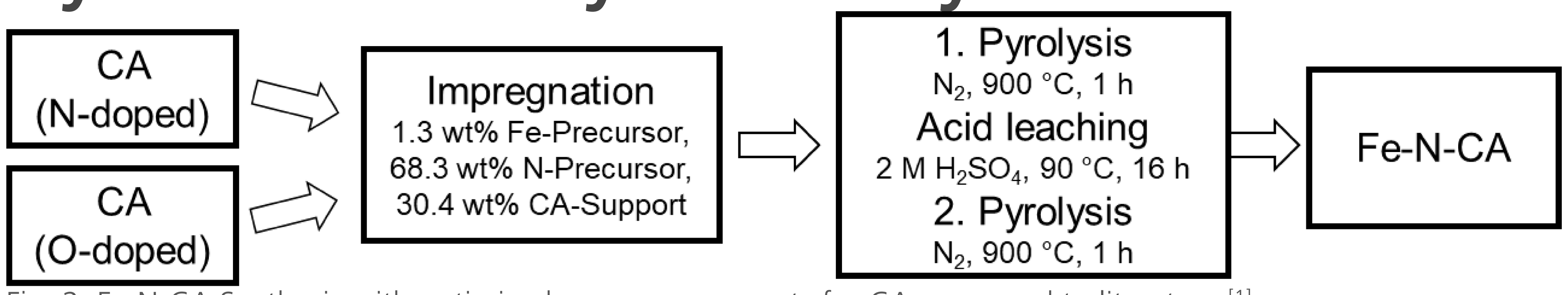


Fig. 2. Fe-N-CA Synthesis with optimized precursor amounts for CA compared to literature.[1]

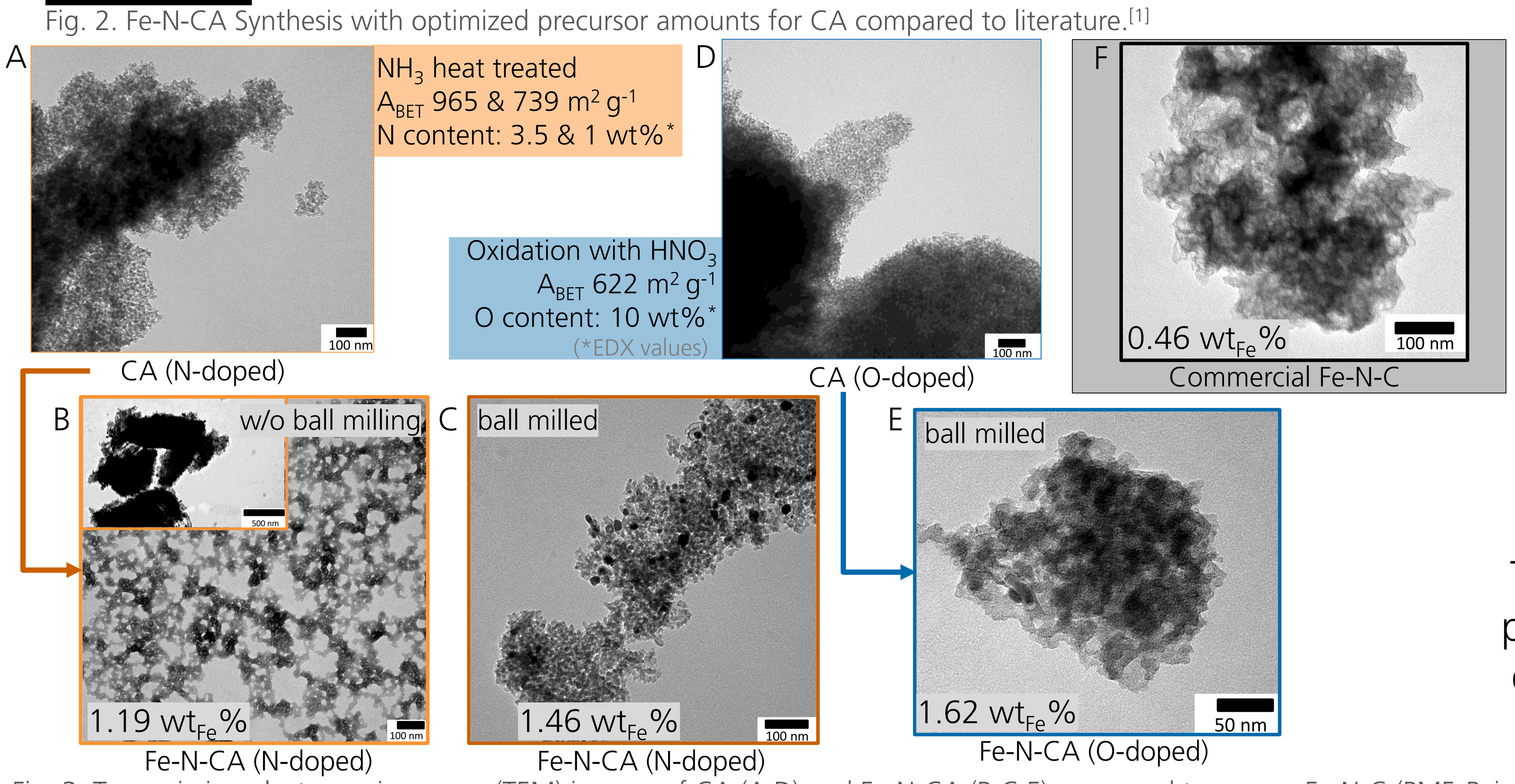
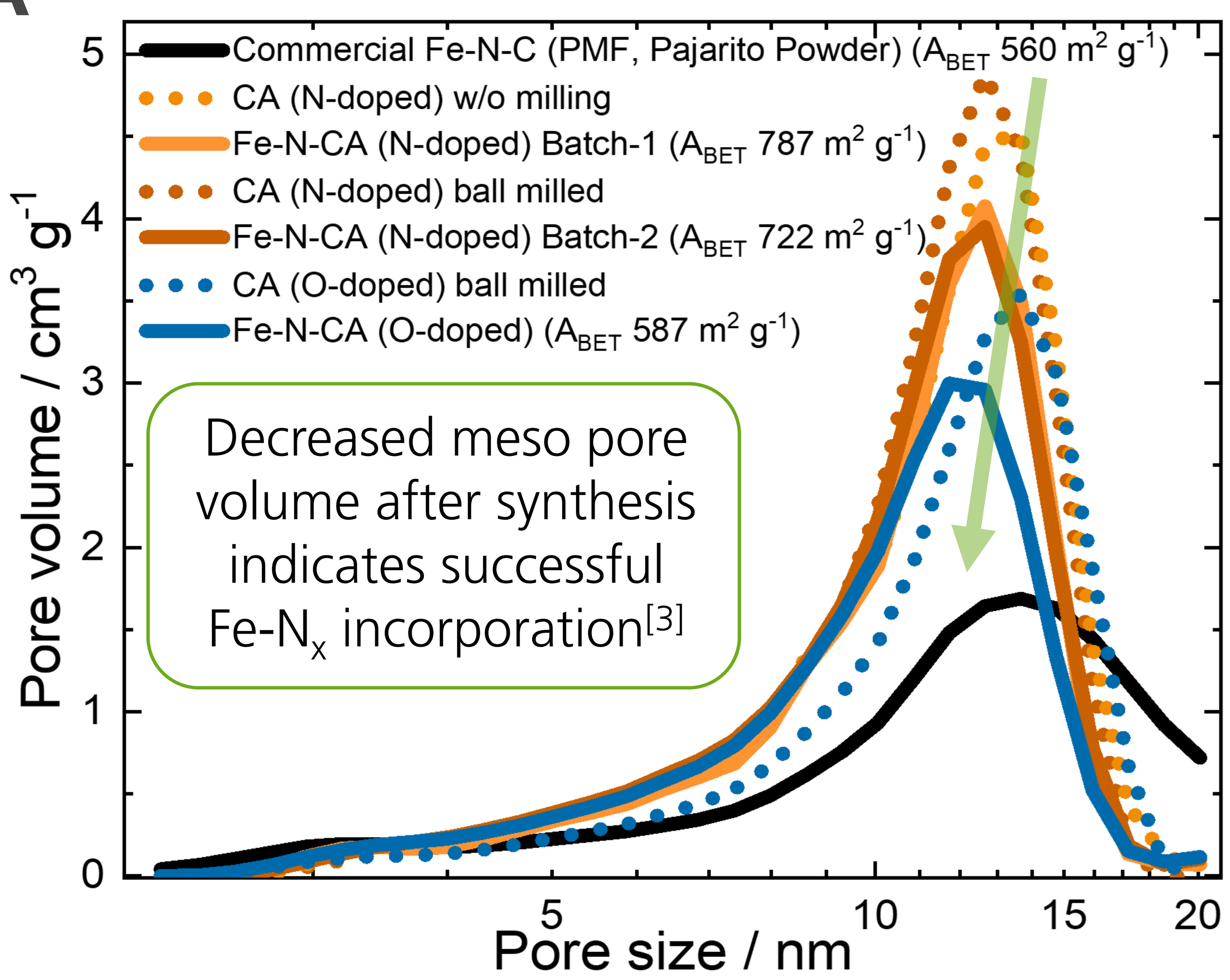


Fig. 3. Transmission electron microscopy (TEM) images of CA (A,D) and Fe-N-CA (B,C,E) compared to comm. Fe-N-C (PMF, Pajarito Powder) (F).



TEM and N_2 sorption: **ball milling necessary** (optimal parameters 3 x 15 mm, 2 min) → Homogenous particle distribution and large agglomerates (Fig.3.) milled into smaller pieces (~50 µm), beneficial for impregnation with precursors

Influence of CA Support on ORR Mass Activity

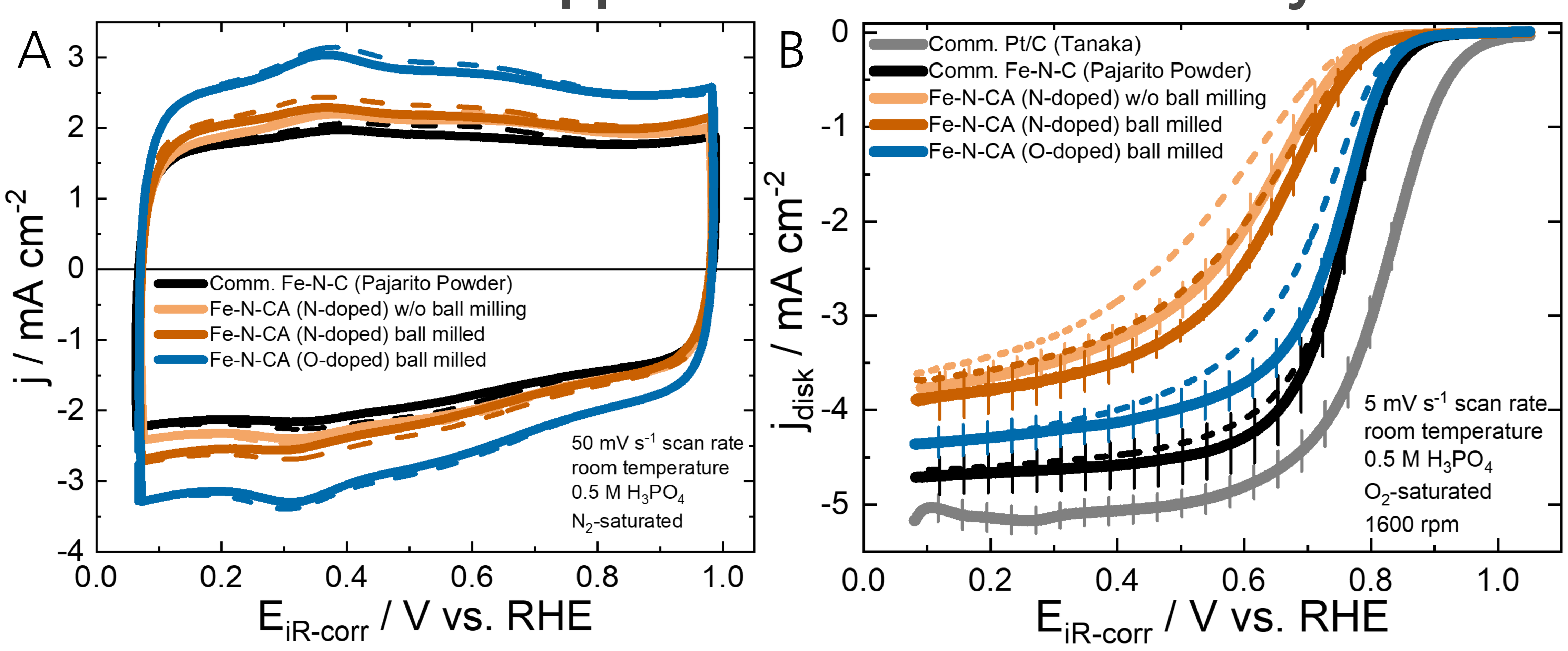


Fig. 5. Activity and Stability determined in rotating ring-disk electrode setup before (solid line) and after (dashed line) stress test (10,000 cycles btw. 0.6 and 1.0 V, 3 s each, O_2-atmosphere) A. cyclic voltammograms (CVs) in N_2-atmosphere B. ORR curves in O_2-atmosphere.

Table 1. Mass activity (MA), stability and selectivity of the catalysts.

Catalyst	MA at 0.80 V / A g^{-1}	MA loss at 0.80 V / %	Selectivity: H_2O_2 yield at 0.7 V / %
Commercial Fe-N-C	3.4 ± 1	8.4 ± 0.6	3.8 ± 0.6
Fe-N-CA (N-doped) w/o milling	0.26 ± 0.08	27 ± 0.01	22 ± 4.7
Fe-N-CA (N-doped) milled	0.48 ± 0.2	11 ± 0.08	10 ± 0.6
Fe-N-CA (O-doped)	2.4 ± 0.5	28 ± 0.3	3.8 ± 1.6

Beneficial structure with O-doped Fe-N-CA → comparable MA and stability to commercial Fe-N-C

Conclusion & Outlook

- Optimization of synthesis, adjusting of ball mill parameters and type of functional groups of CA lead to increase in activity and stability of Fe-N-CA for ORR
- Further studies: Implementation in GDEs and characterization under HT-PEMFC conditions (conc. H_3PO_4, 160 °C) in half-cell setup (Fig. 6).

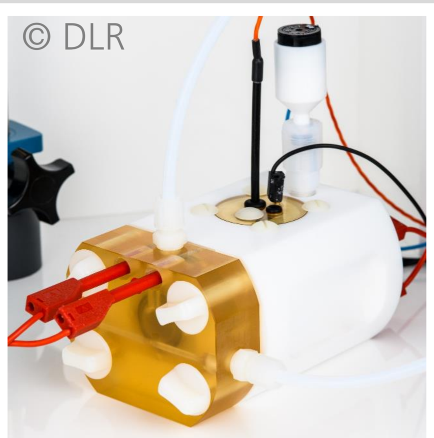


Fig. 6. Commercial GDE half-cell setup (Gaskatel FlexCell PTFE©)

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