Optimization of Performance of Fe-N-C Catalysts on Tantalum-doped Titanium Dioxide Supports for ORR

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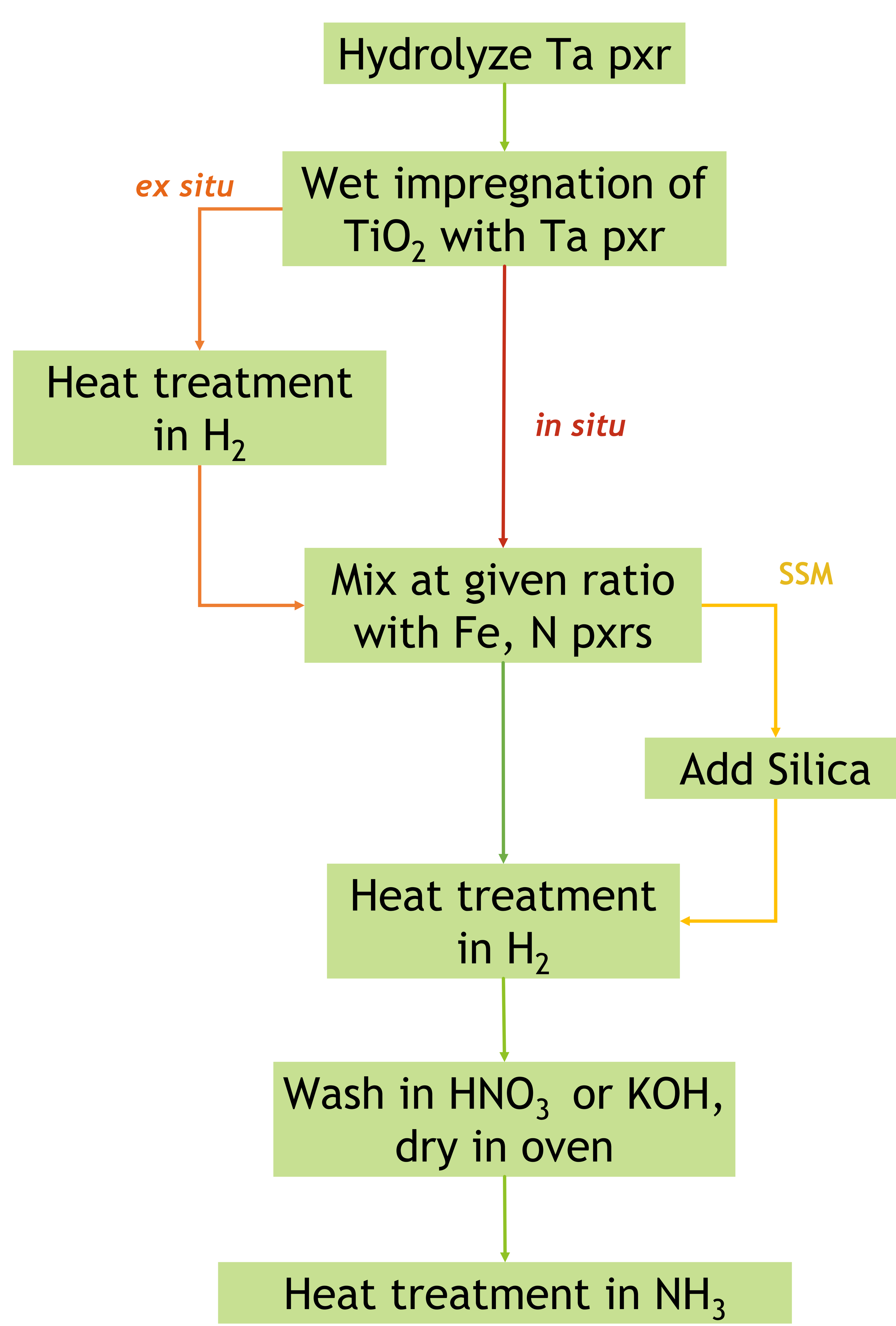
Problem: Fe-N-C catalysts have shown potential to replace expensive PGM-based ORR catalysts in PEMFCs, but are usually supported by conductive carbon. Due to the highly oxidizing environment of the cathode, these supports are susceptible to corrosion. Carbon corrosion can decrease activity by inducing agglomeration and detachment of active sites.

Goal: Demonstrate viability of Ta-doped TiO_2 supported Fe-N-Cs; optimize synthesis parameters for performance of Fe-N-Cs on this oxide support material.

Methods: Both *in situ* and *ex situ* methods were employed for synthesis of $Ta_{0.05}Ti_{0.95}O_2$ supported Fe-N-C catalysts. The following precursors were subjected to various heat treatments.

- 4-Aminoantipyrine
- $Fe(NO_3)_3 \cdot 9H_2O$
- $TaCl_5$
- TiO_2
- Silica (SSM only)

The scheme to the right outlines various synthesis routes. After the catalysts had been synthesized, each was loaded onto a RRDE and DECV tests were run in both acid and alkaline media.



Results: The following table and figures summarize the major results obtained from this study. Other graphs were also generated but are not shown.

Table 1. Summary & Nomenclature of Catalysts Produced

Catalyst ID	AAP:$Ta_{0.05}Ti_{0.95}O_2$	Fe:AAP	Silica added?
FeNC@Oxide 1-10	1%	10%	No
FeNC@Oxide 3-10	3%	10%	No
FeNC@Oxide 5-10	5%	10%	No
FeNC@Oxide 7-10	7%	10%	No
FeNC@Oxide 10-10	10%	10%	No
FeNC@Oxide 25-10	25%	10%	No
FeNC@Oxide 5-10 SSM	5%	10%	**Yes**
FeNC@Oxide 3-10 *in situ*	3%	10%	No
FeNC@Oxide 3-40	3%	**40%**	No
FeNC@Oxide 10-25	10%	**25%**	No
FeNC@Oxide 10-40	10%	**40%**	No

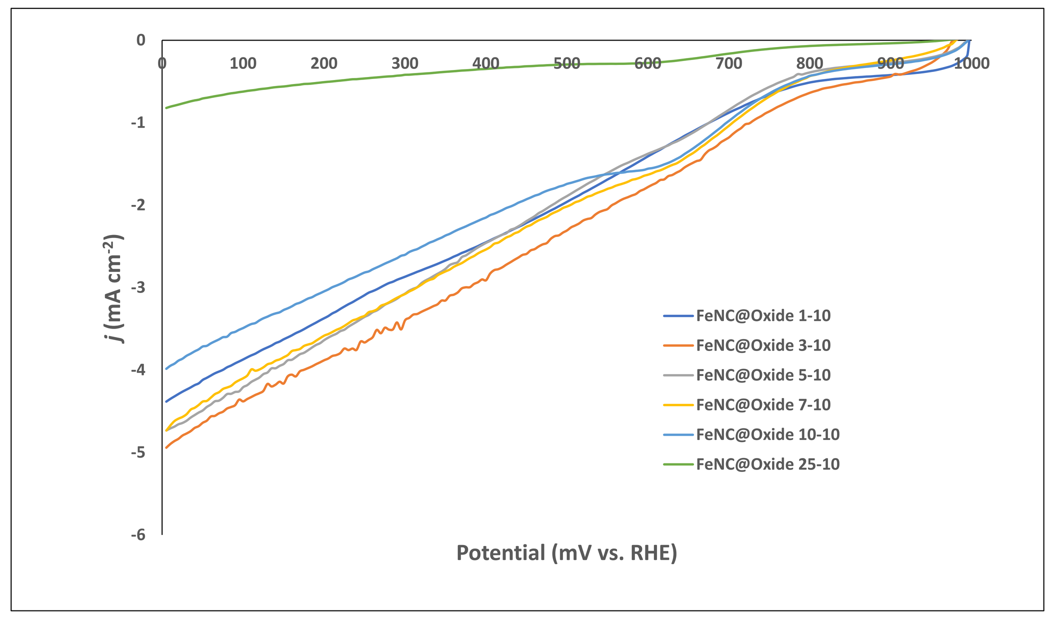


Fig.1. First round of synthesis polarization curves in acid.

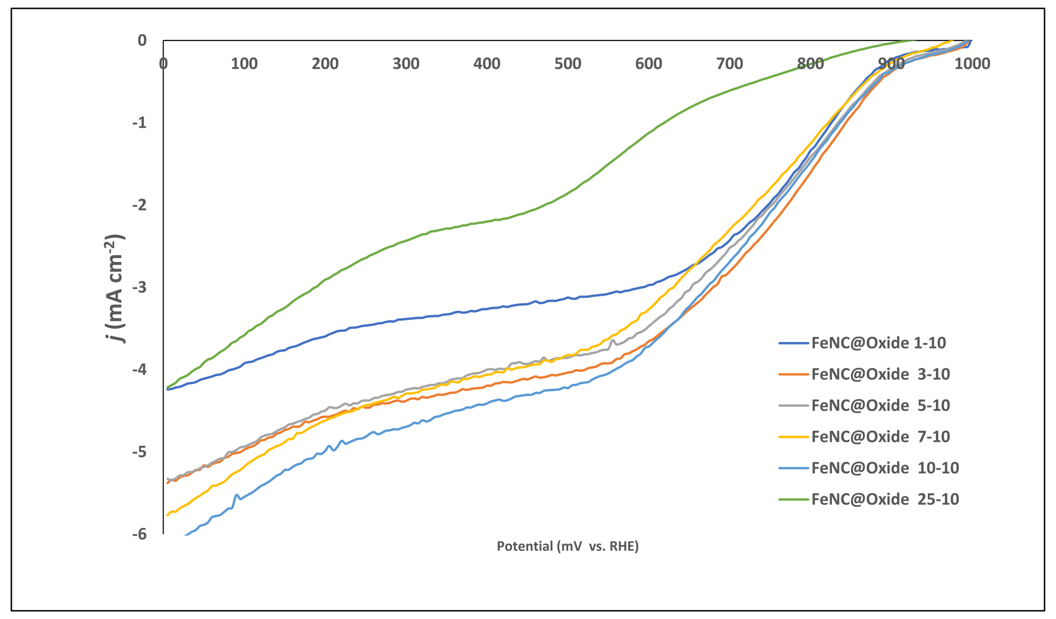


Fig. 2. First round of synthesis polarization curves in alkaline.

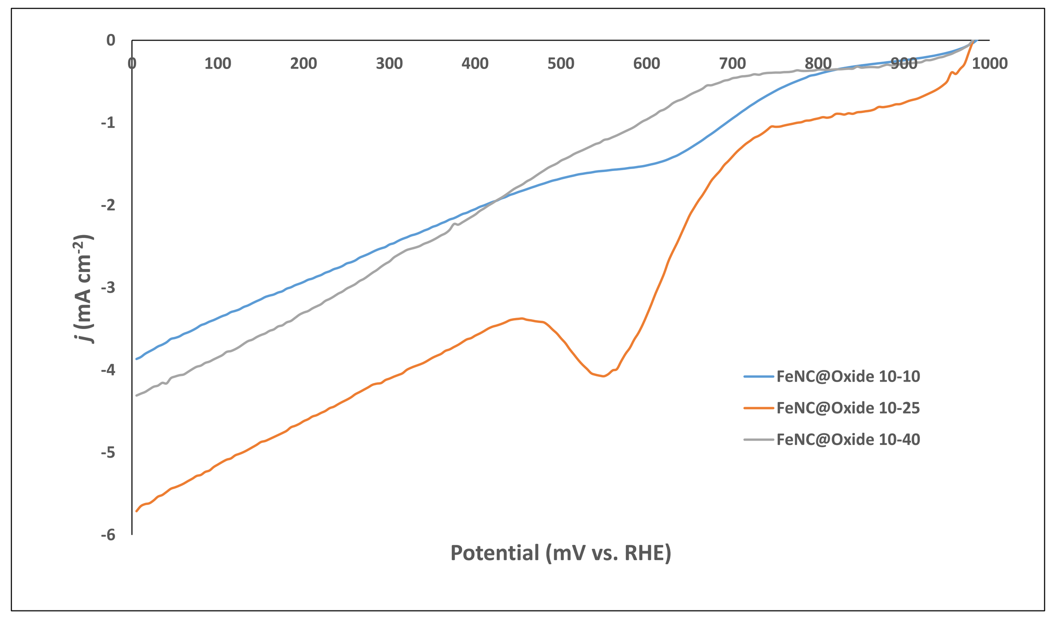


Fig. 3. Final round of synthesis; effect of iron percentage on polarization curves in acid.

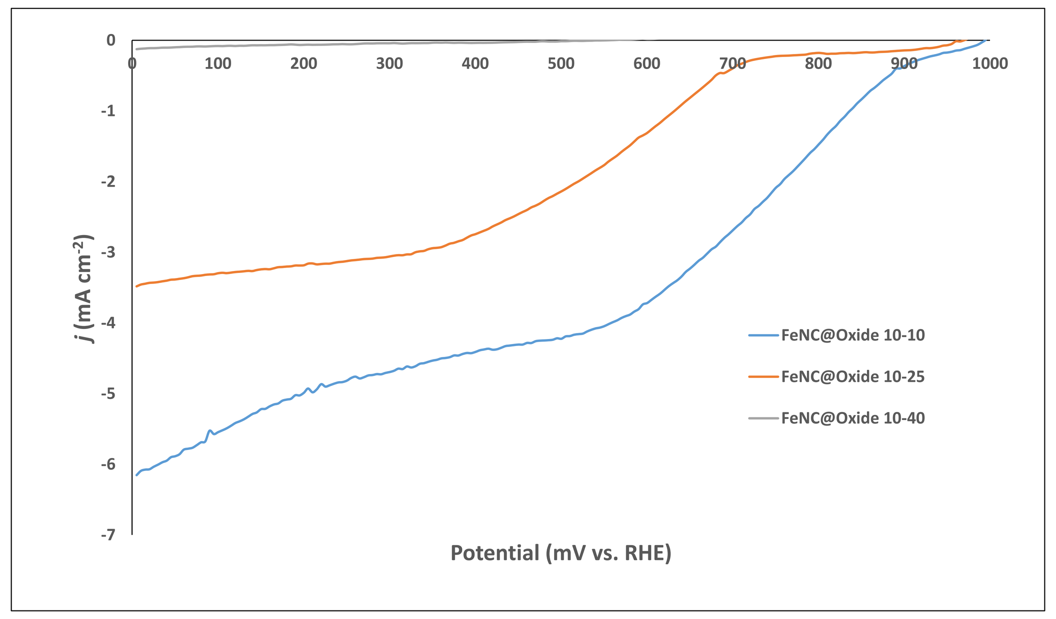


Fig. 4 Final round of synthesis; effect of iron percentage on polarization curves in alkaline.

Conclusions: FeNC@$Ta_{0.05}Ti_{0.95}O_2$ catalysts show ORR activity. The ratio of 10% FeNC:Oxide had the best performance in both acid and alkaline. The ratio of 25% Fe:AAP showed best performance in acid, and *in situ* showed no benefit over *ex situ* processing.

Future Work: Durability testing, physical characterization, development of structure-performance relationship