# $Pd_x$ $Fe_y$/CA FOR OXYGEN REDUCTION REACTION IN ALKALINE MEDIA

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Carbon aerogels (CA) are highly porous 3D, conductive carbon materials with low density (<0.1 g $cm^{-3}$) and high specific surface area (500–2000 $m^2$ $g^{-1}$), serving as next-generation, multifunctional solutions for sustainable energy storage and conversion, environmental remediation, and catalysis. Their unique, tunable structures, derived from polymerization, drying and carbonization, enable superior performance in supercapacitors, gas adsorption, and water purification [1].

Metal-doped CAs have also shown significant potential as electrocatalysts for oxygen reduction reaction (ORR), which is kinetically very slow. These materials enable four-electron ORR pathway for energy conversion in fuel cells and metal-air batteries, and two-electron ORR pathways for green $H_2O_2$ production. Due to their properties, these materials represent a cheaper and more available alternative to Pt-based systems, which are considered as ORR benchmark electrocatalysts.

In this work, the electrochemical performance of CA doped with Pd and Fe in different ratios was investigated for ORR in an alkaline medium (1 M KOH) using cyclic voltammetry, linear sweep voltammetry with rotating disc electrode (RDE) and chronoamperometry. The number of electrons exchanged during ORR for $Pd_{30}Fe_{70}$/CA (3.38) and $Pd_{70}Fe_{30}$/CA (2.80) indicates a mixed mechanism where two-electron and four-electron ORR take place in parallel. The value of the onset potential at a current density of -0.1 mA $cm^{-2}$ for $Pd_{70}Fe_{30}$/CA and $Pd_{30}Fe_{70}$/CA are 0.925 V and 0.885 V, respectively. The corresponding Tafel slope values for $Pd_{70}Fe_{30}$/CA and $Pd_{30}Fe_{70}$/CA are 115 mV $dec^{-1}$ and 73 mV $dec^{-1}$, respectively. The low Tafel slope value for $Pd_{30}Fe_{70}$/CA is comparable to that of Pt/C (78 mV $dec^{-1}$ ) [2].

Thanks to their electrochemical properties and the optimization of experimental conditions, these materials show great potential for electrocatalysis of ORR and thus provide great opportunities for numerous applications.

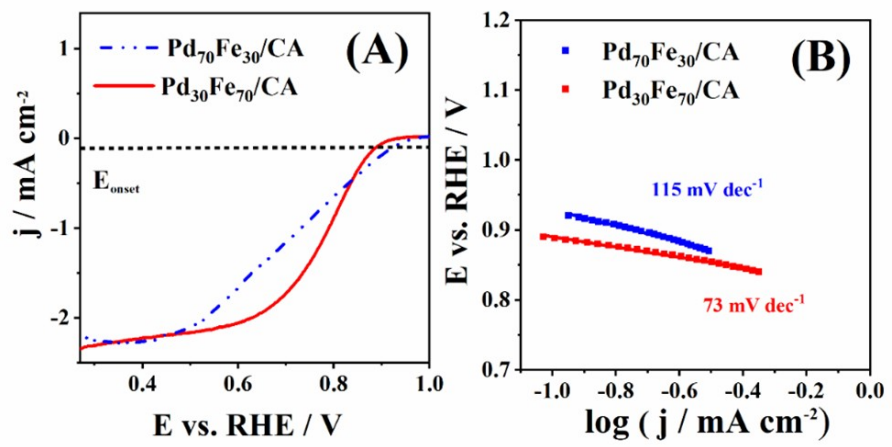


**Fig. 1.** ORR RDE curves of $Pd_{70}Fe_{30}$/CA and $Pd_{30}Fe_{70}$/CA (A) with the corresponding Tafel plots (B) in $O_2$- saturated 1 M KOH solution at 1600 rpm and 20 mV $s^{-1}$ .

**Acknowledgements**

The authors would like to thank the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (contracts no. 451-03-136/2025-03/200146 and 451-03-137/2025-03/200146) as well as Fundação para a Ciência e a Tecnologia (FCT, Portugal) ) (contracts no. LAPMET - LA/P/0095/2020 - IST-ID and UID/PRR/04540/2025, https://doi.org/10.54499/UID/PRR/04540/2025).

[1] D. Tomić et al., "Carbon aerogels and xerogels: next-generation materials for sustainable energy and environmental solutions," Chemical Communications, vol. 61, no. 80, pp. 15510–15523, Jan. 2025, doi: 10.1039/d5cc02477c.
[2] M. Shen et al., "Chemical vapor deposition strategy for inserting atomic FeN4 sites into 3D porous honeycomb carbon aerogels as oxygen reduction reaction catalysts in high-performance Zn-air batteries," Chemical Engineering Journal, vol. 464, p. 142719, Apr. 2023, doi: 10.1016/j.cej.2023.142719.