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LASER-ASSISTED CHEMISTRY TO DESIGN ADVANCED SINGLE-ATOM CARBON-BASED CATALYSTS

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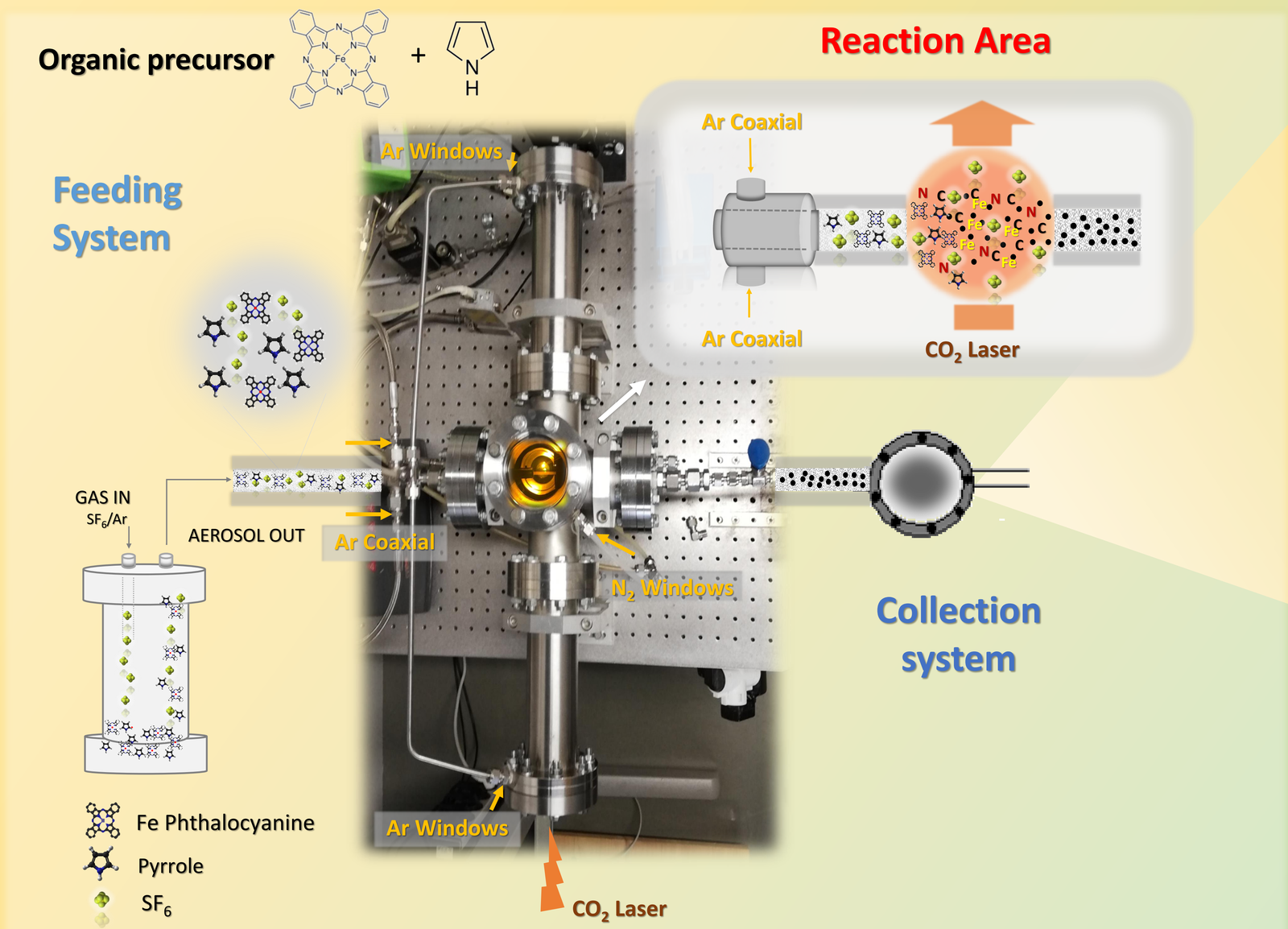
Introduction

The on-going energy and chemistry transition characterized by the progressive electrification and the substitution of raw materials with alternative sources to decrease fossil fuel use, has driven a growing demand for the development of outstanding catalysts that radically change the current concepts of catalysis and related reaction mechanisms. Single-atom catalysts (SACs) are recently emerging as a new frontier in heterogeneous catalysis science.[1] Especially, carbon-based materials have proven to be excellent candidates for supporting single-atom catalysts due to their unique structural and electronic properties. However, fabricating SACs, providing 100% metal centers dispersion under synthesis and catalysis conditions are highly challenging.

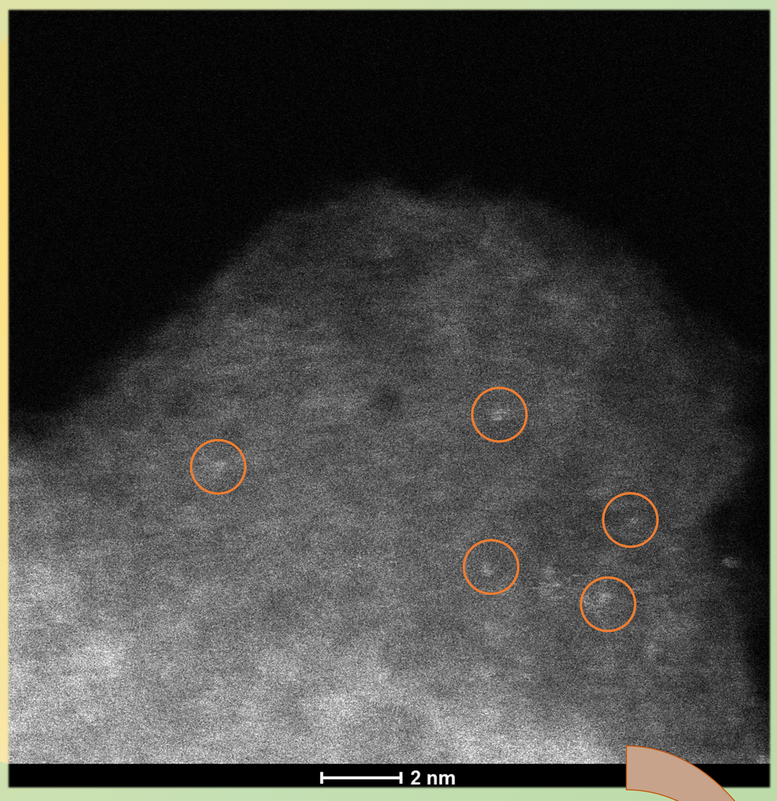
Motivation

This work is set on the establishment of the laser pyrolysis processing as one-pot and up-scale alternative in the synthesis of a single-atom catalyst with multiple catalytic active sites M-Nx (M= Fe) dispersed on a solid carbon surface. Spatial uniformity and high temperature (> 500ºC) in the reaction zone, short millisecond scale residence times, and high heating/cooling rates are the most important advantages of this strategy to control uniform atomic-scale distribution of the metal atoms. Finally, promising applications of the as-prepared catalysts for oxygen reduction reaction (ORR) is described.

Synthesis method: LASER PYROLYSIS

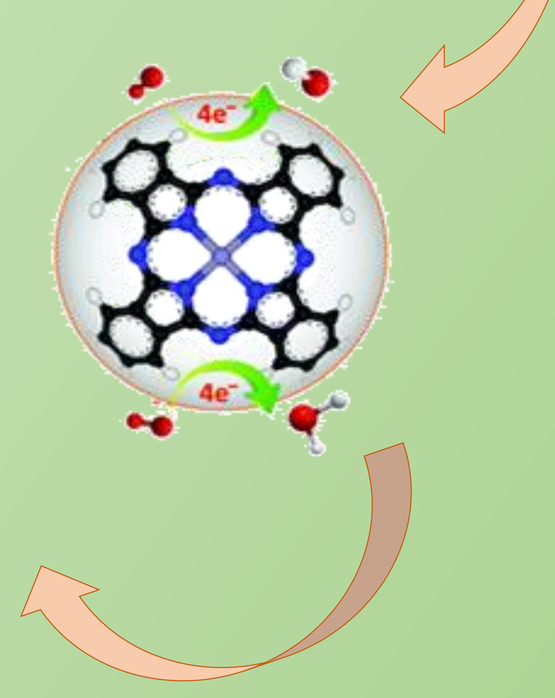


C-supported Single Atom Catalyst



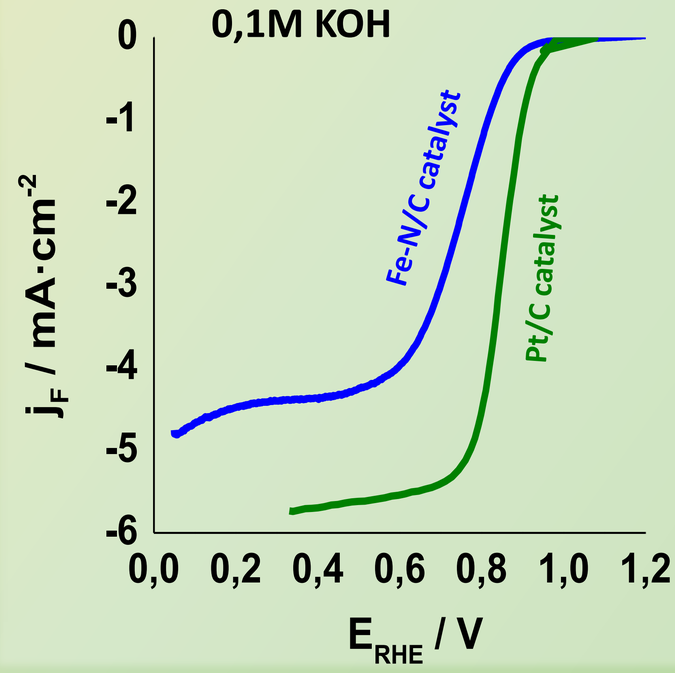
Oxygen Reduction Reaction (ORR)

$$O_2 + 4H^+ + 4e^- \longrightarrow 2H_2O$$



Conclusions

Based on the combination of iron phthalocyanine as metal source and nitrogen-containing solvent, single atom catalyst Fe-N/C has been made through a straight-foward laser-driven pyrolysis process. The Fe-N/C catalysts contain atomically dispersed Fe bonding on carbon with robust Fe-N active moieties. The resultant Fe-N/C catalyst exhibited activity at a constant potential of 0,74 V comparable with 0,80 V relative to Pt/C, and high long-term stability studies by potential cycling (0,0–1,2 V) for ORR in alkaline electrolyte. The as-prepared catalyst can be considered as potential candidate for replacing the noble Pt catalyst in fuel cells.



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[2] Hanguang Z., Hoon T-C., David A-C., Stephan W., Ulrike I-K., Karren L-M., Piotr Z., Gang W., Energy Env. Sci. 12 (2019) 2548.

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